TransGrid

TransGrid Revenue Proposal
2018/19 – 2022/23

Appendix A

Network Vision 2056

TransGrid

Network Vision 2056

Our Network Vision is to connect you to the future of Energy

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> “**My interest is in the future** because I’m going to spend the rest of my life there”
>
> — **C F Kettering**

> “**The best way to predict the future** is to invent it”
>
> — **Alan Kay**

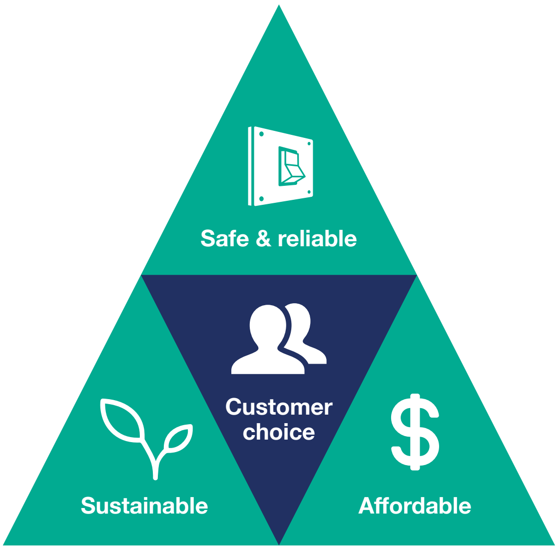
Foreword

I am pleased to provide you with this update of TransGrid's Network Vision. This document does three things. First, it outlines the challenges we are likely to face in planning, operating and managing the NSW electricity transmission network over the next 40 years. Second, it provides an overview of the actions TransGrid is already taking to meet those challenges. Finally, it sets out the Vision and Principles that we'll use to continue to deliver strong value to our customers and end users as we journey into that future.

Our network is the centrepiece of the National Electricity Market (NEM), providing interconnection capability to Victoria and Queensland and playing a crucial role in supporting the economic growth of NSW and the ACT. It is one of the most reliable transmission networks in the world.

Taking a long view of the development of the network is important, particularly now when the ways that we generate, transport and use energy are undergoing rapid, significant change. There is a wide range of opinions as to what that future may look like. Given the uncertainties, this document isn't an attempt to predict which one will come to pass. Nor is it a detailed planning document. Instead, the approach we've taken is to identify the features that those scenarios about the future have in common. We will then discuss the characteristics our network will need to have to effectively play its part in that emerging energy ecosystem.

It is also important to highlight TransGrid's strategic focus as a privately owned business.



As a business, our strategic focus is to understand the preferences of our customers and the consumers and communities we serve to ensure our services meet their long term needs. We know that they want choice when it comes to their electricity and we believe that there shouldn't be a trade off between choice and affordability, sustainability and reliability.

As we look to the future, to achieve this, TransGrid will demonstrate efficiency, responsiveness and innovation in everything we do and this underpins our Network Vision.

There are two further points I'd like to make.

First, the fact that predicting the future isn't easy only reinforces the importance of continuing to engage with our customers and stakeholders about what that future may look like and the challenges we are likely to face in getting there. That dialogue forms an essential half of a virtuous circle: the better we understand our customers, the more effectively we can plan, operate and deliver our network. The more effectively we run our network, the more efficiently priced capability we can offer our customers.

Second, we are already working hard to ensure that TransGrid as a business, and the transmission network itself, have the right capabilities. We continue to invest in our people to ensure a service-oriented, commercially focused and innovative culture as well as in technologies that enhance the performance of the network. I believe that by doing so we will continue to deliver strong value to energy users in NSW and the ACT.

I look forward to your feedback.

Gerard Reiter
Executive General Manager/
Asset Management

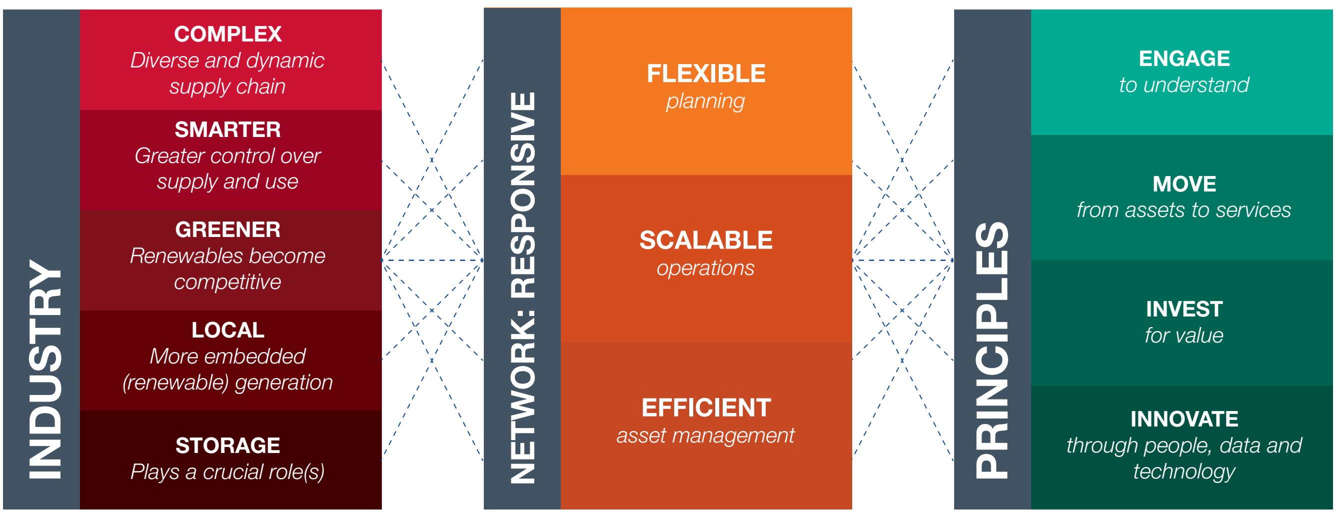
Executive summary

Australia's electricity industry is changing. There is a new smart energy ecosystem developing. Customers will be at the heart of that system, having a far greater say in how their power is provided and the grid will play an important and evolving role in meeting their needs. This document sets out TransGrid's Vision as to how the NSW transmission network will do so over the next forty years and the principles by which it will be planned, operated and managed to deliver that future.

Viewed with suitable caution, trends can provide a starting point for understanding what that future may look like. In recent years, energy consumption and maximum demand (consumption at a single point in time) have trended down due to a confluence of economic and policy factors. Consumption and winter maximum demand appear likely to grow more steady over time, with the impact of economic and population growth largely offset by a contriving focus on energy efficiency and strong penetration of solar panel systems. Depending on the source of the forecast, summer maximum may increase of decrease slightly.

The mix of generation is starting to change with thermal (coal and gas fired) generation being replaced with renewable generation. This trend is likely to accelerate. Over the longer term, it is likely that a greater proportion of that generation will be at the local level rather than large-scale. Advances in battery technologies will lead to the increased takeup of storage options across the supply chain and both networks and customers will deploy more advanced ("smarter") information and control systems to better manage the delivery and consumption of electricity services, respectively. The pace of these trends will depend on a combination of economic, government policy and technology drivers. Whatever the specific outcome, the future of energy supply is likely to be:

- **More complex** with the supply chain evolving from being a one way system with limited product choice to a "many to any" model where a mix of traditional and emerging providers, including customers themselves, supply a much wider range of energy services
- **Smarter** with technology enabling both greater control by customers regarding how their energy needs are met and greater flexibility by networks and other parts of the supply chain in responding to that more diverse and dynamic set of needs
- **Greener** with renewable forms of generation becoming more competitive with traditional fuel types
- **More local** with customers being able to meet a greater proportion of their needs from embedded generation
- Where **storage** will undertake a range of important functions across the supply chain.



The Vision we have for our network over the next 40 years is to connect you to that energy future.

To do this, our business will need to be responsive to our customer's needs, able to grow in ways that meet those needs and efficient. Likewise, our network must be:

> **Flexible** in the range and levels of connection and transport services that it provides to generators and customers

> **Scalable** in its ability to manage larger variations in energy supply and demand in real time

> **Efficient** in delivering those services to our customers at the lowest lifecycle cost.

Delivering this network will require us to operate according to four key principles. Fundamentally, these principles are statements about TransGrid's culture, one that is service-oriented and commercially focused.

We will:

> **Engage to understand** in order to have a more sophisticated knowledge of our customers (generators, directly connected customers and end user consumers)

> **Move from assets to services** to better address their evolving requirements for a more differentiated range of connection and transport services at different service levels

> **Invest for value** to further drive the technical performance of the network in ways that deliver efficient and sustainable costs for customers

> **Innovate through people, data and technology** to leverage more system, asset and customer information, make use of new technologies cost effectively and ensure the right workforce capabilities for that future.

Based on these principles, TransGrid is already taking steps to deliver much of the network capability outlined above. Further actions will follow over the longer term as the specific shape of the smart energy ecosystem becomes clearer.

Key actions now/in the near term and over the longer term:

Flexible planning	Scalable operations	Efficient asset management	Longer term
Area plans developed	Asset Monitoring Centre established	Asset decisions based on lifecycle performance, risks and costs (ISO55000)	Develop advanced customer and market modelling capabilities
Supporting the development of more flexible reliability standards	Piloting the integration of local generation, storage and Automated Demand Response	Using modular designs and moving/ repurposing assets to provide best value	Develop more sophisticated services and service levels
Better joint planning with AEMO and the distributors	Investigating the application of grid storage for other network services	Applying Dynamic Line Rating technology	Consider different customer transaction models
Integrating more closely with state and local planning frameworks	Using new tools and channels to pursue broader non-network opportunities	Using automated substation secondary system designs (IEC61850)	
More flexible approach to connection designs and processes	Encouraging greater policy support for emerging technologies such as electric vehicles	New technologies enabling field services at lower operating costs	
Renewable Energy Hub reduces access costs		Supporting transparent and cost reflective tariff reforms and timely capital recovery	

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> "This Network Vision sets out our strategic approach to planning, operating and managing the NSW transmission network over the next 40 years"

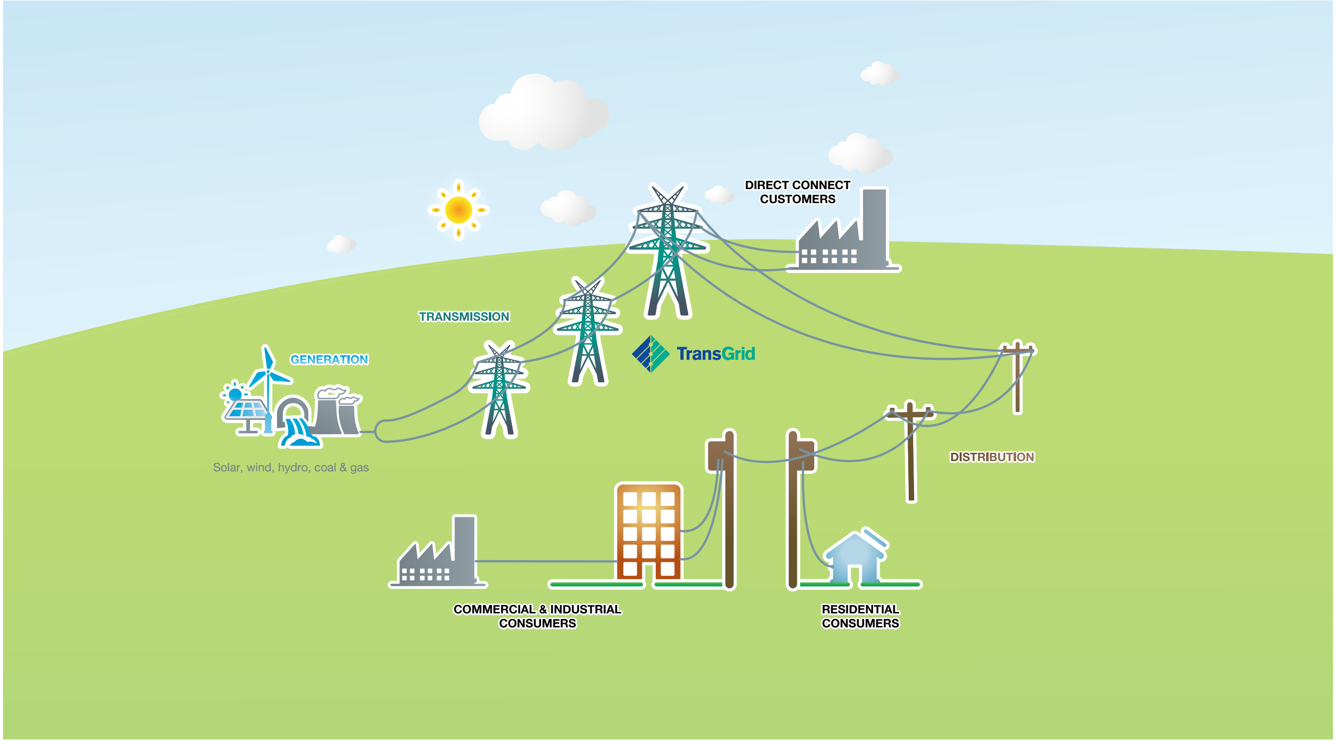
Introduction

1.1 About TransGrid

TransGrid operates the major high voltage electricity transmission network in NSW and the ACT. Our network comprises 99 substations and nearly 13,000 kilometres of high voltage transmission lines and cables. We connect generators, distributors (Ausgrid, Essential Energy, Endeavour Energy and ActewAGL) and major end users (Figure 1.1).

Our core function is the safe, secure and reliable bulk supply of electricity for use by NSW and ACT energy consumers. Interconnected to Queensland and Victoria, the network also provides a strong electricity system that makes energy trading possible between Australia's three largest states along the east coast and supports the competitive wholesale National Electricity Market (NEM).

Figure 1.1– TransGrid's role in the electricity supply chain



1.2 Purpose

This Network Vision outlines the challenges we are likely to face in planning, operating and managing the NSW electricity transmission network over the next 40 years. In doing so, this document also serves as a link between TransGrid's overarching business plan and our network asset management system. That system comprises our Asset Management Policy, Asset Management Strategies and Objectives and the Network Development Strategy (NDS).

Both the Vision and the NDS look out to a 40 year horizon, a strategic timeframe consistent with the long life spans of many of the network's key assets. Each year we also publish a Transmission Annual Planning Report (TAPR) which has a ten year horizon. The focus of the TAPR and NDS is to set out where, in the short and medium term (the TAPR) and longer term (the NDS), limitations may emerge on the network and identify what opportunities there may be to address them.

The Network Vision is different. Its purpose is to:

> Look at the network's role within the overall electricity supply chain

> Identify how that role may need to change in order to continue to deliver strong value to customers

> Set out our guiding Vision and Principles for how we do so.

This document will be revised as and when appropriate. We published our first Network Vision in 2014. This update is designed to capture and understand the implications for TransGrid's network of the significant work that has recently been undertaken in the public sphere regarding the likely future of the energy market.

1.3 Structure

The rest of this document is structured as follows:

> **Section 2: Trends** — describes the potential trends in key aspects of TransGrid's network operating environment over the next ten to 40 years

> **Section 3: Scenarios** — considers two different views of the future based on how those trends may be brought together, one view provided by AEMO and the other by the Future Grid Forum led by CSIRO

> **Section 4: Implications and actions** — outlines how TransGrid will need to plan, operate and manage its network in light of those views in order to continue to deliver strong value to our customers and end users and the actions it is taking to enable that capability

> **Section 5: Vision and Principles** — sets out our Network Vision and four key principles for achieving it.

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> “Our energy future will be smarter, greener and more local”

Trends

This section provides an overview of current trends in electricity use and supply and emerging related technologies to set the scene for how the future of the energy market, and TransGrid's network, are likely to evolve over the longer term. The industry has changed relatively slowly over the last half a century but it is now altering rapidly, driven by a range of technological developments, government policies and wider economic changes.

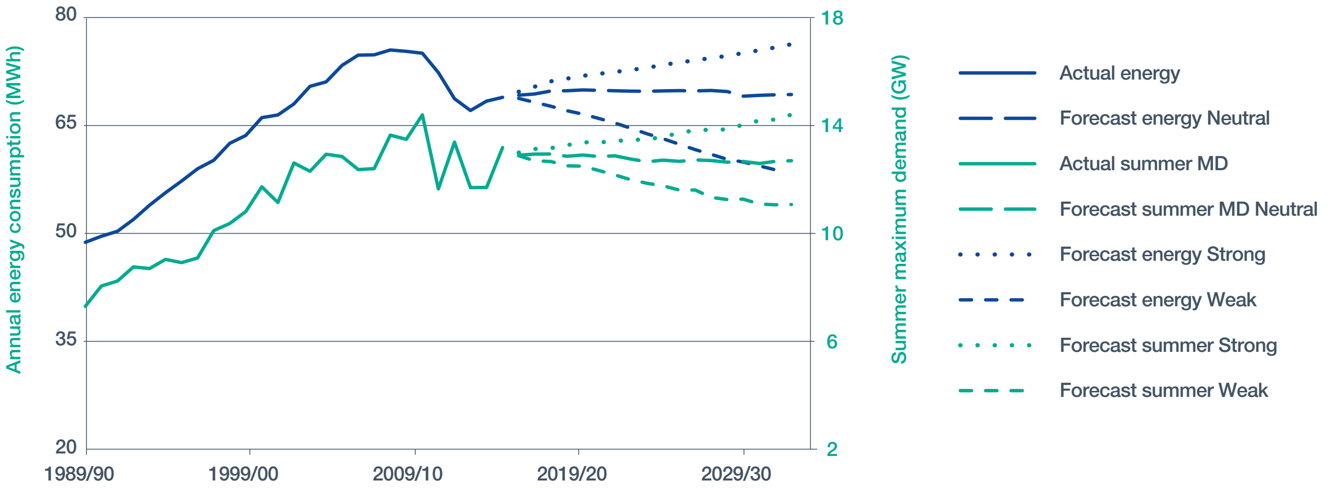
2.1 Use

Electricity use is measured in two ways: consumption over a period (typically in megawatt hours or MWh) and demand at a point in time (GigaWatts or GW). Both consumption and demand in NSW (which includes the ACT) had risen steadily for several decades. This was largely driven by a combination of:

- Economic growth with the Australian and NSW economies growing between 1998/99 and 2007/08 at average annual rates of 3.6% and 2.6%, respectively
- The increasing affordability of electrically powered goods (notably air conditioning but also white goods, computers and televisions).

However, consumption began to decline in 2003/04 and maximum demand after the 2007/08 Global Financial Crisis (GFC). The rate of the decline in consumption increased for several years after the GFC as shown in Figure 2.1.

Figure 2.1 – Annual NSW energy consumption (MWh) and maximum demand (GW)[3]



The key factors in these decreases were:

> A rise in electricity prices (see Figure 2.2 below), driven significantly by increases in (mainly distribution) network charges. The increases were to fund new network capacity to address forecast demand growth as well as to replace those parts of the asset fleet approaching the end of their useful lives

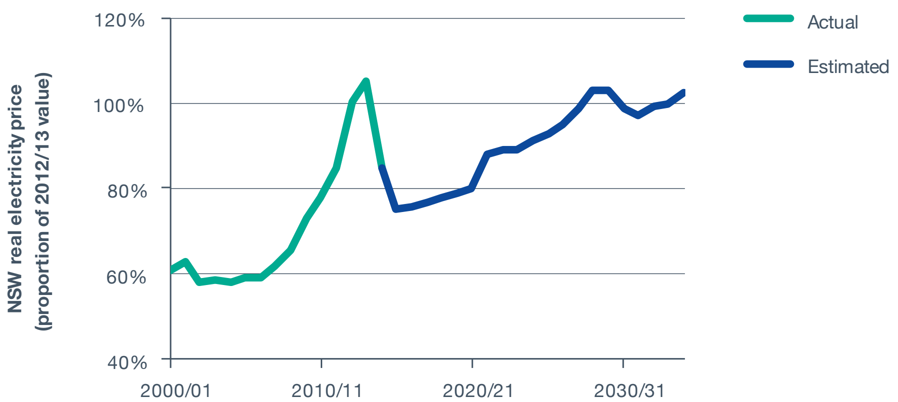
> A fall in energy-intensive manufacturing in NSW, particularly the closure of the Kurri Kurri aluminium smelter in 2014 and one of the two remaining BlueScope Steel blast furnaces at Port Kembla in 2011. The closures were driven by the rise in electricity prices, an increase in the import of competing goods produced overseas and the appreciation of the Australian dollar between the GFC and 2012. The closures marked a step change in a long shift in the national and state economies away from manufacturing towards the less energy-intensive services sector[1]

> An increase in energy efficiency, also partly as a result of the rise in electricity prices but also due to a greater awareness of the impact of fossil fuels on the environment. This trend was enabled by improvements in the availability and affordability of energy efficient appliances as well as government mandates to improve efficiency through building construction standards and broader-based schemes (such as the NSW Energy Savings Scheme).

Looking forwards, it is exceptionally challenging to predict the likely local economic circumstances out 40 years and how this may impact energy use. However, what can be noted is that NSW has recently emerged as the leading state in terms of economic growth, primarily as the result of low interest rates fuelling an increase in real estate activity and the Australian dollar returning to a lower level more typical of its longer term trend. In the last few years, the NSW Gross State Product (GSP) has crept closer to the Australian growth rate of 3 per cent but is expected to return to its long term average of 2 per cent[2].

The residential and commercial sectors now represent some 80% of total NSW consumption with industrial load making up the remainder. Sydney's importance as the state's load centre is expected to continue to grow. Total electricity consumption is forecast to grow very modestly at an annual rate of 0.1% over the next twenty years. This is because impact of economic and population growth largely offset by a continuing focus on energy efficiency and strong penetration of rooftop photovoltaic (PV) systems (solar panels). Under a neutral economic growth scenario, winter maximum demand is forecast to grow modestly with summer maximum demand either slightly increasing or decreasing, depending on the source of the forecast[3].

Figure 2.2 - Residential and commercial electricity prices in NSW (2012/13 baseline)



1. For example, the contribution of manufacturing to the NSW economy has steadily declined from 11% in 1990 to 7% in 2015 whereas the contribution of financial and insurance services has risen from 7% to over 12% in the same period (Australian Bureau of Statistics, series 5220.0, Table 2, issued 20 November 2015.)

2. Australian Bureau of Statistics, series 5206.0 (GDP) issued 2 March 2016 and series 5220.0 (NSW GSP) issued 20 November 2015.

3. AEMO, National Electricity Forecasting Report, 2016, http://www.aemo.com.au/Electricty/Plannig/Forecasting/National-Electricity-Forecasting-Report and TransGrid Transmission Annual Planning Report 2016, chapter 2.

2.2 Supply

Changes to the amount and mix of generation are also occurring.

Large scale generation

For large scale plant, the proportion of renewables is currently increasing. This is being driven by government subsidies and the withdrawal of older, less competitive thermal (coal) power stations.

In recent years, wind farm developments had stalled due to the uncertainty surrounding the Federal Government's Large scale Renewable Energy Target (LRET) scheme. In 2015, the Government announced that the annual targets for the scheme would be reduced to 33,000 GigaWatt Hours (GWh) per annum by 2020[4]. The announcement appeared to restore confidence in the industry[5]. In its 2015 National Transmission Network Development Plan (NTNDP), the Australian Energy Market Operator (AEMO) forecast that, under the revised LRET, up to 6,700 MW of additional large scale renewable generation investment will be required across the NEM[6] to meet that target with 5,000 MW of that expected to be met by wind farms in NSW, Victoria and South Australia[7]. TransGrid recently connected AGL's 53 MW solar plant at Broken Hill to the grid and is currently in the process of connecting Goldwind's 400 MW White Rock wind farm[8].

Large-scale solar farms are currently more expensive than their wind counterparts. The Australian Renewable Energy Agency (ARENA) is attempting to reduce the gap through a $100 million large-scale solar photovoltaics (PV) program[9]. It is expected that 200 MW of additional PV capacity will be installed in the NEM with eight of the twenty-two shortlisted projects planned to connect in NSW. This reflects NSW's strong solar resources relative to other states. These one-off solar projects will continue to be heavily subsidised by ARENA and renewable energy financing organisations such as the Clean Energy Finance Corporation (CEFC) until the costs become competitive with wind.

State governments are increasing their consumption levels of renewable energy through Power Purchase Agreements (PPA). Some have started to implement reverse–auction style tenders, with the ACT and Queensland seeking 450 MW[10] and 150 MW[11] of renewables, respectively. The NSW government recently went to market to procure 137 GWh of renewable energy for the Sydney Metro Northwest rail project[12].

The current oversupply of generation in the NEM has led to the withdrawal of older and less efficient thermal power stations in NSW, notably Redbank, Munmorah and Wallerawang. Regions that have a high penetration of renewable energy have an increased reliance on synchronous generators, such as coal-fired generators, in order to maintain system stability. There is a concern that this will become a pressing issue as the existing fleet of synchronous generation reaches end of life and is withdrawn. AEMO flagged in the NTNDP that South Australia, with a very high level of renewable generation, is now facing this problem. At present, this is not an issue in NSW as it has a lower proportion of renewable energy than the other jurisdictions (although see further below). Looking forwards, several key trends are expected to influence the generation mix beyond the next few years.

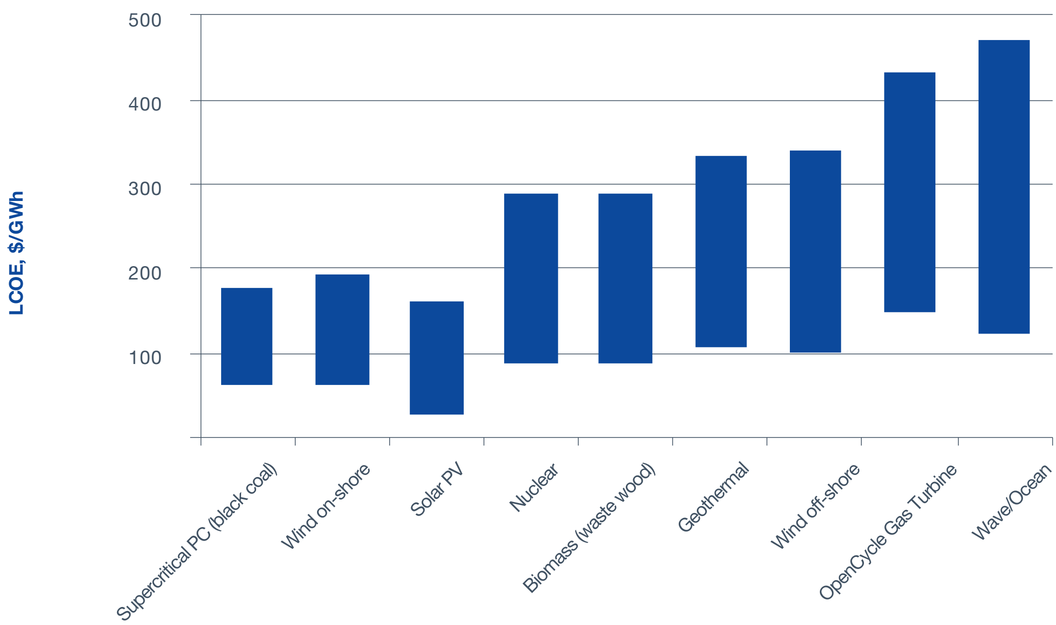
First, the 2015 Paris Climate Change Conference negotiated a global agreement between 196 countries to limit global warming by two degrees Celsius from pre–industrial levels. If the agreement is ratified by at least 55 countries that make up 55% of global greenhouse emissions, it will become legally binding[13]. If bound by the agreement, Australia will need to set even more aggressive renewable energy targets to limit global temperature rises, as Australia has some of the highest carbon emissions per capita in the world[14].

Second, the Bureau of Resources and Energy Economics (BREE) has estimated that PV solar will become the lowest cost option across all generation technologies by 2040[15] (Figure 2.3). Consequently, an increasing proportion of new generation is expected to come from large–scale solar. It is also expected by then that the most valuable wind-rich sites will already be utilised, and windy sites close to a NEM connection will be limited, meaning connection costs will become more expensive the further they are from the grid. Offshore windfarms remain prohibitively expensive due to physical constraints such as steeply increasing water depths and the presence of marine parks along the east coast of Australia[16].

4. Renewable Energy Target (RET) Scheme, https://www.environment.gov.au/climate-change/renewable-energy-target-scheme
5. The impact of the Government's March 2016 introduction of the Clean Energy Innovation Fund is not yet clear. See https://www.environment.gov.au/minister/hunt/2016/mr20160323.html
6. AEMO, 2015 National Transmission Network Development Plan (NTNDP), November 2015, p 15, http://www.aemo.com.au/Electricity/Planning/National-Transmission-Network-Development-Plan
7. Sydney Morning Herald, 25/01/2016, "Renewables sector on verge of revival: EY", http://www.smh.com.au/business/energy/renewables-sector-on-verge-of-revival-ey-20160122-gmbxq4.html
8. https://www.transgrid.com.au/news-views/blog/Lists/Posts/Post.aspx?ID=98
9. ARENA Large-scale solar photovoltaic, http://arena.gov.au/programmes/advancing-renewables-programme/large-scale-solar-pv/
10. ACT Environment and Planning Directorate, http://www.environment.act.gov.au/energy/cleaner-energy/wind_power
11. Ergon Energy Expressions of Interest open for large scale renewable energy projects, https://www.ergon.com.au/about-us/news-hub/talking-energy/business/expressions-of-interest-open-for-large-scale-renewable-energy-projects

Thermal generation retirements are also expected to continue. Liddell (AGL) and Vales Point (Sunset Power) power stations are expected to be retired around 2022 and Eraring (Origin) and Bayswater (AGL) are expected to reach the end of their technical lives in 2035. The last thermal generator in NSW, Mt Piper (Energy Australia), has a technical end of life in 2042. Similar trends of withdrawing ageing plant are also expected in other states and may accelerate if the pricing of carbon emissions is reintroduced[17]. The withdrawal rate may be mitigated by the fact that life extensions will become more economic as the value of the remaining synchronous generation rises. A joint AEMO and ElectraNet study[18] on integrating renewable energy in South Australia found that the withdrawals would, over the longer term, require consideration of "further enhancements to the operational processes and network infrastructure required to maintain power system security".

Figure 2.3 – Levelised cost of energy (LCOE) for generation technologies in 2040 (zero carbon price)



12. NSW tenders for renewable energy projects to power Sydney Metro rail, https://tenders.nsw.gov.au/?event=public.rft.show&RFTUUID=61A292E1-F724-D7DD-74277856584945B6

13. United Nations Framework Convention on Climate Change, http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

14. The Paris climate deal: What it means for Australia and its policies, http://reneweconomy.com.au/2015/the-paris-climate-deal-what-it-means-for-australia-and-its-policies-61728

15. Australian Energy Technology Assessment 2013 Model Update, BREE, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/aeta/AETA-Update-Dec-13.pdf

16. Diesendorf, M., Potential Sites for Off-Shore Wind Power in Australia, Wind Engineering Volume 33, No.4, (2009), pp335

17. Business Spectator, 19/08/2015, "Origin urges shut-down of coal – here's why a purist ETS has been abandoned", http://www.businessspectator.com.au/article/2015/8/19/

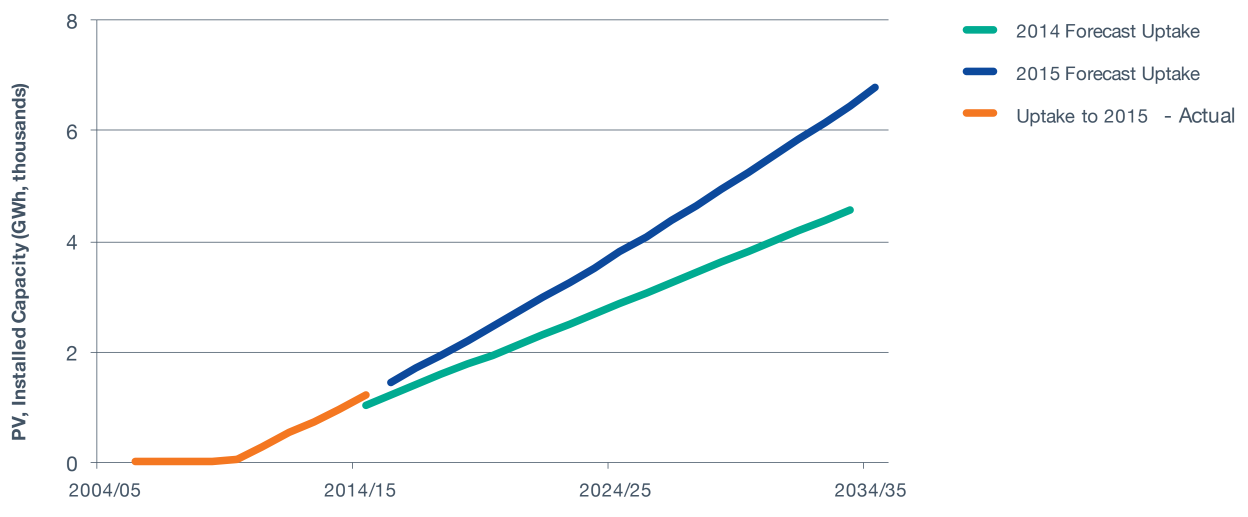
18. Renewable Energy Integration in South Australia, AEMO, October 2014

Small scale generation

In recent years there has been a rapid rise in the amount of solar PV installed on household rooftops. This has been driven mainly by generous government feed-in tariff schemes and declining costs. The former have led to many household systems being oversized. The NSW Solar Bonus Scheme (feed-in tariffs) will cease at the end of 2016[19]. This will encourage households to store the excess PV output during the daytime and 'self-consume' the energy during the evening. Consumers' appetite for this option will depend on the value offered by home energy storage devices which is expected to improve over time (see further below). Meanwhile, PV costs are expected to continue to decline. The combination should drive a greater uptake of more appropriately sized rooftop PV installations. The emergence of "no upfront financing" options will drive this further. Figure 2.4[20] suggests that there is an increasing pace of change with the 2015 forecast rate of uptake higher than the 2014 forecast.

It is also expected that the majority of owner-occupiers will invest in PV as costs continue to decrease. Landlords and tenants are both less likely to do so due to the split incentives they face although PPA models are currently being developed that could help to overcome this barrier[21]. The ease and value of adopting such a model will determine its success.

Figure 2.4 –2014 and 2015 estimates of rooftop PV uptake in NSW in a medium consumption scenario



19. NSW Solar Bonus Scheme; http://www.resourcesandenergy.nsw.gov.au/energy-consumers/solar/solar-bonus-scheme

20. AEMO 2015 NEFR, Detailed Summary of 2015 forecasts for NSW, http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report

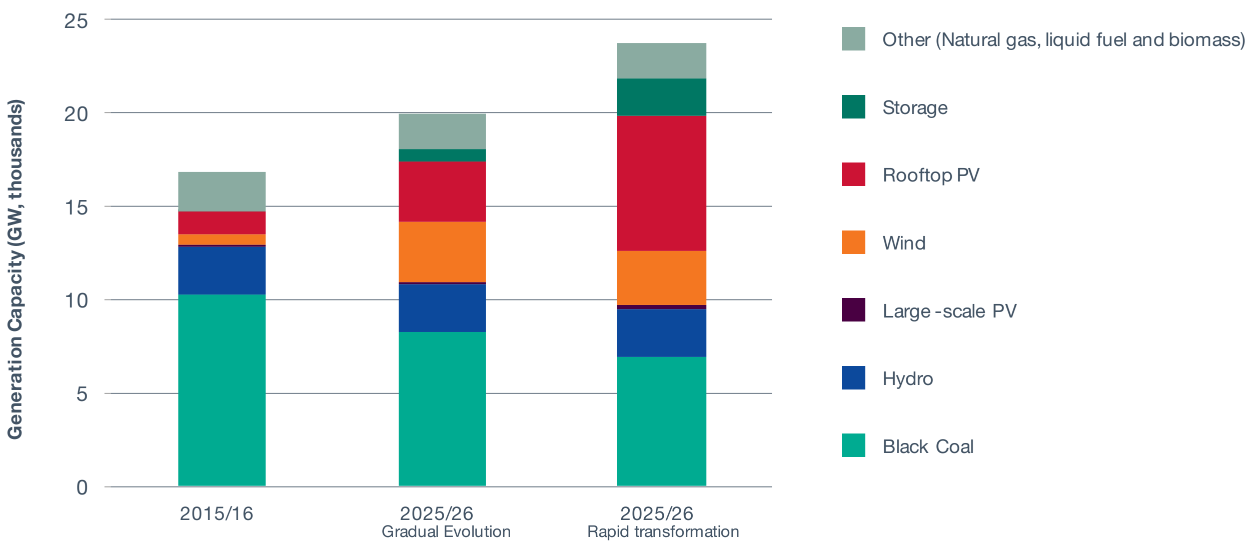
21. Stucco Sustainability Project, http://www.stucco.org.au/stucco-blog/

The decline in installation costs has also seen commercial and industrial customers[22] starting to install large PV systems to reduce their energy bills. These systems are typically over 10 kilowatts (kW) in size. Unlike residential customers, business loads are typically coincident with PV output so they are less incentivised to self-consume with storage. The business decision to install PV generation is based on the economics and less on sustainability. Typically, businesses require a payback period of three years or less for their investment, like any other energy efficiency measure[23].

The uptake of small scale PV will only be limited by the amount of such generation that the local distribution company will allow without additional capital expenditure to manage the impact on system voltage levels.

AEMO's NTNDP 2015 considers two scenarios for the overall generation mix in 2025-26: "gradual evolution" and "rapid transformation" based on slower and faster industry rates of change, respectively. These are set out in Figure 2.5. The higher proportion of rooftop PV and storage in the Rapid Transformation scenario is driven by the faster uptake of combined PV and storage systems based on lower costs. The impact that a larger volume of these combined systems is likely to have on how networks are utilised is explored further below and in the next section.

Figure 2.5 – Forecast generation mix, installed capacity in GW, to 2025-26, under two AEMO scenarios



22. ICC Sydney: Community-funded solar energy, http://www.iccsydney.com/news/sustainability-first-for-icc-sydney-community-funded-solar-energy and IKEA Tempe Solar Project, http://www.ikea.com/ms/en_AU/pdf/Tempe_News_Issue4a.pdf

23. City of Sydney Draft Energy Efficiency Masterplan, 2015

2.3 Emerging technologies

In recent years, we have seen the emergence of new technologies that, as their adoption reaches scale, are likely to significantly disrupt traditional business models of supplying electricity.

Storage

There are a range of storage technologies (for example, hydroelectric, compressed air, solar thermal) at various stages of commerciality and suitable for different functions. The most significant recent developments have been in battery storage.

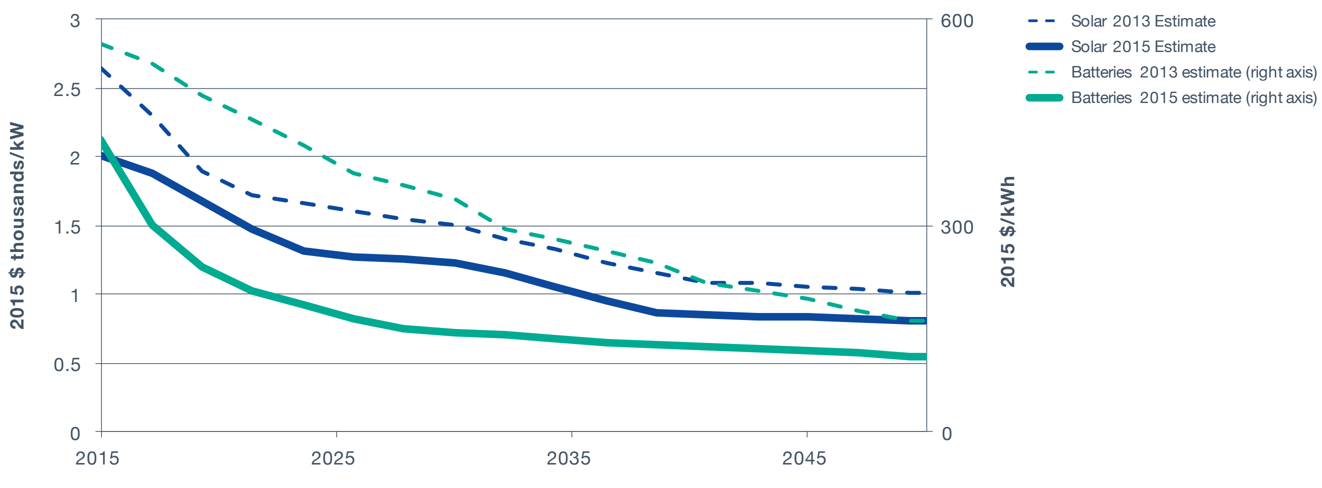
There are now many new entrants into the domestic energy storage market, with offerings starting from 3-4 kWh using on lithium-based technologies and targeting the large number of households with existing PV rooftop systems. These capacities aren't enough to take the average home off-grid but they increase consumers' self-reliance and decrease their exposure to rises in electricity rates. As noted above, the end of generous feed-in tariffs will encourage these customers to self-consume as it becomes more expensive to import than export the electricity generated. This makes home energy storage even more attractive to consumers with oversized PV systems.

In the short term, the full system costs are still uneconomic for most with payback periods greater than fourteen years[24]. However, recent estimates of the costs for consumer rooftop PV and battery storage by the CSIRO and Energy Networks Association (ENA) (Figure 2.6[25]) show that these systems are already around 20% cheaper than the costs estimated as part of the Future Grid 2050 study in 2013. Batteries may therefore be affordable for residential consumers by 2020[26] due mainly to the decreasing manufacturing costs. One recent estimate is that the demand for distributed energy storage systems will grow to $70 million per annum by 2025, as prices fall[27]. Investment banks have been more bullish valuing the home energy storage market in Australia at $24 billion or 2.4 million homes[28].

Due to the high current battery costs, we've also only seen a handful of grid-scale energy storage trials funded by government bodies like ARENA[29], CEFC, and the Australian Energy Regulator (AER). Grid-scale storage projects will be limited to these one-off trials over the short to medium term. However, once those costs decline significantly, storage will be able to provide a range of important services including helping to manage the impact of intermittent renewable generation on the network, alleviating market constraints, acting as backup supply and allowing energy arbitrage[30].

New market participants such as Reposit Power, Sunverge and SwitchDin, are emerging to co-ordinate the dispatch of multiple storage sites owned by different customers, both large and small, using that aggregated capacity as a virtual power plant to provide a number of these applications.

Figure 2.6 - Projected battery (right axis) and rooftop PV (left axis) technology costs



24. Powerwall payback, https://www.choice.com.au/home-improvement/energy-saving/solar/articles/tesla-powerwall-payback-time
25. ENA and CSIRO, Electricity Networks Transformation Roadmap presentations, December 2015, http://www.ena.asn.au/roadmap-presentations-and-workshops
26. Alternative Technology Association, "Household Battery Analysis" November 2015, http://www.ata.org.au/news/grid-connected-the fact that mosty batteries-economically-attractive-by-2020-ata-report
27. Energeia, "Sound and Fury: the outlook for Australia's distributed energy storage market to 2025", 2015
28. Business Spectator, 20/05/2015, "Morgan Stanley downgrades Origin and AGL due to Tesla Powerwall", http://www.businessspectator.com.au/article/2015/5/20/energy-markets/morgan-stanley-downgrades-origin-and-agl-due-tesla-powerwall
29. Energeia, "Sound and Fury: the outlook for Australia's distributed energy storage market to 2025", 2015
30. AECOM, Energy Storage Study, July 2015

Energy management systems

At present, most residential customers in NSW and the ACT have access to only limited information regarding their energy use and a very basic ability to optimise how and when that use occurs. The typical household features a simple accumulation meter and a declining block tariff structure[31], appliances with a limited ability to program their time of use and other sources of information that provide fairly limited flexibility in the solutions they can provide (such as energy efficiency audits).

Importantly, improvements to both information and control are developing steadily.

Smart meters combined with time of use (TOU) tariffs could provide strong signals for customers to better manage their peak demand. However, the current NSW government policy[32] is that the rollout of both the meters and TOU tariffs be retailer-led and optional to customers. This is partly driven by the currently relatively high cost of the meters. The retail industry is dominated by vertically integrated “gentailers” that are internally hedged[33]. This means they may have less interest in providing these offerings. However, small retailers with exposure to the electricity wholesale market spot price to offer smart meters plus TOU tariffs after 2020. In 2016, NSW’s distribution businesses will propose new tariff structures to the Australian Energy Regulator (AER) for review[34], where TOU tariffs will be optional.

However, more sophisticated metering and tariff structures may not be necessary for consumers to reduce their overall consumption and make meaningful cost savings. Demand Response Enabled Devices (DRED, AS4755) are broadly analogous to the traditional network “ripple” control of hot water systems designed to take advantage of off-peak tariffs. These can extend to a range of appliances although the current takeup has largely been confined to heating, ventilation and air conditioning (HVAC) systems.

Potentially more attractive because of the lower cost is the Internet of Things (IoT) revolution where home appliances connect to the Internet over WiFi or Bluetooth, allowing users to remotely control energy use via the web. This IoT shift has the most potential to smooth out residential loads for networks and improve energy efficiency. The large technology players (Google Nest, Apple Home Kit) have moved to establish alliances with traditional appliance manufacturers to embed IoT devices into those products[35]. However, the take up rates of these products remain low, partly due to long turnover rates for large appliances.

Industry standardisation will occur over the next few years to determine the winning intra-home communications standard, where it is being fiercely contested. A few utilities in the US have partnered with Google Nest, with mixed results[36]. In the meantime, devices able to be retrofitted (Tado, Sensibo, Ninja Blocks) are proliferating to turn ‘dumb’ appliances into smart ones. These are driven by mostly community and crowd-sourcing campaigns. These are open devices that provide programmable interfaces to allow them to be configured with other services.

An interesting variation on the above is emerging with companies like Pooled Energy[37] and OPower[38] offering energy audit services combined with electricity retailing. These companies can also install an IoT device to remotely control pool pumps and air conditioning. Other retailers/distributors (AGL, United Energy, Powershop, Transpower) provide a mobile app to let users monitor their energy use if they have smart meters. Some even provide users the ability to buy blocks of electricity from time to time. This capability would engage the most active prosumer and could potentially be used for behavioural demand management to reduce the pressure on networks during times of peak demand.

To date, most network businesses have engaged with customers and stakeholders in relatively limited ways such as in relation to proposed tariff reforms or new network investments. However, the rise of social media and digital marketing platforms provides an opportunity to build personalised engagement strategies with end-load customers. This can form a component of delivering those customers with greater energy efficiency, demand management programs and lowered costs. Accenture found that digitally engaged customers are more satisfied and trust their utilities, and are more likely to participate in energy efficiency or demand-side management programs.

31. Network NSW, Electricity tariff reform in NSW discussion paper, September 2015.
32. Smart meters in NSW, http://www.resourcesandenergy.nsw.gov.au/energy-consumers/energy-providers/smart-meters-in-nsw
33. ACCC disappointed by Tribunal decision authorising AGL to acquire Macquarie Generation, https://www.accc.gov.au/media-release/accc-disappointed-by-tribunal-decision-authorising-agl-to-acquire-macquarie-generation
34. Network NSW, Electricity tariff reform in NSW discussion paper, September 2015
35. Google Nest, https://nest.com/thermostat/meet-nest-thermostat/
36. Austin Energy Rush Hour Rewards, https://nest.com/energy-partners/austin-energy/
37. Pooled Energy, http://www.pooledenergy.com/
38. Opower, https://opower.com/

Transport

The electrification of transport is a key strategy to de-carbonise NSW's economy. For this reason, energy dense load centres will continue to require a robust electricity grid to support rail and electric vehicles. Both electric vehicles (EVs) and new rail projects present new spot load opportunities for the grid. There is no shortage of proposed NSW rail projects, with the Sydney Metro Northwest[39] and CBD and South East Light Rail East presently under construction. As mentioned previously, the Sydney Metro Northwest is purchasing 137 GWh of renewable electricity in a NSW tender and this may be replicated for future rail projects.

EVs currently account for 3% of the global automotive market[40]. Goldman Sachs predicts the sales of both hybrid and pure electric cars "to increase by a compound annual growth rate of 26 per cent, expanding market share from 3 per cent today to 22 per cent in 2025." In Australia, AEMO forecasts the "uptake of electric vehicles to continue to be small, with a projected 165,734 electric vehicles across the NEM in 2024–25, increasing to 524,775 in 2034–35. The expected impact of this level of uptake on the 2015 NEFR residential and commercial consumption forecasts is a 0.20% increase in 2024–25 and a 0.54% increase in 2034–35"[41]. These predictions are driven by the falling cost and increased in performance of automotive grade energy storage. However, it is also dependent on the cost of oil, with low oil prices likely to dampen EV takeup, and the rollout of charging infrastructure which is at a very early stage within Australia. It may also be that these predictions are conservative given recent signs that the major car manufacturers are investing significantly in the production of more affordable EVs. TransGrid recently joined AGL Energy and Tesla in calling for greater policy incentives to drive the wider takeup of electric vehicles[42].

39. NSW tenders for renewable energy projects to power Sydney Metro rail, https://tenders.nsw.gov.au/?event=public.rft.show&RFTUUID=61A292E1-F724-D7DD-74277856584945B6

40. The Low Carbon Economy, Goldman Sachs Investment Research, November 2015

41. AEMO, Emerging Technologies Information Paper, June 2015

42. http://www.smh.com.au/business/energy/agl-energy-tesla-in-alliance-to-drive-uptake-of-electric-vehicles-20160406-gnzhq4.html

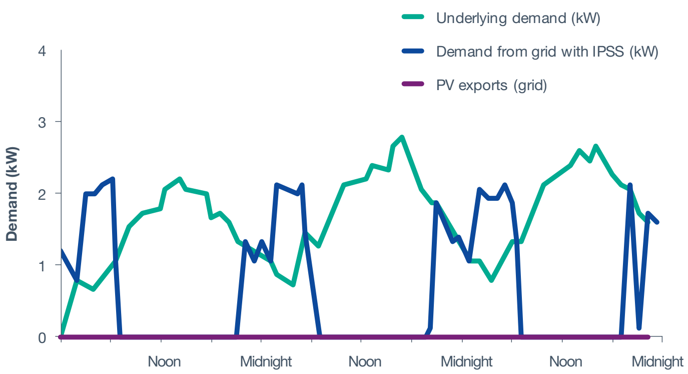
3

"The grid is a key part of the future but its role is evolving"

Scenarios

This section attempts to weave together the threads of the individual trends discussed in the last section to provide an integrated picture of the longer term industry future. It does this by referring to two pieces of work: AEMO's NTNDP 2015 and the CSIRO's Future Grid 2050 research. These look forward 20 and 35 years, respectively. The section concludes with a short perspective on the likely key features of the future energy ecosystem suggested by those pieces of work.

Figure 3.1 – Forecast impact of integrated rooftop PV and battery storage on daily load of large NSW household in 2035 around times of maximum summer regional demand over three days[43]



3.1 AEMO's NTNDP 2015

The NTNDP 2015 examines how the wider industry pace of change may affect the development of the national transmission flowpaths over the next twenty years. Its main conclusions were that:

- Continuing recent trends, expenditure to replace ageing transmission network infrastructure is likely to outweigh investment in new capacity for the next twenty years
- Minimal new transmission network infrastructure is likely to be required to deliver the 6,700 MW of large-scale renewable generation arising from the LRET to consumers, provided that generation is located to balance fuel availability and network costs
- As noted, new power system infrastructure may be required to provide frequency control and network support services due to the increasing penetration of renewable generation
- More detailed information on small scale generation will be needed to plan and operate the market effectively as the proportion generated behind the meter increases.

As noted in the previous section, the NTNDP 2015 examined at two scenarios: "gradual evolution" and "rapid transformation". Both predict the continuing uptake of rooftop PV combined with battery storage in an integrated system.

The gradual evolution scenario sees a gradual uptake of residential electricity storage to 2.5 GWh installed by 2035 in NSW, without any major cost reductions or other incentives to drive a faster uptake, in a medium planning scenario. Consumers will remain connected to the grid, which will provide reliable backup and emergency response for failure. The rapid transformation scenario envisages a faster uptake of integrated systems driven by residential incentive schemes within a low economic growth scenario. In this case, low electricity consumption is lowered further by the greater uptake of residential integrated rooftop PV and battery systems. It also assumes 20% of households own an electric vehicle by 2035.

The key point is that integrated systems have the potential to have a significant impact on the way networks are used to supply energy. Electricity consumption and peak demand will change, and the time of peak demand will shift away from the traditional times. This is illustrated in Figure 3.1 which shows a simplified daily load profile of a large NSW household with such a system across three summer days at times of regional maximum demand. Excess electricity generated from the PV is used to charge the battery system before exporting to the grid, so exports are smaller than for a PV system without storage. There is no export to the grid on high-demand days. On normal days, there may be some small export. In summer, the integrated system shifts the household peak to early morning, when the battery charges from the grid. In winter, the peak does not shift or reduce much, but does not last as long. There's also a new morning peak in winter, again when the battery is charging from the grid.

43. AEMO, "Emerging Technologies Information Paper", June 2015, p 40

3.2 Future Grid Forum 2050

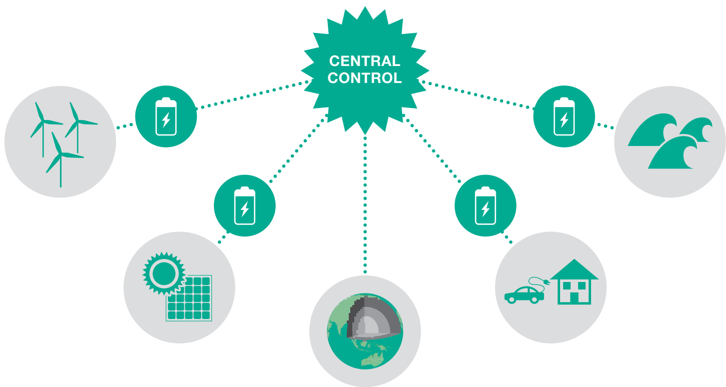
In 2013, the CSIRO-led Future Grid Forum[44] considered a range of consumer choices and responses in the changing electricity supply environment and developed four scenarios for transmission and distribution networks in 2050. Information and modelling of these scenarios and consumer choices was developed further in the 2015 Network[45]. Transformations Roadmap Interim Report. In all four scenarios:

> Both rooftop PV and battery storage become more affordable, as costs decrease and manufacturing ramps up. As noted further below, those costs are expected to fall by around one-third and two-thirds respectively over the next ten years

> The share of income spent on residential electricity bills remains stable at around 2% through to 2050

> Electricity consumers take up more of the investment decision making (and associated expenditure) — between 23% ($224 billion) and 41% ($469 billion) of all electricity system expenditure is made directly by consumers or their agents.

The four scenarios are summarised below.



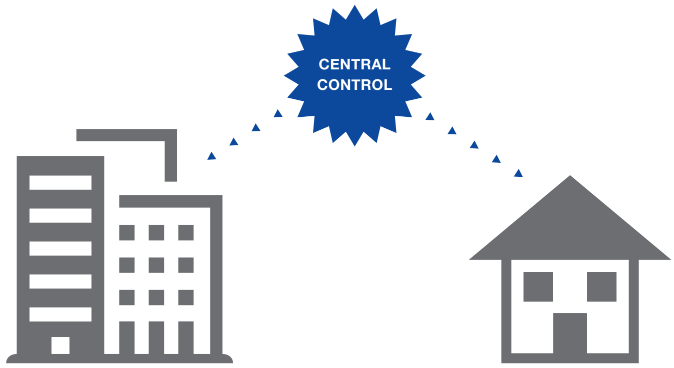
Renewables thrive

Both small and large scale renewable generation thrive supported by energy storage. There is a high uptake of EVs and strong demand control managed by the networks. The focus here is on renewables becoming the main source of electricity.

> **Affordability:** Rooftop PV and battery systems become more affordable in the next ten years. Consumers invest 27% ($268 billion) of total system expenditure ($984 billion)

> **Consumer choice:** Highly developed small and large scale renewable generation is available to consumers, supported by energy storage. Electricity is sourced through the grid and on-site

> **Grid:** In 2050, 73% of electricity is sourced from central generation, which includes a high proportion of large scale renewables. This scenario has the best carbon emissions abatement outcome: 99% below 2005 levels in 2050. Transmission investment is some 6% ($62 billion) of the total.



Set and forget

Consumers sign up to voluntary demand control schemes but, rather than playing an active role, rely on the utilities for solutions to integrate and operate the schemes. There is some uptake of on-site generation and electric vehicles by 2050 but mostly centralised electricity generation is relied on.

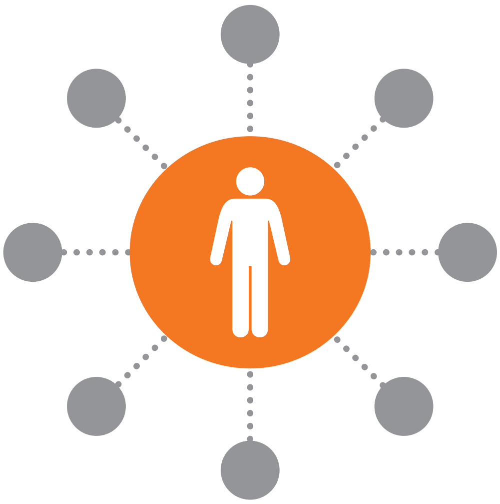
> **Affordability:** Consumers invest (on-site and off-grid generation) 23% ($224 billion) of total anticipated expenditure ($954 billion)

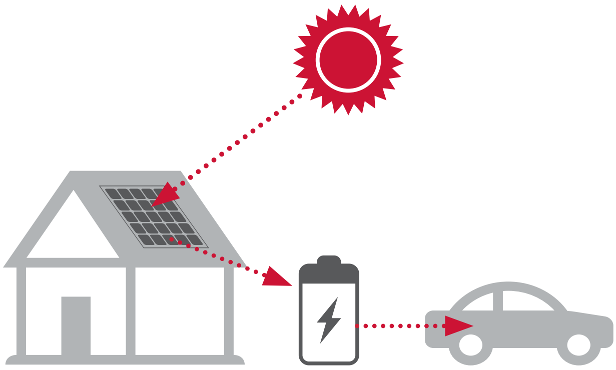
> **Consumer choice:** Mainly demand control schemes. There is light consumer engagement in early stages of implementing the demand schemes but the schemes are allowed to run automatically once established with limited input from the consumer

> **Grid:** Since consumers largely remain connected to the grid, 75% of electricity is sourced from central generation in 2050. Transmission expenditure is 5% ($48 billion) of total expenditure to 2050.

44. CSIRO Future Grid Forum, http://www.csiro.au/en/Research/EF/Areas/Electricity-grids-and-systems/Economic-modelling/Future-Grid-Forum

45. CSIRO/ENA, Electricity Network Transformation Roadmap, Interim Program Report, Dec 2015





Rise of the prosumer

Consumers increasingly take up on-site generation and storage options such as electric vehicles and to use, store and trade.

> **Affordability:** Consumers invest 38% ($383 billion) of total anticipated expenditure ($1,017 billion)

> **Consumer choice:** Highly developed on-site generation, storage and electric vehicle technologies are available. A material proportion of consumers are engaged, knowledgeable and capable of managing their own on-site generation and storage, leading to strong uptake of these technologies

> **Grid:** Approximately 55% of total electricity consumption is sourced from central generation in 2050. Transmission expenditure is 5% ($51 billion) of total expenditure.

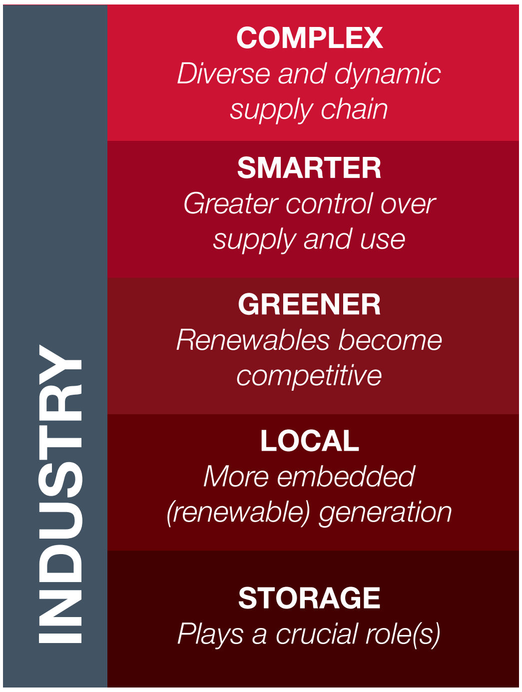
Leaving the grid

Prompted by the continued dominance of volume-based pricing, consumers take up energy efficiency measures but there is no accompanying reduction in peak demand growth. Declining network utilisation leads to increasing retail prices.

> **Affordability:** Disconnection from the grid is expected to be economically viable from the late 2030s. Consumers invest 41% ($469 billion) of total expenditure ($1,136 billion)

> **Consumer choice:** About a third of consumers are not engaged with the network and completely disconnect from the grid. They take up gas or solar on-site generation, storage and energy efficiency measures

> **Grid:** 69% of total electricity consumption is still sourced from central generation in 2050. Interestingly, this is higher than in the "rise of the prosumer" scenario. This may be attributed to higher levels of engagement of prosumers across the whole community, who take up new electricity solutions and EVs (which leads to increased electricity consumption overall) whereas, "leaving the grid" does not envisage such strong engagement across the community, with about a third of consumers disconnecting due to increasing retail prices.



3.3 Perspective

Whatever the eventual outcome, all of the scenarios described above have, to differing degrees, five common features.

The future electricity industry will be more complex with the supply chain evolving from being a one way system with limited product choice to a "many to any" model where a mix of traditional and emerging providers, including customers themselves, supply a much wider range of energy services. That future will also be smarter with technology enabling both greater control by customers regarding how their energy needs are met and greater innovation and flexibility by networks in responding to that diverse and dynamic set of needs.

Renewable power will be more competitive with traditional fuel types, leading to changes to the generation mix and customers will also be able to meet a greater proportion of their electricity needs from smaller-scale, local generation. Finally, energy storage will undertake a range of important functions across the supply chain. These include storing power for use when renewable generation isn't available, helping to keep the network stable and selling back into the grid when prices favour doing so.

These five features will result in two key changes: a more customer-focused future and an evolving role for networks.

Energy in Transformation

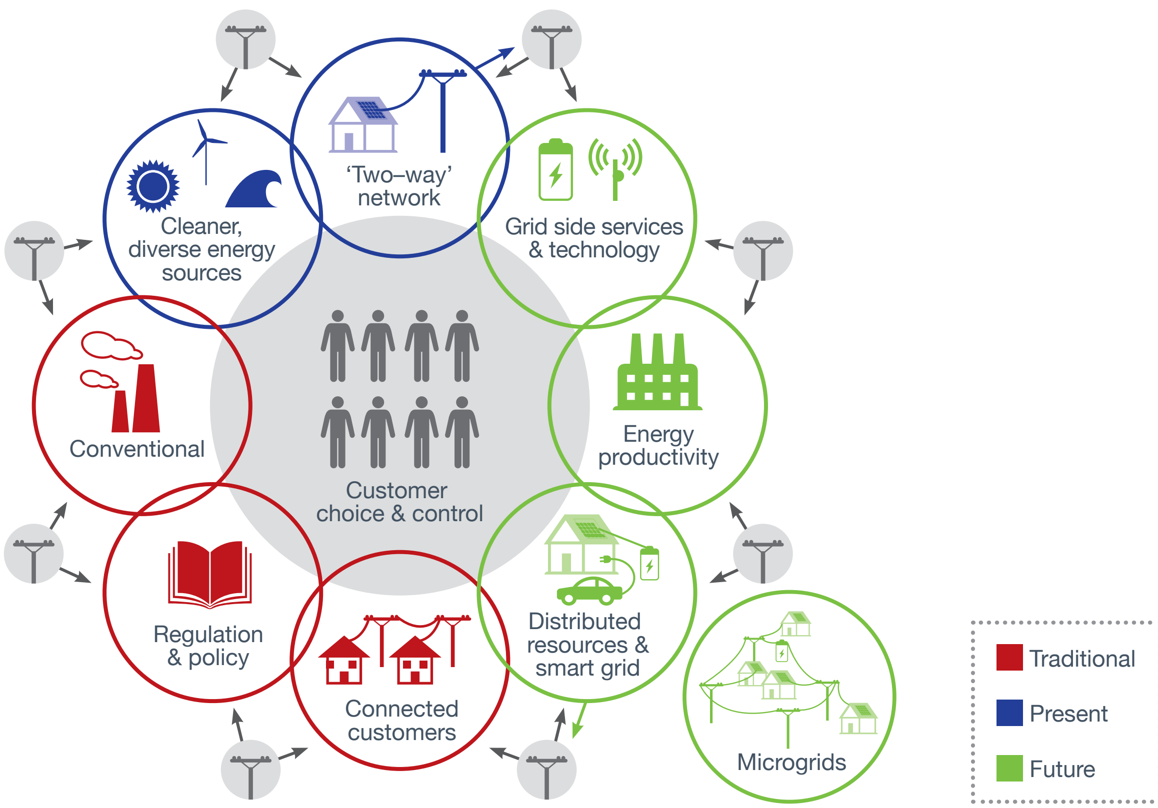


Figure 3.2 – Transformation of electricity networks to a customer-focused model[46]

46. CSIRO/ENA, Electricity Network Transformation Roadmap, Interim Program Report, Dec 2015

The customer-focused future

Increasingly, electricity consumers will have more scope to decide what their needs are and how best to meet them. Different consumers will have different needs and may adopt different approaches. For example, a consumer could:

> Purchase energy from a retailer during those parts of the day, and at a reliability level, that are cost effective to do so

> Supply the balance through their own on-site renewable generation

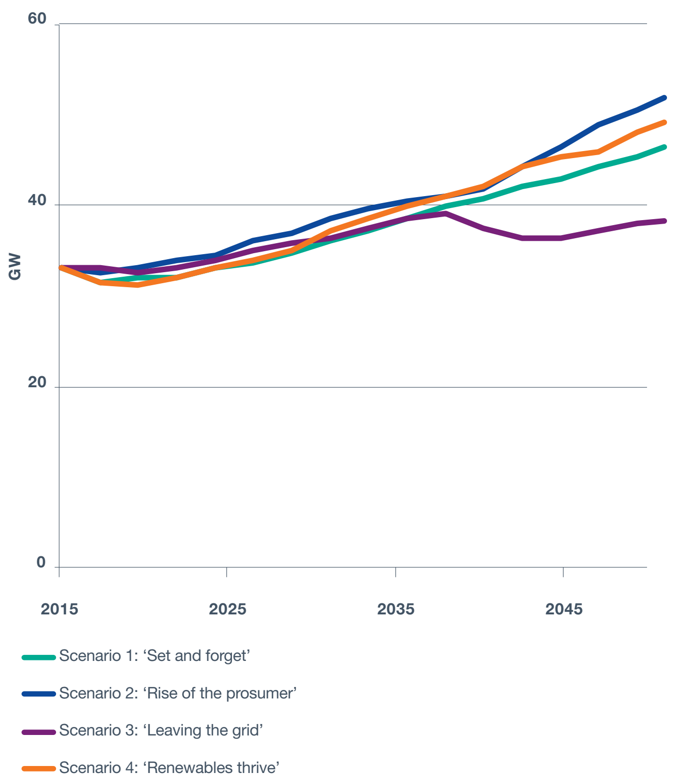
> Export any excess on-site generation back into the grid at times that maximise the value of doing so

> Contract with a network for the right-sized connection and energy balancing services required to ensure that two-way capability

> Contract an energy services company to either provide the analysis to optimise all the above or manage those contractual arrangements for the consumer.

Not every consumer will want this level of complexity and the scenarios described above suggest that the adoption of more sophisticated approaches will take time to reach scale.

Figure 3.3 – Projected networks contribution to meeting peak demand under Future Grid 2050



The grid is a key part of the future but its role is evolving

Electricity networks will continue to be needed although their role will change as they become enablers for new energy services and uses, such as renewable generation, home automation, battery storage and electric vehicles. What this is likely to mean as to how the NSW transmission network is planned, operated and managed is the subject of the next section.

However, before turning to that discussion, both the NTNDP 2015 and Future Grid 2050 raise the prospect of some consumers going "off grid" at some point between now and 2050. The development of local generation and battery storage technologies are making this possibility more feasible and it has already been noted that the costs of such systems are decreasing faster than expected even two years ago.

Importantly, even with these trends, the CSIRO and ENA estimate that between half and three quarters of electricity consumers would remain connected to the grid with departures only beginning to scale in the mid-2030s[47].

These retention levels would be driven by a number of factors including:

> Not every consumer will be in a position to install on-site generation and/or storage

> Customers are expected to continue to place material value on the high reliability of the power supplied to them through the grid

> Network costs are projected to reduce and remain relatively steady in the medium term

> Customers will increasingly value additional network services such as access to the grid for the export and sale of the energy they generate on-site that is surplus to their requirements and

> The additional costs of the enabling technologies required to go off grid.

Overall, energy provided by the grid for consumption (excluding distributed generation) is, except in the Rise of the Prosumer scenario, projected to increase. In that scenario, consumption is expected to first decline and then rise above current levels by 2050. Maximum demand is also expected to increase except under the Leaving the Grid scenario where it declines from 2030 and then levels off towards 2050 (Figure 3.3[48]).

47. ENA and CSIRO, "Electricity Network Transformations Roadmap: Interim Program Report", December 2015, pp 63-65

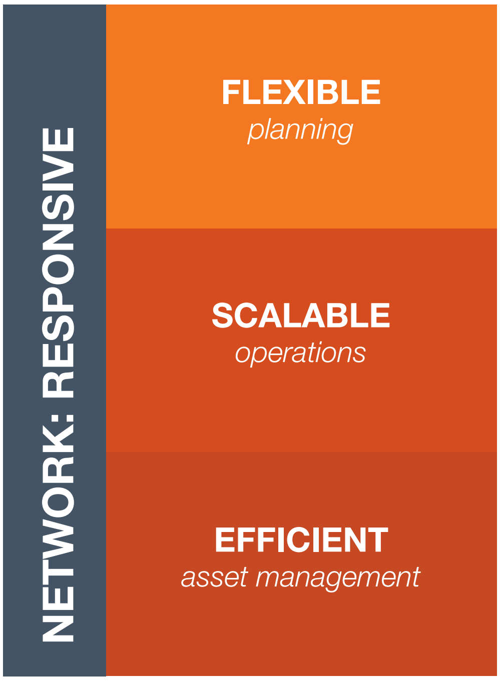
48. Ibid, p 58

4

> “We’re acting now to ensure our network is flexible, scalable and efficient for the future”

Implications and actions

TransGrid’s transmission network will need to be responsive to the changes described in section 3. This section focuses on how TransGrid will need to plan, operate and manage the network in order to do so. This section also notes the key actions TransGrid is taking to deliver that capacity and provides a perspective on what this may mean for the evolution of transmission services and how they are regulated.



4.1 Implications

Flexible planning

In the future, there is likely to be less certainty regarding the location, levels and technology mix of generation, both large and small scale. The introduction of a larger number of renewable generators of smaller individual size than the coal powered fleet they will replace across a wider range of locations will make planning more complex. This includes the configuration of the network, the types of assets most appropriate to use and the levels of investment that will ensure that future connection requirements in the same locations can be met at the lowest overall cost.

Currently, TransGrid has limited visibility of distributed (local) generation and storage. This is also largely true of TransGrid’s ability to understand the more detailed energy preferences of its end user customers. This partly reflects the fact that the technologies available to date haven’t been capable of collecting and synthesising that information, nor providing a wider range of transmission products and service levels in response, in timely and cost effective ways. Those technologies are starting to change, increasingly enabling a stronger understanding of those needs as well as the ability to offer more bespoke solutions to them without compromising the performance of the overall network.

Scalable operations

The above issues are also likely to impact TransGrid’s ability to operate the network. The increasing penetration of wind and solar generation is already starting to impact the ability of transmission and distribution businesses in Western and South Australia to securely manage their network. It will also be more difficult to balance supply and demand in real time with that larger proportion of intermittent generation. Further, consumers will require network services based on a more sophisticated understanding of their own needs. Finally they will also have a greater capacity to both meet and manage those needs themselves and sell energy back to grid. To meet these challenges, the network of the future will need to be able to more rapidly scale up and down through a wider performance range.

The ability to do so will require a deeper knowledge of the technical condition of the network's assets, the ability to receive and respond to much larger volumes of information in real time and use technology to both control and optimise network performance. That optimisation will also rely on TransGrid's ability to more effectively co-ordinate its actions with those of other stakeholders by, for example, being able to remotely access and dispatch local generation and storage systems (potentially including EVs). Again, this will require a greater understanding of how consumers are using their own generation and storage systems.

Efficient asset management

The more dynamic future is likely to impact the way that network assets are utilised. For example, a sudden increase in the demand on an asset may raise the risks associated with its operating, safety and/or environmental performance. A sustained decrease may mean an asset is only contributing limited value to customers, increasing the financial risk associated with the investment in that asset and potentially jeopardising TransGrid's ability to continue to provide services sustainably.

These issues will have an effect on the way that assets are designed, used, maintained and eventually disposed of and/or replaced. Greater focus must also be brought to individual assets in terms of their fitness for purpose[49] as well as how the overall portfolio of assets should be optimised to maximise customer value.

Part of being able to deliver greater value from an asset involves effectively signalling that value to customers. Networks starting to deliver more targeted value to consumers is likely to have implications for how energy tariffs are structured moving forward. This is especially important in the context of a multidirectional energy supply. It may involve the introduction of different forms of pricing such as capacity charging, critical peak pricing or peak time rebates to encourage consumption at times of greatest value to the customer. Further into the future, it may mean the introduction of transactional markets for network services, perhaps starting with power quality (ancillary) services and backup support.

4.2 Actions

Based on the Vision and Principles set out in the next section, TransGrid is already taking steps to deliver much of the network capability outlined above. A number of these are explained in more detail in the next section. Additional actions will follow over the longer term as the specific shape of the smart energy ecosystem becomes clearer.

Table 4.1 Key actions now/in the near term and over the longer term

Flexible planning	Scalable operations	Efficient asset management	Longer term
Area plans developed	Asset Monitoring Centre established	Asset decisions based on lifecycle performance, risks and costs (ISO55000)	Develop advanced customer and market modelling capabilities
Supporting the development of more flexible reliability standards	Piloting the integration of local generation, storage and Automated Demand Response	Using modular designs and moving/ repurposing assets to provide best value	Develop more sophisticated services and service levels
Better joint planning with AEMO and the distributors	Investigating the application of grid storage for other network services	Applying Dynamic Line Rating technology	Consider different customer transaction models
Integrating more closely with state and local planning frameworks	Using new tools and channels to pursue broader non-network opportunities	Using automated substation secondary system designs (IEC61850)	
More flexible approach to connection designs and processes	Encouraging greater policy support for emerging technologies such as electric vehicles	New technologies enabling field services at lower operating costs	
Renewable Energy Hub reduces access costs		Supporting transparent and cost reflective tariff reforms and timely capital recovery	

49. For example, assets may be designed in a more standardised way to make them more interchangeable or in a more bespoke way if there are compelling customer requirements.

50. For example, see Accenture 2015, "Network business model evolution: an investigation of the impact of current trends on DNSP business model evolution", Melbourne, http://www.ena.asn.au/roadmap-presentations-and-workshops

4.3 Perspective

Before turning to the Vision and Principles, it is worth briefly noting two implications of the above.

First, a flexibly planned, scalably operated and efficiently delivered network has the potential to underpin additional energy service offerings beyond the wider range of existing services already discussed. Commentators have already identified this potential[50]. Examples of such offerings include:

- Behind the meter services such as energy management services
- Data/information services
- (Distributed) energy production and/or
- Energy trading.

The second point is that all of these developments, delivering the network of the future and the potential for further service offerings, will almost inevitably lead to changes to current policy and regulatory arrangements. For example, it will become increasingly difficult, indeed counterproductive to the interests of consumers, to restrict members of the energy ecosystem to their traditional roles in the supply chain. Conceivably, a more diverse and dynamic "many to any" supply chain may eventually even remove the need for periodic network revenue regulation. This is because networks will provide their services into a market where there is effective competition with other suppliers. The industry is already discussing these issues with policymakers and other stakeholders.

5

> "Our network vision is to connect you to the future of energy"

Visions and principles

5.1 Vision

Our Network Vision is our commitment to meeting the needs of our customers and end users as the energy ecosystem continues to transform. Our Vision is to connect you to that energy future.

5.2 Principles

Principles assist in delivering the desired outcome in times of uncertainty. Four principles guide how we will plan, operate and manage the network in order to achieve our Vision. They have been designed to be resilient to whichever particular future eventuates. In essence, they are statement about TransGrid's culture, one that is service-oriented and commercially focused.

PRINCIPLES

ENGAGE
to understand

MOVE
from assets to services

INVEST
for value

INNOVATE
through people, data and technology

5.2.1 Engage to understand

- **Generators and consumers' wider range of needs and service levels are understood at a more granular level**
- **Engagement confirms that the appropriate trade-offs are being made between performance levels and costs**
- **TransGrid's social licence to operate the network is maintained**

TransGrid is already embracing a customer-focused model with an engagement process that is proactive, transparent and represents a genuine desire to inform, consult and collaborate effectively with interested parties. Our stakeholder engagement is based on a continuing two-way conversation about the upcoming electricity challenges faced by NSW and the ACT.

However, we will need to go further in order to meet the requirements of the future. In particular, we will need to enhance the current mix of direct and representative approaches with additional sources of information in order to understand the more differentiated range and levels of services that our customers, including generators and end user consumers, will require. This could involve the use of new third party data sources.

5.2.2 Move from assets to services

> **A wide range of customer needs and service levels can be met without compromising network performance**
>
> **In the longer term, different transactional models for those services may offer additional value to customers**

Transmission businesses provide two core products: connection (access to the wholesale electricity market) and transport (the bulk supply of electricity purchased via that market). They are capital intensive businesses with those products delivered through the construction, operation and management of a large fleet of network assets.

Compared with more competitive markets, those connection and transport products are typically more standardised than bespoke, offering a relatively narrow range of service levels applicable to only selected product characteristics. For example:

- There is not a range of connection products being offered that provides different levels of firm access to the connecting party
- For transport, there is only a limited range of service levels (n-1, n-2) for one key product dimension (reliability) with the service levels for most dimensions of the product determined centrally.

As noted in the previous section, this has been a pragmatic approach given the technological constraints associated with collecting and synthesising information regarding the preferences of, and then delivering products to, more than 3 million of the same network simultaneously.

These characteristics of the transmission industry arguably make it harder for consumers to understand the value of the network's assets in meeting their needs. This is especially true given the vast bulk are indirect consumers and the charges for the products delivered by those assets comprise a small portion of their retail bill.

However, as also outlined above, a likely key feature of the changing industry is that those core products will need to evolve over the longer term into more differentiated service offerings. As consumers become more empowered to self-manage their energy needs and/or engage in the energy market in more sophisticated ways, they (or their intermediaries) will begin to seek a menu of service offerings packaged (including priced) in more diverse ways and sourced from a wider potential range of providers[51]. People are already increasingly concerned about the kind of generation they are willing to pay for. In those more advanced scenarios, they may also become more discriminating about the network services they are prepared to pay for.

To address this, transmission businesses will need to shift focus from building and operating assets to one more directly concerned with delivering the services and service levels that consumers value. In the future, those services might involve different "firmness" of access (connection) or different levels of reliability, stability and/or security (transport). TransGrid is, in consultation with its generation customers, already taking steps to provide greater flexibility in the service levels it offers connecting generators by, amongst other things, offering site specific design specifications. It has also supported the development of more flexible reliability standards. The existing standards are currently being reviewed by the NSW Independent Pricing and Regulatory Tribunal (IPART)[52].

In one sense, these changes should have little impact on the basic physical infrastructure used to deliver those services. Networks will need to become "smarter" to be able to meet that wider range of services and service levels. This transformation is already underway and the innovation principle described below explains how it will continue. Perhaps the more significant impact concerns how the business will interact with the evolving marketplace for energy services. As more sophisticated consumers and intermediaries arise, different models for transacting with them beyond the current arrangements, where retailers aggregate supply chain charges, may provide those customers with more flexible and efficient energy solutions.

51. It is also possible that different transaction platforms will emerge that have the potential to bypass parts of the current vertical supply chain (the "Uber effect").

52. http://www.ipart.nsw.gov.au/Home/Industries/Electricity/Reviews/Electricity_Transmission/Review_of_Electricity_Transmission_Reliability_Standards

5.2.3 Invest for value

> - **Asset and portfolio lifecycle performance, risks and costs are well understood**
> - **Risk management strategies appropriately reflect customer and other societal expectations**
> - **Investment decision-making processes are robust**
> - **Options for future choices are accommodated by a 'responsive' network**
> - **Transmission services are priced and structured in ways that signal value**

A network is efficient if its assets maximise the benefits they provide to customers at minimum cost (maximise value). Asset management is the discipline of generating that knowledge and using it to optimise lifecycle costs and make the relevant investment decisions. In short, it is about investing for value. It affects how the network is planned and operated, how assets are designed, integrated and run and when and how they should be retired and/or replaced. Its foundation is a deep understanding of the lifecycle performance, risk and cost profile of every asset. Without that knowledge, and the application of a robust investment process, a network is not delivering the value to customers that it should.

TransGrid is currently certified to ISO55001, the world's best practice asset management standard and is committed to continual improvement of its asset management practices and system.

There are four aspects to investing for value that are worth highlighting.

First, the ways the risks associated with delivering the required services are managed should broadly align with customer and wider societal expectations. Put another way, customers would be paying too much if a disproportionate part of the service price was used to manage a risk they considered to be relatively insignificant. For some key risks, such as public and workplace safety and the protection of the environment, society imposes its view of the appropriate way to manage the risk (and the component of the price). TransGrid is closely aligned with society's view of the significance of those two particular risks.

Second, being an efficient, 'responsive' network means not investing in excess capacity. Energy network investments tend to be "lumpy" in that incremental capacity can often be achieved for relatively minor additional cost. It may make sense to add that extra capacity when a generator connects to the network and there is a reasonable expectation that more generators will connect at the same point in the near future. This is because doing so can lower the average cost for each connecting generator. Investing for value means focusing on the reasonableness of those expectations and the incremental costs to ensure that the investment delivers value for all relevant customers. TransGrid is already applying this approach to deliver value from its Renewable Energy Hub located in northwestern NSW.

Third, the best way to manage the risk of under and overutilised assets is to understand the benefits those assets deliver to the customer. As noted above, part of doing so is achieved through proper pricing signals. Prices should be transparent and efficient. Ideally, they should also be reasonably stable but also flexible in circumstances where there are unexpected step declines in asset utilisation. Pricing reforms will only become more important as customers begin to require a wider range of services and service levels. TransGrid recently adopted a new pricing methodology based on peak demand rather than energy and locational demand charges reflective of how much of the network is utilised[53].

Finally, it is important to state that investing for value applies equally to investments that meet customer needs but don't involve the construction of network assets. TransGrid will pursue those solutions whenever they are expected to deliver greater value. For example, TransGrid acquired 40 megawatts of demand management in the metropolitan Sydney area for the 2012-13 summer. This involved over 80 consumer sites being able to either shed load or bring embedded generation online in order to support the high voltage network in times of peak demand. To enhance our ability to deliver value in the future, we are actively developing a better understanding of the potential for other non-network solutions across our franchise area.

53. https://www.transgrid.com.au/what-we-do/our-network/our-pricing/Pages/default.aspx

5.2.4 Innovate through people, data and technology

> **Data and technology are leveraged to improve network performance and reduce service costs**
>
> **The skills and capability of our people are enhanced to meet our customers' needs**

Finding new ways to deliver value to customers, either through new services or reduced risks or costs, means incorporating the aptitude for, and desire to, innovate into our organisational DNA at every level. It means engaging people with new skillsets, harnessing the power of data to drive better decisions and leveraging smart technologies. Current examples of the latter include:

- Establishing an Asset Monitoring Centre to provide a wider range of real time information to the system operation unit and inform decisions about the return to service of equipment after faults as well as further enhance asset strategies
- Investing in Dynamic Line Rating (DLR) equipment that gathers real time information about transmission line physical conditions in order to improve their loading capacity
- Using drones to improve site accessibility and inspection response times as well as reduce safety risks
- Piloting integrated local generation and battery systems to facilitate research into the development of demand management opportunities that, applied at scale, could lead to the deferral of significant amounts of network expenditure
- The use of automated, remote demand management technologies to effect that deferral when needed
- Investigating the use of grid scale storage for other network services such as constraint relief, supporting the dispatch of intermittent generation and the provision of ancillary services
- Implementing new automated substation secondary system designs under IEC61850 which will both increase the performance and reduce the operating costs of those installations.

Your feedback is important

We are interested to hear your thoughts and views on this Network Vision and the issues presented here. Join the energy conversation and provide your comments in the following ways:

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