Network Vision

TransGrid

Network Vision

May 2014

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Foreword

I have pleasure in presenting this Network Vision which provides a long term vision for the development of the NSW transmission network.

The electricity transmission network has played a crucial role in supporting the economic growth of New South Wales. TransGrid's network is one of the most reliable transmission networks in the world, and is arguably one of the key factors allowing the state to produce the largest Gross State Product in Australia.

In recent years the generation mix has begun to change. We have seen a steady increase in wind generation, with around 370 megawatts of wind generation capacity connecting to TransGrid's network since 2008. Penetration of distributed energy sources has also risen, with rooftop solar panel capacity skyrocketing to over 450 megawatts and further increases expected. The nature, location and quantum of future electricity generation is uncertain, and will be driven by a number of factors including policy on greenhouse gas emissions, the economic climate and the likely electricity demand.

At the same time, the demand side of the electricity market in Australia has changed. Five years ago, the industry was forecasting that annual peak demand for electricity would continue its historic trend and rise sharply. Expectations have now changed. The Australian Energy Market Operator's most recent forecast is for an average annual increase in peak demand of just 1 % in NSW. In some locations this figure may be even lower.

The changing electricity environment has significant ramifications for the network of the future. Three key factors could influence whether electricity users choose to disconnect from the network at some point in the future. These factors are the uptake of distributed energy sources such as rooftop solar panels, the likely reduction in cost of electricity storage options and the rising cost of electricity.

The purpose of this Network Vision is to provide stakeholders with an understanding of the circumstances that could affect the development of the NSW transmission network in the future. It is my belief that the important decisions about planning the transmission network must be done transparently with the engagement and participation of consumers and other stakeholders.

I envisage that the transmission network of the future will first and foremost deliver safe, secure, environmentally responsible and cost-effective electricity transmission services. We will engage meaningfully with stakeholders and the community to align expectations with our ability to deliver. The network itself will be optimised to accommodate future requirements, while also being planned adaptively to match demand requirements and changes in the supply mix as they emerge. Technology and innovation will be leveraged to optimise the capacity and capability of the network. Finally, flexible and tailored connection services will be business as usual for connecting customers.

I strongly believe that the transmission network will form part of a cost-effective future electricity grid, although it may not look the same as it does now. Deserting the electricity network is not the answer for providing low-cost and efficient electricity services. Rather, flexible planning and collaboration by all interested parties is the key to the future grid.

Peter McIntyre
Managing Director

Executive summary

Australia's electricity market is changing. Electricity demand has declined in recent years, consumers are increasingly both generators and users of electricity, and the generation mix is changing. Moreover, the economic and political environments impacting the electricity industry are more volatile than ever before.

This Network Vision lays out TransGrid's intended approach to planning the NSW electricity transmission network in light of the uncertainty facing the electricity environment.

TransGrid envisages that the transmission network of the future will first and foremost deliver safe, secure, environmentally responsible and cost-effective electricity transmission services. TransGrid will engage meaningfully with stakeholders and the community to align expectations with our ability to deliver. The network itself will be optimised to accommodate future requirements, while also being planned adaptively to match demand requirements and changes in the supply mix as they emerge. Technology and innovation will be leveraged to optimise the capacity and capability of the network. Finally, flexible and tailored connection services will be business as usual for connecting customers.

With this future in mind, TransGrid is applying six key objectives to its network planning and asset management processes:

1. deliver safe, secure, environmentally responsible and cost-effective electricity transmission services
2. meaningfully engage stakeholders and the community to align expectations with our ability to deliver
3. optimise the network in anticipation of future requirements to ensure value is being delivered
4. adaptively plan the network to match demand requirements and the changing mix of generation sources
5. leverage technology and innovation to optimise the capability and capacity of the network
6. implement flexible and tailored connection solutions.

TransGrid's network vision cascades down to its asset management policy, strategies, objectives and plans as described in the following sections. These principles are network management-specific applications of the strategic objectives defined in TransGrid's Corporate Plan.

1 The changing electricity environment

The days of steady-load growth, year-on-year, have changed. The typical electricity consumer is markedly different to that of a decade ago. The reliance on large centralised power stations to provide the bulk of the state's energy is also shifting.

The uncertainty associated with these changes in the demand and supply sides of the market will significantly impact how TransGrid makes its network planning and asset management decisions. Electricity transmission is a long-term business as transmission assets typically last for more than 40 years and increments in capacity are generally large. This means that an 'incorrect' investment decision will result in either under-utilised ('stranded') assets or risk delivery of transmission services through failure to make sufficient investment.

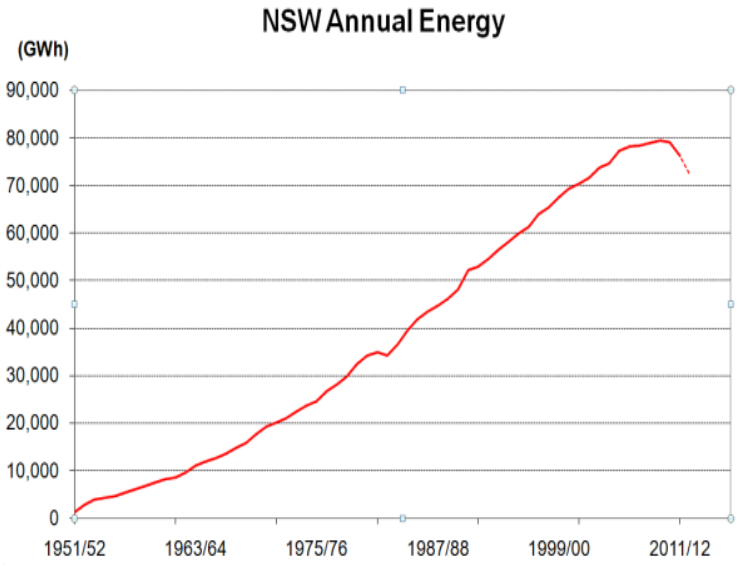
In the face of both demand and supply side uncertainty, deciding how best to develop the network and optimise asset utilisation will be TransGrid's key challenge over the coming decades.

In this section, we consider first the changing demand side and then the changing supply side of the electricity industry in Australia.

1.1 Changing demand

The demand side of the electricity market in Australia has changed.

At the time of TransGrid's revenue application for 2009 to 2014, peak electricity demand over the next decade was forecasted to rise sharply.



This is no longer the case. The Australian Energy Market Operator (AEMO) now forecasts an average annual increase in maximum demand over the coming decade of just 1 % in NSW, compared to a forecast of 2.2 % back in 2008.

For total annual energy consumption, AEMO forecasts a growth rate of just 0.6 % for NSW.

Three factors that could support or accelerate this trend are already in play:

- regulatory and policy incentives to reduce peak demand, for example, the Australian Energy Market Commission's intention to improve the 'cost reflectivity' of network charges
- regulations to drive down consumption, including changes to the minimum performance standards for air conditioners and fridges
- potential for technological change on the consumer side, such as the introduction of smart meters and potential widespread uptake of battery storage.

1.2 Changing supply

The supply side of the electricity market in Australia is changing.

Since the development of the NSW interconnected transmission network in the 1950s and 1960s, planners have largely designed the transmission network to move bulk power from generation centres in the Hunter Valley, Central Coast, Lithgow area and Snowy region, to load centres.

In recent years the generation mix in NSW has begun to change. For example, around 370 megawatts of large-scale wind generation has been connected to TransGrid's network since 2008, and a number of additional plants to the lower-voltage distribution networks. At the same time, penetration of distributed energy sources including rooftop solar panels has risen and is expected to rise further.

The nature, location and quantum of future electricity generation is uncertain and will be driven by a number of factors such as policy on greenhouse gas emissions, the economic climate, and the likely electricity demand. TransGrid will need to accommodate this uncertainty with adaptive planning and operations.

1.3 Three scenarios for the future

The eventual demand and supply mix in the electricity market will have implications for the development of TransGrid's network and how well the network is utilised.

Network utilisation and 'going off the grid'

In an extreme case of reducing network utilisation, the prospect of increasing costs that must be recovered from consumers to maintain the transmission system has led to conjecture around a so-called 'death spiral[1]'. This is where consumers reach a point where they are better off disconnecting from the network as transmission and distribution service prices rise. This reduces utilisation even more, further increasing costs and reducing the customer base.

In a worst case scenario, the spiral could result in an increasing number of stranded distribution and transmission assets that could threaten the viability of network businesses. It could also result in a portion of consumers going 'off the grid': that is, meeting their own electricity requirements through local generation and storage installations.

However, it is also possible that in the presence of increased population growth, potentially large renewable energy developments and economic conditions favouring development of manufacturing and energy intensive industries, it is conceivable that, over the 30-year outlook, utilisation could grow considerably faster than that forecast for the next ten years.

The economic regulatory regime for network businesses is designed to encourage efficient investments in network assets, through the use of an incentive for efficient capital expenditure (the capital expenditure sharing scheme), ability for *ex ante* review of capital expenditure by the Australian Energy Regulator in particular circumstances, and the use of efficiency-focused objectives for the regulator to apply to its initial assessment and allowance of capital expenditure by the business.

[1] AGL Working Paper 31, 'The Energy Market Death Spiral - Rethinking Customer Hardship', Simshauser and Nelson, June 2012

Decentralised generation and going 'off the grid'

Views on decentralisation of generation are mixed. The NSW power system, as with most other Australian states, started out with many small, isolated power systems. These were interconnected first on a state basis and then with other states, driven by economies of scale. Generation technology and storage may change these economies of scale, leading to debate as to whether a fully decentralised power system is the most economic. One view is expressed below:

'The reality is, however, that fully decentralised systems are not necessarily desirable. Decentralisation is instead part of a more global solution. The secure, clean and economically sound electric energy systems of the future will be those flexible enough to allow for a spectrum of hybrid modes of operation and investment combining the best attributes of centralised and distributed systems.'

Francois Bouffard and Daniel Kirschen, 'Centralised and distributed energy systems', Energy Policy Vol.3636

The CSIRO's Future Grid Forum

The Future Grid Forum convened by the CSIRO in 2012 brought together more than 120 representatives of the electricity industry, government and community to develop plausible scenarios for Australia's electricity future.

This forum developed four scenarios that have far-reaching implications for the current and future electricity supply chain and would alter the electricity system in Australia. Whilst the scenarios were not predictions, they provide a view of potential futures for Australia's electricity sector.

Not all the issues identified in the scenarios require a new response as in many cases existing processes and market arrangements would be sufficient, however, some new options for consideration were also developed. These issues have been taken into account and considered in part by our own scenario analysis identified in this network vision document.

TransGrid's three scenarios for the future

In light of the changing demand and supply sides of the market, and potential implications for network utilisation and development, TransGrid has identified three possible future outcomes (scenarios):

- demand and asset utilisation similar to current and forecast levels
- significantly lower utilisation and increased distributed generation
- higher utilisation caused by increased demand and large scale or remote renewable generation.

When things are uncertain, it is natural to exercise greater caution and to even change behaviours so that risks associated with the decisions made by TransGrid are reduced. TransGrid can test network planning and management decisions by assessing how well they perform for each of the three scenarios.

2 TransGrid's response to the changing environment

This section explains TransGrid's response to the changing electricity environment. TransGrid is undertaking effective engagement (Section 2.1), adaptive planning and operations (Section 2.2) and smart regulation and business practices (Section 2.3).

2.1 Effective engagement

Although TransGrid has not traditionally had a deep understanding of end consumers' needs and behaviour, by virtue of its place in the electricity supply chain, the time has come for this to change. TransGrid is now engaging much more broadly with end consumers and their representatives, so as to incorporate consumer preferences into TransGrid's network planning decisions as appropriate.

Key priorities for engaging effectively
value stakeholders' input
undertake early and broad consultation
empower consumers to inform TransGrid's decisions

2.2 Adaptive planning and operations

Changes in the demand and supply sides of the electricity market will mean TransGrid's network planning must accommodate changing flow patterns on the network and respond quickly to new connections or changed forecasts. That is, adaptive network planning and system operations will be crucial.

Key priorities for adaptive planning and operations
open, responsive planning
innovative non-build options
'just in time' capital works

2.3 Smart regulation and business practices

As TransGrid is a natural monopoly and therefore closely regulated, the design of the regulatory framework governing investment decisions is a key determinant of TransGrid's network management practices. TransGrid contributes its technical expertise wherever appropriate to ensure that regulatory and policy settings are aligned with ensuring that the long-term interests of electricity consumers are served by TransGrid's planning decisions.

Key priorities for smart regulation and business practices
engage in development of transmission reliability planning standard
contribute to design of incentives for efficient expenditure
support non-network options

3 TransGrid's Network Vision

In this section, TransGrid's response to the changing electricity environment is translated to a tangible vision for the future of the transmission network. Six objectives are then identified to guide TransGrid's activities as it moves toward achieving the Network Vision.

In Section 3.1, TransGrid's Network Vision is laid out. In Section 3.2 TransGrid's three scenarios for the future, based on its understanding of the changing electricity environment, are mapped against the six objectives for guiding TransGrid's network management decisions. Finally, in Section 3.3 the six objectives are laid out in more detail, with intended outcomes and examples of existing practices aligning with the objectives.

3.1 The Vision

TransGrid owns, operates and manages the high-voltage electricity transmission network in NSW. The network is made up of 96 substations and almost 12,800 kilometres of lines and cables that deliver bulk electricity from generators to consumers in NSW and the ACT, via the distribution networks. TransGrid's network is connected to the Queensland and Victoria networks, and so forms the backbone of the National Electricity Market. This facilitates the sale of electricity between the states on the eastern seaboard, allowing least-cost generation to get to market.

TransGrid's role in the electricity supply chain is shown in Figure 1.1.

Figure 1 The electricity supply chain

Generation Transmission Distribution Retail Consumers

TransGrid's network operates primarily at high voltage levels of 500 kilovolts, 330 kilovolts, 220 kilovolts and 132 kilovolts. The substations are normally located on land owned by TransGrid, with the transmission lines and underground cables generally constructed on easements on private or public land.

TransGrid's Network Vision

TransGrid envisages that the transmission network of the future will first and foremost deliver safe, secure, environmentally responsible and cost-effective electricity transmission services. TransGrid will engage meaningfully with stakeholders and the community to align expectations with our ability to deliver. The network itself will be optimised to accommodate future requirements, while also being planned adaptively to match demand requirements and changes in the supply mix as they emerge. Technology and innovation will be leveraged to optimise the capacity and capability of the network. Finally, flexible and tailored connection services will be business as usual for connecting customers.

3.2 Objectives to guide TransGrid to its Vision

The scenarios outlined in Section 1.3 above will be used to test the robustness of initiatives and strategies developed to achieve TransGrid's Vision. Table 1 shows how applying the objectives will position TransGrid to respond to the three scenarios for the future

Table 1 How the key objectives might apply under the scenarios for the future

	Scenario 1 **Demand and asset utilisation similar to current and forecast levels**	Scenario 2 **Significantly lower utilisation and increased distributed generation**	Scenario 3 **Higher utilisation caused by increased demand and renewable generation**
Objective 1 **Deliver safe, secure, environmentally responsible and cost-effective electricity transmission services**	✓ Similar to present requirements	✓ Focus on existing assets	✓ Increased requirements due to additional assets
Objective 2 **Meaningfully engage stakeholders and the community to align expectations with our ability to deliver**	✓ Conversations on the role of the network and cost/reliability trade-off	✓ Collaborate on substitutes for transmission services	✓ Understand drivers and requirements to inform decision making
Objective 3 **Optimise the network in anticipation of future requirements to ensure value is being delivered**	✓ Focus on cost-effectively improving network capability	✓ Focus on asset maintenance	✓ Focus on cost-effectively improving network capability
Objective 4 **Adaptively plan the network to match demand requirements and the changing mix of generation sources**	✓ Focus on network flexibility	✓ Focus on end-of-life options for exiting assets	✓ Facilitate generation and load connections
Objective 5 **Leverage technology and innovation to optimise the capability and capacity of the network**	✓ Focus on network capacity and flexibility	✓ Focus on condition monitoring	✓ Focus on network capacity and flexibility
Objective 6 **Implement flexible and tailored connection solutions**	✓ Engagement with parties proposing to connect	✓ Focus on providing "back-up"	✓ Expanded engagement with parties proposing to connect

Ultimately, TransGrid's activities must promote the National Electricity Objective, which is set out in the National Electricity Law. The National Electricity Objective is:

to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to —

- *price, quality, safety, reliability and security of supply of electricity; and*
- *the reliability, safety and security of the national electricity system.*[2]

[2] *National Electricity Law,* Section 7.

3.3 The key objectives in practice

Objective					
01	**02**	**03**	**04**	**05**	**06**
Deliver safe, secure, environmentally-responsible and cost-effective electricity transmission services					
The network is operated safely at all times					
TransGrid's business model is continuously refined to adapt to the changing environment					
Reliability and quality of supply are in line with expectations					
Electricity transmission services are cost-effective					
Real price increases are minimised					

Safety and the environment are key priorities

The safe operation of the electricity transmission network is TransGrid's highest priority. TransGrid incorporates public safety and safety of employees into all of its activities – from design, through an asset's operating life, up to its decommissioning.

Ensuring safety of employees and the wider community is and will remain a fundamental tenet of everything TransGrid does.

Minimising the impact of TransGrid's activities on the environment is also a key priority. This is supported by strategies targeted at preventing environmental incidents and fostering an environmental culture that integrates environmental management into everyday business activities. Through engagement with the community and building partnerships, TransGrid endeavours to balance the needs of our building program with the impacts on the wider community.

Finally, TransGrid's focus on both safety and the environment includes comprehensive bushfire risk assessment and management.

Best practice asset management

TransGrid's asset management system aligns with the new ISO 55000 asset management standard specifying how to optimise the management of physical assets. TransGrid's standardised approach asset management system presents a methodology to provide additional benefits including:

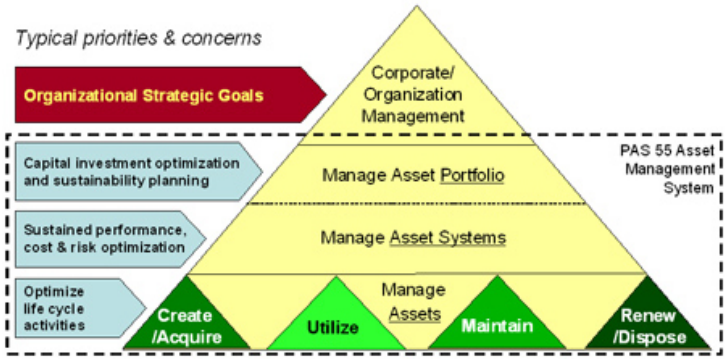
- **Portfolio management.** Acquiring and holding spares of a standard range of assets allows interchangeability, and sharing of spare parts and maintenance equipment holdings. Calculating whole-of-life asset costs identifies where it is more cost-effective to buy particular asset classes with high initial costs but lower life costs.
- **Condition-based maintenance.** TransGrid is increasingly using sophisticated technologies to capture detailed asset condition information. This information can be used to reduce maintenance costs where possible, and to better target activities to prevent asset failure.
- **Refurbishment strategies.** TransGrid is investigating how to match the life cycle of secondary system assets, for example protection and communication systems, to the longer

lives of primary assets. This could include the use of initial investments in long-life communication systems (such as optical fibre) to reduce the need to replace copper cables.

- **Use of new technologies**. TransGrid adopts new technologies for condition monitoring of assets, therefore allowing extension of asset life and safe levels of loading.

Key aspects of the ISO 55000 standard are shown in Figure 2.

Figure 2 Overview of the PAS 55 asset management standard



Understanding and meeting customer performance requirements

Customers are affected by the performance of the transmission network as well as the cost of achieving that level of performance. TransGrid's objective is to offer a cost-effective service with the desired performance characteristics.

To develop appropriate cost-performance balance TransGrid needs to understand the requirements of transmission customers, including new connections. Once the customers' expectations and valuation of performance are known, the cost implications of differing service levels can be considered.

TransGrid's planning of the transmission network is undertaken transparently and consultatively to ensure that we can best accommodate the customer's required performance levels at the lowest possible economic cost. This process must take into account the long-term nature of the business, the life of transmission assets, and the 'common good' nature of the network in supplying many customers.

TransGrid engages with customers through regular consultation to understand the customer's and end consumers' needs and required level of service. A key consideration is the fact that a transmission system serves many customers, each of whom could possibly have a different expectation of the required performance. For this reason, performance requirements are typically set as a standard and each transmission customer receives at least this standard.

Balancing cost and performance

Selecting the right balance between performance and cost does present challenges since network performance at a transmission level is uniformly consistent across the network. That is, it will not normally be possible for TransGrid to use the same assets to provide a range of performance levels at a particular location. The cost of delivering a particular level of performance increases significantly as the performance level rises. Intuitively, the optimal outcome is reached when the required service level just matches the requirements of a customer.

TransGrid will explore ways to move away from a one-size-fits-all approach and offer differentiated services from the same set of assets. There may be opportunities to increase asset utilisation through provision of non-firm services, where there are customers requiring such services.

Objective

01 | **02** | 03 | 04 | 05 | 06

Meaningfully engage stakeholders and the community to align expectations with our ability to deliver

A transparent and consultative planning regime is applied, consistent with the asset strategy and delivering network capability to closely match identified needs

Customers' needs and preferences are considered in network management decisions

Engagement with customers confirms that the appropriate trade-offs are being made between performance levels and costs

TransGrid's social licence to operate critical infrastructure is maintained

Consultation

While TransGrid's key interface has historically been with generators, distribution businesses and some large customers, all electricity consumers are impacted by TransGrid's operations in terms of the prices they pay for electricity, their access to electricity when and where they need it, and any direct impacts through capital investment.

TransGrid is increasingly engaging and communicating with consumers and external stakeholders to ensure we involve the broader community in our business operations and decisions.

Throughout 2013, TransGrid established a comprehensive consumer engagement program, to give consumers a voice in the development of our business plans and ensure that our vision for the future takes into consideration consumers' perspectives and priorities.

Powering NSW's Future

TransGrid's vision for stakeholder engagement is based on opening up the conversation about the electricity challenges faced by NSW. This conversation covers how to continue to supply a secure, reliable and affordable electricity network whilst considering the environment, the changing energy market, the influence this has on energy prices and the impact this has on households.

TransGrid is committed to opening up its planning processes and engaging with the community on plans for the future. TransGrid is embracing this electricity conversation by discussing:

- the program to replace infrastructure that is nearing the end of its serviceable life
- ways to respond to changing demand forecasts
- smarter reliability standards and grid innovation
- non-build options such as demand management to defer building new electricity infrastructure
- new ways of delivering critical infrastructure
- smarter planning initiatives to continue delivering reliable electricity to 3 million homes, industry and over 700,000 businesses across NSW.

TransGrid is committed to a stakeholder engagement process that is proactive, transparent and represents a genuine desire to inform, consult and collaborate effectively with interested parties.

Listening to the Community

To assist in informing the vision, TransGrid consults on planning and maintaining the network, the cost of operating the network, ways to reduce energy demand with the view to deferring and reducing the amount TransGrid will need to spend on new infrastructure, business incentive schemes, and its pricing methodology. TransGrid is seeking to better understand the most important aspects from a consumer's perspective and better align its priorities and objectives with community expectations.

TransGrid consults with residential consumers, small and medium businesses, large industrial and commercial customers and a range of consumer representative groups. A key outcome from this consultation has been to establish a TransGrid Consumer Advisory Panel and Large Energy User Roundtable with the view to bring together peak organisations to influence TransGrid's business decisions and help to facilitate wider community consultation and information dissemination. The purpose of these consultations is to maximise the opportunities for all consumers to share their perspectives and priorities with TransGrid.

The key themes emerging from conversations so far have been that:

- TransGrid needs to educate energy consumers about its business and its place in the energy supply chain.
- Messages need to be targeted to specific audiences (technical and non-technical) and a broad range of communications mediums utilised.
- TransGrid needs to help rebuild trust in the energy industry and our business, which in recent years has been subject to concerns such as rising bills and infrastructure disputes.
- TransGrid needs to become better at listening to the views of the community about industry and business impacts, as well as communicating what TransGrid does and how it manages its business and the challenges it faces.
- TransGrid must continue to improve its engagement practices.

TransGrid will continue its commitment to meaningful stakeholder engagement to ensure customers' needs and preferences are considered in network management decisions.

Objective

01 02 **03** 04 05 06

Optimise the network in anticipation of future requirements to ensure value is being delivered

Changing load patterns are met by a flexible network

Options for future choices are accommodated by a 'right–sized' network

Performance levels meet customers' needs

A transparent pricing methodology is applied

Transmission services are appropriately priced

Regulatory and stakeholder requirements are met

The cost of network services is a primary concern for all stakeholders. We should do everything we can to deliver increased value to customers and every decision should be tested to confirm that value is added.

TransGrid follows two key principles in this area:

- **Test for value.** Is the cost justified? Is it a cost-effective solution?
- **Test for impact on pricing**. What will happen to prices?

TransGrid is committed to providing cost-effective transmission services. This means TransGrid must test its actions to confirm they are adding value. This will also include cost control and the use of innovation to continuously improve productivity of both the workforce and assets. A key future challenge is to increase the utilisation of existing assets and to match future investments to needs.

Economic planning of transmission investments

The need to augment the capability of the transmission network can arise as a result of load growth, changed consumption patterns or new generation investments. New investments can be required even in a low or negative energy growth environment. A key planning risk is that of investment in an asset which is subsequently stranded because future projections do not materialise.

In determining the nature of a new investment to meet a transmission need, it is desirable that the economic driver behind the need is well understood and that the investment selected does not have an economic cost higher than that of the need.

A hybrid transmission reliability planning standard

TransGrid has helped develop and actively advocate for a hybrid transmission reliability standard. This standard is currently being considered by the standard-setter (the NSW government). The hybrid standard should be designed to transparently balance customers' willingness to pay against the cost of delivering reliability, while also accounting for the impact of low probability high consequence events on the network.

Planning criteria – probabilistic, deterministic or hybrid

The planning criteria are a means to an end. If an economic approach is taken to planning, the criteria become less important. The over-arching requirement is that economic balance is made between any proposed investment and the need for an investment.

Incremental and large-scale solutions

Transmission investments are often characterised by significant increments in capability and high costs. It makes sense then to focus on incremental capacity investments using advanced technology or by managing peak demands. However, it may not be economic to invest in many incremental augmentations rather than a smaller number of larger investments. The key element in selecting whether to apply a large or small investment is the level of uncertainty pertaining to assumptions about the future. Higher uncertainty will favour incremental augmentations.

Option values

Where some uncertainty exists about the longevity of a need or how the need may grow over time, investments can be considered that are designed specifically to allow a future upgrade to capacity. Similar logic can be applied to solutions that are otherwise scalable or reversible. Examples include the deployment of demand side contracted response, storage and use of relocatable assets. Consideration of option values will reduce the risk of stranded assets while still providing scope to cost-effectively meet expected growth.

Real options analysis in transmission planning

'Transmission lines are far cheaper and quicker to construct if provision for them is made by far-sighted planners well in advance. One reason is obvious: if easements are acquired before an area is densely populated, future lines can be installed much more cheaply and are therefore more readily justified. Another reason relates to engineering economies of scale.

Recent major projects have benefited from the foresight of the planners from the 1960s and 70s. For example, NSW transmission's largest project, the "Western 500 [kilovolt] Project" took advantage of such foresight by upgrading 330 [kilovolt] lines to 500 [kilovolt] (TransGrid 2009)'.

P.33, Garnaut Climate Change Review Update 2011, Update Paper 8 'Transforming the electricity sector'.

Long-term planning

State and town planning requires the orderly development of infrastructure to meet projected growth and changes in economic activity. Transmission assets, such as lines and cables, are long-lived and can have very long implementation times. It is desirable to consider the long-term planning requirements of the transmission system and integrate these plans into the broader state and local government planning frameworks. This provides the best opportunities for appropriate investments in an area and for shared infrastructure corridors.

In the early stages of development and route selection, TransGrid recognises that the competing issues of residential density, environmental impact and a balance of community impact, commercial impact and network reliability are essential to the development process. The identification and use of existing infrastructure corridor or joint use corridors such as road reserves, parks and other infrastructure are critical to minimising community impact and maximise efficient project delivery.

Sharing infrastructure corridors

TransGrid's establishment of the Rookwood and Holroyd Substations and associated transmission cables included the sharing of infrastructure corridors, for example with a Sydney Water pipeline and an existing canalway. This allowed the community impact of TransGrid's construction and ongoing maintenance works to be minimised.

TransGrid aims to identify preferred and alternative solutions where impacts can be minimised and joint corridors can be utilised to enhance community and environmental outcomes. TransGrid has recently used a construction route through a water corridor and provided access to its easements for gas infrastructure development. TransGrid supports the development of joint use infrastructure corridors and works with other infrastructure providers to mitigate safety and operation constraints for these joint corridors to enable improved environment and community outcomes. TransGrid also continues to work with planning and development regulators to provide great transparency and knowledge of its infrastructure projects within the state planning framework.

Structured option development

The development of options to meet an identified need will be focused on delivering not only an economical solution but also an appropriate one. TransGrid will adopt a priority approach to the development of new investments by considering, in order:

- upgrade options for existing assets
- non-network alternatives such as demand response, storage an distributed energy resources
- new transmission assets, for example using new technologies to reduce stranding risk

Refurbishment and augmentation

When an asset reaches the end of its useful life, there is an opportunity to re-assess the value the asset is providing to the power system and transmission customers. TransGrid considers:

- decommissioning with no replacement if the asset is no longer required
- re-conditioning of the asset if this is technically feasible
- replacement of the asset with a similar asset
- replacement with a higher rated asset if appropriate, such as where doing so avoids a later augmentation
- reconfiguration of the network.

All refurbishments and replacements are assessed to confirm cost-effectiveness.

Pricing of network services

TransGrid aims for appropriately priced transmission services, and development and application of a transparent pricing methodology clearly linking prices to the types of services provided.

Electricity bill component

Transmission is a relatively small component of the residential electricity bill.

In March 2013, the AEMC found that: 'The transmission network component is a small part of the total retail electricity price paid by customers, contributing around 8 % to the aggregated national retail electricity price in 2012/13.' (Electricity trends 1July2012 to 30June2015, March 2013).

TransGrid estimates that it contributed around 6 or 7 % to the average NSW resident's annual bill in 2012/13.

Objective

01	02	03	04	05	06

Adaptively plan the network to match demand requirements and the changing mix of generation sources

Reliability and resilience are maintained against failures of critical network assets

Risk management strategies matching the appetite for a major transmission failure are in place

Constraints and barriers to the connection of new generation sources are minimised

Non-network solutions (incorporating demand management) are always pursued where economic

Energy storage is an integral part of the overall solution where economic

Planning for uncertainty and risk

Transmission systems are designed to withstand credible contingencies with disruptions not exceeding those specified in the planning criteria. Typically, credible contingencies are the loss of any single item of transmission equipment or the loss of any generator. From an asset perspective, transmission plant is designed on a probabilistic basis to withstand other environmental factors such as wind, lightning, seismic activity and temperature. Assets are also exposed to external risk factors such as fire and physical impacts.

The nature of transmission operations and asset design means that there are low probability events that may exceed design ratings and result in damage to or failure of assets. Further, there may be common mode failures due to wide-area events such as earthquakes, storms and flooding. While these risks are low, the consequences can be severe. Public safety can also be threatened.

The principles TransGrid will follow in managing transmission system risks are as follows:

- continue to plan the network in line with the current reliability obligations
- adhere to an asset strategy that provides greater interchangeability of assets
- develop response plans to minimise repair times for major (non-credible) outages
- adopt designs that provide a natural robustness against common mode failures (for example, diversity) where this can be shown under reasonable assumptions to be economically sound
- continue to contribute to the NSW Government's consideration of a 'hybrid' transmission reliability standard, to transparently balance the cost of reliability against customers' willingness to pay, while also accounting for high impact low likelihood events.

TransGrid needs to be aware of low probability events that can have severe consequences and, potentially, threaten public safety. Understanding these risks and methods of mitigating the risks is an important consideration in the planning, design and operation of assets.

Wide-area events may be caused by earthquakes, storms, wind and fire. These external phenomena may affect larger parts of the transmission system and could result in multiple asset failures or disconnections. Several overseas blackouts have demonstrated that transmission systems are susceptible to cascading failures. It is important to have strategies in place to deal with wide-area events.

In the interconnected National Electricity Market, the Australian Electricity Market Operator has accountabilities for power system restoration after such events but the restoration actions are undertaken by network service providers like TransGrid. There are also actions that TransGrid can take to either reduce the probabilities of these events or mitigate their consequences.

In TransGrid's Network Vision of the future, it will have in place risk management strategies to:

- provide restoration services to AEMO
- allow, through design, rapid restoration of assets
- protect assets in the event of a major or cascading failure, so that vital equipment is not damaged
- provide priority supplies to customers that have contracted for high levels of performance.

Easement reservation

It is becoming increasingly difficult to obtain planning consents to build overhead transmission assets. The risks associated with obtaining planning consents are greatly mitigated if easements are acquired in advance. Easements should thus be acquired where they are:

- shown to be required through an economic assessment of plausible alternatives
- coordinated with state and local government planning bodies
- located in shared utility corridors, to minimise impact on the environment.

Inclusion of transmission easements in local plans will encourage appropriate development in the vicinity of the proposed assets and avoid the need for property resumptions or the adoption of costly alternatives in the event that a transmission asset is required.

TransGrid aims to develop long term plans that identify likely easement requirements that can be shown to be economically justified. Where easements are acquired, their holding costs will be periodically reviewed to avoid ongoing costs with unnecessary land or easements.

Non-network alternatives to meet network needs

TransGrid has been a leading procurer of demand management as network support in the National Electricity Market. TransGrid is committed to continuing to invest in cost-effective demand management.

Non-network alternatives to network options include load shedding, bringing embedded generation online, and potentially energy efficiency. Together, these approaches can be thought of as 'demand management'.

Thoughtful application of demand management can reshape the demand profile and allow cost-effective deferral or avoidance of investment in network capacity and in network measures to ensure reliability and security of supply.

TransGrid acquired 40 megawatts of network support for the 2012-2013 summer. This involved over 80 consumer sites across metropolitan Sydney either shedding load or bringing embedded generation online, in order to support the city's high voltage network.

This project claimed the top award in the Best Demand Response category of the Energy Efficiency Council Awards for 2013.

Demand management also provides a more 'granulated' approach to delivering network services, allowing network planning to be responsive to changes in demand forecasts.

Innovation in demand management

The demand management market is in its infancy in Australia. On the customer side, large businesses are uncertain about how best to reduce their peak electricity use, and residences remain unaware of the importance and ultimate benefits of demand management. On the network side, the full potential of innovation in demand management is yet to be realised and key technical considerations are still unclear, such as the link between energy efficiency efforts and peak demand reduction.

As such, innovation is needed to boost the uptake of demand management. TransGrid is committed to making demand management a 'business as usual' part of its planning process, using cost-effective non-network alternatives to network investment wherever possible. TransGrid's key focus areas for demand management are collaboration with industry and expert stakeholders, understanding and development of the demand management market, and trialling of demand management technologies and techniques.

Objective

01	02	03	04	05	06

Leverage technology and innovation to optimise the capability and capacity of the network.

Technology and innovation are leveraged to improve the utilisation of individual network assets and reduce overall service costs

New technology is adopted early

Enhanced monitoring, control and automated system technologies gather dynamic data about TransGrid's assets

The skills and capability of the workforce are enhanced to match requirements

An important way to improve efficiency is to increase asset utilisation. If asset utilisation is low, the cost of the asset is spread across fewer users, thereby increasing the charges they pay for an asset. There are many ways of achieving higher utilisation rates and reducing the risk of stranding, some of which are considered below.

Adopting dynamic asset ratings

This may allow TransGrid to safely increase the transfer capability of existing assets though use of more precise information on asset condition. Most primary transmission assets (transmission lines, cables, transformers) have capabilities that are temperature dependent. In some cases, asset temperatures are measured directly, as in the case of transformers. In other cases, a statistical approach is used to estimate ratings. More precise knowledge of the asset temperature, its operating environment and even forecasts of loads that need to be carried by the asset, can allow greater asset utilisation when environmental conditions are more benign than those used to develop standard ratings, without adversely affecting asset condition or life.

Adopting technologies to manage or avoid the need for major investments

In the 20- to 30-year outlook period use of new technologies will become cost-effective that will provide means to control peak demands. Energy storage and control of non-essential loads are examples of how the peak demands can be reduced and energy usage either avoided or shifted to a time where transmission network loading is lower. Where cost-effective, the reduction of peak demand can defer the need for network investment.

Upgrading existing transmission assets

Most assets have been designed to operate at a specific maximum temperature. In some cases, it may be possible to upgrade an existing asset to either increase the permissible asset operating temperature (for example, increasing the height clearance of a transmission line) or providing increased cooling (additional fans on transformers, cooling ducts in cable trenches). In the case of transmission lines, there are opportunities to use special high temperature conductors or, much more rarely, install additional or larger conductors on an existing line. These opportunities depend on asset characteristics and retrofit costs can sometimes be high. Where cost-effective, the resulting increase in ratings can defer the need for network assets.

Using special control schemes

Conditional control actions are presently used in some locations to reduce energy transfers on specific assets following the occurrence of a fault on the network. The benefit obtained is that assets may routinely be used closer to their ratings rather than having to leave spare capacity to allow for greater transfers following a fault. This approach can defer or avoid the need for new investments. Greater use of these control schemes is expected in the future.

Substation automation systems

Substation automation systems are a critical part of TransGrid's network. TransGrid is currently investigating how to implement ISO standard 61850, intended to more tightly integrate multiple automation systems within a substation, such as protection, automation, system operations, asset management, high voltage plant, communications, metering and maintenance. The goal of implementing 61850 is to improve the automation systems' throughput and so provide a platform for future generations of switchgear technology.

Objective

01 02 03 04 05 **06**

Implement flexible and tailored connection solutions

Customer connections are competitively priced

Value-added solutions are provided for customers

Diversified business enhances the operation and effectiveness of core activities

Connecting customers to TransGrid's network

There are a number of reasons for customers to connect to TransGrid's transmission network. These include the capacity of the load or generation that a customer is wishing to connect and the geographic location of the connection in relation to the transmission network. In either situation, customers are looking for TransGrid to meet their connection needs in a timely and cost-effective manner.

What do customers want?

- increased sense of urgency
- greater responsiveness to issues
- improved understanding of their business and commercial drivers
- market reflective pricing
- improved delivery time frames
- greater commercial transparency

Customer Experience Survey: TransGrid conducted its first Customer Experience Survey in 2012 to better identify customer requirements and to assess how TransGrid was performing in relation to those needs. This survey is now carried out on an annual basis and is supported by Touchpoint surveys, which are simplified surveys completed at key milestones throughout a connection project to provide more timely feedback.

Following the feedback obtained in the first survey, TransGrid implemented a number of initiatives to address the concerns raised. While there was no appreciable difference in the overall survey results from 2012, indicating there is still work to be done, the 2013 findings did identify areas of notable improvement relating to the early stages of a connection i.e. submitting and progressing an enquiry, up 7.8 and 16.0 points respectively. These results substantiate the effectiveness of the improvement initiatives that were implemented.

Innovative and cost-effective connection solutions

TransGrid is committed to actively supporting customers' connection requirements. To achieve this objective and further address the improvement opportunities identified in the surveys, TransGrid has initiated a corporate initiative aimed at providing more timely and cost-effective connection services. Outcomes of this initiative should be progressively implemented from 1 July 2014, with key changes including:

- revised and site specific design specifications
- reduced delivery time frames
- significantly reduced costs to provide customers with a commercial offer
- dedicated resources focussed on customer connections.

A key aspect of providing more timely and cost-effective solutions is the development and application of innovative solutions. Examples currently being developed and applied, which will support the abovementioned corporate initiative deliverables and provide a better overall result for customers, include:

- integrated offerings that combine negotiated and non-regulated works
- value add non-regulated services, such as system spares
- hubs that facilitate cost-effective connections for multiple parties
- innovative financing options.

It is anticipated the outcomes of the corporate initiative, in conjunction with a focus on providing more innovate connection solutions, will significantly contribute to addressing the customers' needs that have been identified.

Benefits associated with offering expanded services: In an effort to support customers' connection requirements, TransGrid is now offering services that extend beyond those traditionally provided by the organisation. In other words, TransGrid is now able to provide additional services to the mandatory transmission connection components required by a transmission network owner. These additional services include:

- substation (transformer and associated switchgear) components of the connection
- telecommunications and metering
- operations and maintenance.

This approach enables TransGrid to provide customers with a 'one stop shop' for their complete connection needs, which simplifies and reduces the number of interfaces required to complete the connection. The provision of these services in a competitive environment (customers are able to choose their own service provider to carry out these works) will emphasise and support the enhanced commercial focus being adopted by TransGrid. The learnings will not only drive the delivery of innovative and cost-effective connection solutions, but may also be applicable also TransGrid's prescribed works.

What are customers saying? Areas that have improved

- positive improvements recognised throughout the early stages of the connection process
- increased levels of collaboration and communication being experienced by customers
- TransGrid staff being more understanding of customers' needs, particularly in the early stages of the process

What are customers saying? Areas requiring improvement

- increased sense of urgency and responsiveness to issues
- greater timeliness and flexibility of solutions
- improved costs and greater commercial disclosure