Powerlink Queensland

# NETWORK VISION

Powerlink QUEENSLAND

Valued Customers and Stakeholders,

We at Powerlink are proud to provide you with a summary of the first edition of Powerlink's Network Vision.

We know the future of energy won't be the same as it is today and that our customers and the way they access and use energy are at the forefront of this transition.

At Powerlink we believe that we must anticipate, influence and navigate the challenges and opportunities coming our way to continue to deliver for our customers.

What won't change is our commitment to providing safe, reliable and affordable high voltage electricity transmission network services to more than four million Queenslanders and our directly-connected customers.

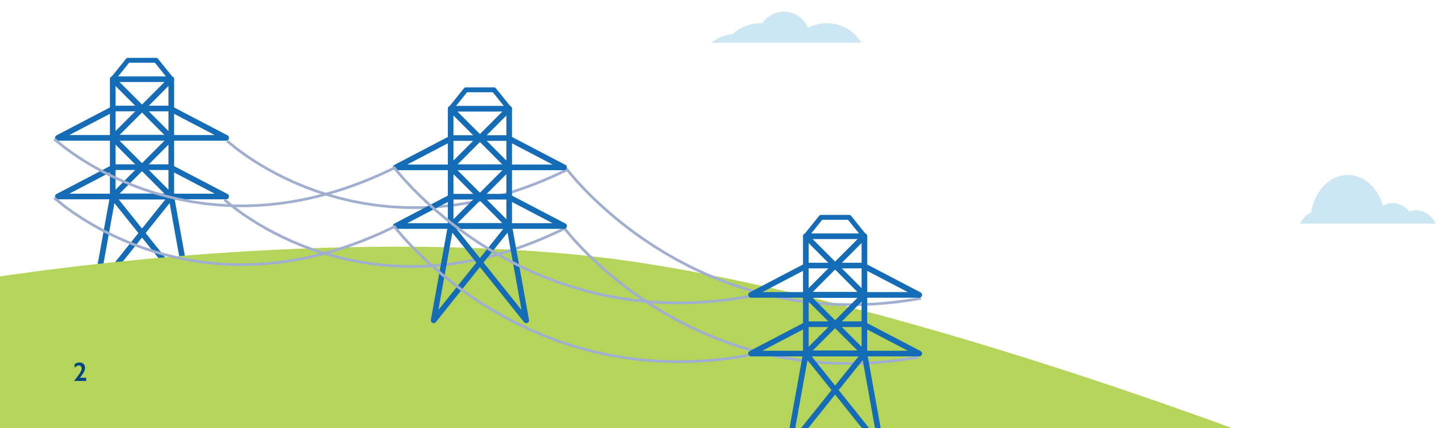
The 30 year Network Vision explores different roles Powerlink may play, and the implications for a transmission platform, across a range of future scenarios. It identifies a range of uncertainties, drivers and opportunities that will shape the future. Monitoring the drivers and opportunities in the Network Vision will help Powerlink, and our network, adapt to its future role in electricity supply for our customers, stakeholders and Queensland communities.

The Network Vision will be periodically reviewed and updated to stay current with the evolving energy sector. It will inform and shape our future strategic direction and be used as a key input to our Revenue Determination process.

Powerlink has engaged with our customers to develop the Network Vision and their input has been invaluable.

I hope you find our Network Vision a valuable insight into where our industry is going and we encourage you to provide any insights you may have.

**Kevin Kehl**
Interim Chief Executive Officer



# NETWORK VISION

## Purpose

We know that energy systems are transforming, from:

- fossil fuels to renewable energy
- centralised power generators to distributed generation at household, business and community level
- forecasting demand to forecasting both supply and demand.

The Network Vision explores the possible services desired by customers from the future energy system over the next 30 years and allows us to consider future roles for a transmission company to meet these needs. This time horizon forces the organisation to consider profoundly different futures as opposed to incremental extrapolation of the present.

While not developing specific initiatives, investment recommendations or strategies, the Network Vision allows Powerlink to explore a number of plausible scenarios. These scenarios are neither predictions, forecasts nor preferred futures. They are a way to better understand the range of uncertainty in the future and identify future impacts and implications of the decisions made in the present.

The goal is to challenge current thinking and decision-making to enable Powerlink to adapt as transformations emerge.

## Approach

In exploring the future energy system, we engaged with industry experts, interest groups, key stakeholders, our customer panel and our staff. This was done to provide a better understanding of why and how customers will use electricity into the future and the role transmission could play to add value. We used a design thinking approach to harness this expertise, scan broadly, explore many possibilities, then condense this back to trends and scenarios which were most meaningful.

## Key trends and uncertainties

Trends were identified through external (industry and interest groups) and internal Powerlink interviews, desktop research and environmental scanning. These trends were then analysed and clustered to assess the impact, likelihood, feedback loops, uncertainty and change over time.

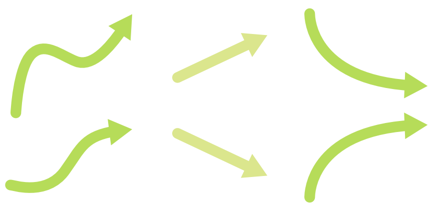
This approach highlighted three key uncertainties relating to the future of the electricity system including:

1. Changing electricity consumption patterns
2. Decarbonisation - transition to a lower emissions power sector
3. Decentralisation - uptake of decentralised energy resources

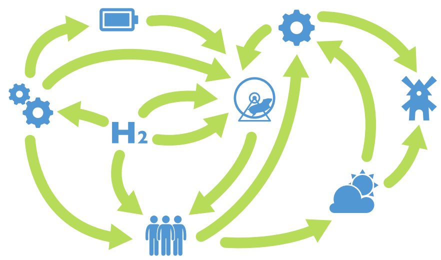
These key uncertainties were consistent with the feedback received through the stakeholder interviews, literature research and workshop feedback.

***Trends** have clear patterns that move incrementally in a specific direction, you can say something is increasing, decreasing or remaining stable and can make an educated estimate of how it will play out.*

***Uncertainties** are where feedback loops between trends interact to generate multiple plausible outcomes for how they will develop in the future, they are impacted by decisions yet to be made and unforeseen events.*



Trends




Uncertainties

## Changing electricity consumption patterns

Overall electricity consumption refers to the energy used from any form of electrical power generation and/or storage. This includes not just the centralised power generators, but also generation and storage at an individual household or business. Overall electricity consumption will generally increase with changing overall energy consumption and/or fuel switching to electricity.

***Why is this an important uncertainty?***

*The range and number of devices that require energy are increasing, but there is also increasing energy efficiency in many products. People may shift to electricity as their energy source of choice, but they may also switch to an alternative fuel source as advances are made and new options emerge.*

## Decarbonisation

Power generation for the transmission and distribution of electricity is the largest source of greenhouse gas emissions in Australia (around 33%) and has the best prospects for timely and cost-effective reductions out of all sectors of the Australian economy.

It has been the focus of the majority of carbon emissions reduction initiatives because there are a localised number of aged power generators that produce the majority of emissions.

The transition to a lower carbon future will be driven by both societal pressures to mitigate climate change and economics of both large scale (solar, wind and hydro) and small scale (rooftop PV) renewable generation.

***Why is this an important uncertainty?***

*Timelines for change and extent of decarbonisation is unknown and could be influenced by a range of factors. Renewable generation presents technical challenges in keeping electricity supply and demand balanced.*

## Decentralisation

The energy industry is rapidly moving away from one-way power flows along the supply chain of centralised generator to transmission, distribution and customer to more of an eco-system of supply and demand.

Advances in technology, particularly solar, have driven significant changes in supply and demand patterns. We are seeing two-way power flows over network as more households and business install their own solar generation and export back into the grid.

There have been greater amounts of electricity produced closer to places were electricity is used with distribution networks playing a more active role in managing local power supply and demand. This is occurring concurrently with the development of large-scale projects in remote locations.

***Why is this an important uncertainty?***

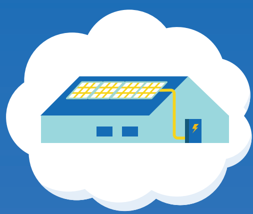
*The grid of the future will be largely dependent on third party alterations to networks/centralised generation, consumer preferences, regulations and policies. This is a shift in control from a centralised co-ordinated system, which transmission businesses will need to cope with as changes emerge.*

## Four scenarios

The scenarios developed for the Network Vision were created collaboratively using the three uncertainties as guiding pillars. Narratives (stories) for the scenarios explore:

- how and when change will impact Powerlink
- where the change is coming from
- what strong or weak signals may precede the change.

For example, change could be driven by a shift in consumer preferences, technology advancements or an economic shift. Through using the narrative technique, these impacts and shifts are highlighted.



**Prosumer-led market**

Decentralised

Lower carbon

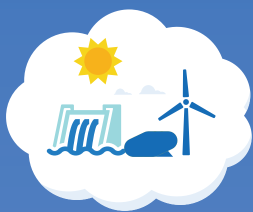
High overall electricity consumption

**Community-based power**

Decentralised

Lower carbon

Low overall electricity consumption

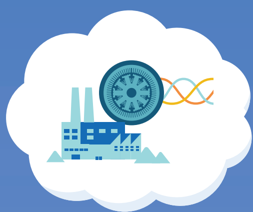


**Renewable super grid**

Centralised

Lower carbon

High overall electricity consumption



**An evolving market**

Centralised

Moderate to high carbon

High overall electricity consumption

### Prosumer-led market

Decentralised

Lower carbon

High overall electricity consumption

A high-growth electricity future where more 'prosumers', both residential and commercial, produce their own electricity and store it for use at peak times. In this scenario, consumers are digitally connected to the world around them. Their smart home, appliances and electric vehicles have a symbiotic relationship with the energy system they trade and interface with.

#### *How it may happen…*

Power bills just kept going up without any additional value which led to a high level of scepticism towards the electricity sector. Customers' motivation to take back control of their electricity needs coincided with several technological developments that enabled them to do so. The flexibility offered by energy storage enabled many consumers to source their electricity directly from the market, bypassing any retailer. Consumers implemented a range of approaches to shift their energy consumption to the middle of the day, and society gradually adjusted its patterns to work in harmony with the natural availability of solar energy.

#### *How life could change…*

Bakeries now bake their bread during the day, industry always schedule their maintenance downtime to align with cloudy weather, and most households pre-chill their houses during the daytime so that it will be comfortable come evening.

### Community-based power

Decentralised

Lower carbon

Low overall electricity consumption

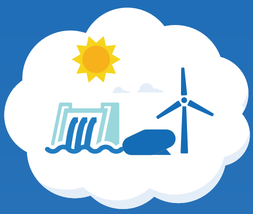
In this scenario third parties are successful in selling alternative energy supply solutions to customers and everyone who can go off the grid, does go off-grid. Consumers generate their own electricity and are largely energy self-sufficient as electricity demand is lower than other scenarios due to more energy efficient appliances and industry. Very high energy reliability is no longer provided solely by the interconnected power system as mobile energy services such as vehicle-to-grid technologies provide the 'last-mile' wireless connection to electricity.

#### *How it may happen…*

As the cost of new technologies became more competitive smaller communities were able to rely on their own sources of energy. Electric vehicles became a virtual alternative to distribution networks. Many such vehicles were already getting charged at work during the daytime, and so it was a natural extension to use the excess charge to top up the household's battery each evening. Distribution networks were largely retired, as their utilisation fell so low as to make them commercially unviable. The transmission network became much more focused around the key activity centres, clusters of commerce, industry and high-density residential, often with a need for reliable 24x7 power in an environment with inadequate space to generate their own electricity.

#### *How life could change…*

For those without a vehicle of their own, autonomous mobility services integrate power deliveries into their service offering with very competitive costs. Ordering a load of energy is no harder than ordering a home-delivered meal!



### Renewable super grid

Centralised

Lower carbon

High overall electricity consumption

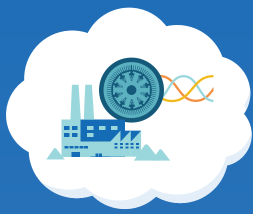
Global and national commitments to addressing the effects of climate change result in a rush of renewables connecting to the network while fossil fuel generation retires as it reaches end of life or becomes uneconomic. High electricity growth follows the transition due to lower cost electricity and the transition to an increasingly electrified economy is managed through innovation and a data-driven approach.

#### *How it may happen…*

As a low cost energy producer in the low-carbon world economy, Australia became a natural home for energy intensive industries. The shift to renewables revitalised the manufacturing and heavy industry sectors first, and then supported developing new industries including the hydrogen export industry which resulted in substantial growth in demand for electricity. Supportive policy and low-cost, emissions-free energy also incentivised other sectors of the economy to switch fuel sources and transform the nation to an all-electric economy.

#### *How life could change…*

The international export of energy is facilitated by the High Voltage Direct Current (HVDC) technology to transport power from Australia's red interior (with its excellent solar yield, decent wind, infrequent cloud, and inexpensive land) to the coastline, where desalinated water is converted to ammonia for export via ships.



### An evolving market

Centralised

Moderate to high carbon

High overall electricity consumption

A slow transition to renewables occurs in response to the gradual retirement of coal fired power stations. Investment in generation is predominantly in economically attractive large-scale renewables firmed by gas powered generation. Domestic electricity consumption grows in line with the overall economy, but then a step change occurs as hydrogen export becomes a reality enabled by lower cost renewables and increased demand. Domestically, grid electricity remains cost competitive with networks providing customised reliability services and developing efficient asset life extension measures.

#### *How it may happen…*

In the absence of long-term Australian energy and climate policy certainty, the uptake of lower cost renewable generation during the 2020's and 2030's was slower and many centralised thermal power plants invested in life extension works. In a similar fashion, it became apparent that the most efficient direction for transmission companies was to extend the life of their own assets. This was achieved by leveraging a range of emerging technologies, including autonomous drones, wireless sensors and data analytics to precisely measure the condition of their assets, resulting in very targeted, low cost life extensions.

#### *How life could change…*

Transmission companies mitigate the risk of existing large generators leaving the network by owning and operating a fleet of containerised batteries, which can be redeployed throughout the system as needed. Where once a transmission company might have had to make a large and long-term investment in infrastructure, it can now incrementally add or remove battery modules in line with the system need.

## Insights, implications, drivers and opportunities

While the scenarios were fundamentally based upon the three key uncertainties, they also featured a range of emerging and anticipated trends such as developments in technology or shifts in consumer behaviour. The interaction of the key uncertainties with these trends (which have been grouped thematically according to their driver), and the resultant impact upon the network are discussed further below. Seven key drivers were identified, which were:

1. Changes in mobility
2. Changes in industrial and commercial loads
3. Energy export industry
4. Distributed energy resources
5. Network design and operations
6. Large scale generation
7. End-use customer expectations

Exploration of these drivers provides an understanding of how the network may need to change, what key things should be monitored and what future opportunities exist.

## Changes in mobility

The uptake of Electric Vehicles (EVs) will be dependent on the evolution of the international markets, including bans on internal combustion engines, e.g. European Union standards are also driving the move to electric motorcycles.

There will be a need to consider how to collaborate with distribution networks and government bodies to ensure the charging regimes take account of the network, e.g. incentivise charging during the day so as to not contribute to the peak demand, or charging in the afternoon to reduce solar flooding into the market at a peak supply time.

Key considerations around passenger vehicles include the evolution of ride sharing, vehicle automation and the impact on total kilometres travelled by vehicles and how that translates into demand on the network.

An important consideration is the evolution of the emission targets and the potential for other industries such as the transportation and agriculture industries to reduce their emissions. This could result in an increase in the electrification of bulk train haulage and as well as the uptake of hydrogen vehicles, which may displace the electricity demand for EVs, however this is dependent on where electrolysers connect to the network.

## Changes in industrial and commercial loads

This driver focuses on how large industrial customers, who connect directly to the transmission network, will use electricity in the future. It is expected that these customers will need to have greater predictability and control of their long-term electricity supply, to maintain competitive advantage. To achieve this, they may continue to look to install their own renewable generation onsite, entering into Power Purchase Agreements or implementing flexibility into their processes, e.g. through the use of variable speed drives to operate at different speeds and demands.

If electricity prices remain high, there is a risk of lower returns for businesses, or that energy intensive industrial loads shut down or relocate overseas. This results in decreasing utilisation of the network, which will have a further financial impact on end user customers who have to bear the costs of network operation.

The evolution to automation in manufacturing, Industry 4.0, may remove the competitive advantage of low cost labour regions and result in a relocation of industry closer to raw materials and skilled workers. Further, the growth in digitisation and information will lead to an unprecedented growth in data centres, which would represent a 24x7 constant demand.

## Energy export industry

Federal and State Governments are looking at strategies on how to best develop a local hydrogen export industry, however there is also investment interest from other countries.

If Australia was successful in winning contracts to supply international markets, transmission may play a key role in the transportation of cheap renewable electricity to electrolysers and export infrastructure. This evolution depends on the comparative economics of producing hydrogen at the renewable generation site and then piping it to the ports for export, or stand-alone systems with no connection to the gas or electricity network.

International interconnection is more likely to be in the form of a liquid/gas transported by ship (as opposed to a physical cable connection). In the longer term, the ongoing development of high voltage direct current (HVDC) technologies could eventually lead international interconnection to be economic.

While there is currently a lot of focus around the hydrogen industry, this theme is broad to consider that there may be other markets that are viable into the future. For example, expanding interstate interconnectors and regional intraconnectors to increase their export capacity, may support the development of additional renewable generation within Queensland.

## Distributed energy resources

It's fair to say that Distributed Energy Resources (DER) is one of the largest transformations in the electricity sector and even though this is happening mostly on the distribution network, transmission is already and is likely to be further impacted. We know that customers are putting solar panels on their roofs, batteries to store and use this energy during the night, and home automation systems are being developed. The impact on transmission is three-fold.

Firstly, it has and will continue to change the demand and utilisation of our network. With the growth in rooftop solar, demand in the middle of the day is supplied by solar so that the daytime utilisation is diminished while the peak time load in early evening still grows.

Secondly, consumers have the capability to become prosumers, creating more change and disruption. Virtual Power Plants (where local communities can combine rooftop solar to be a bigger generator) and third party aggregators (who can enable prosumers) add complexity to network operations. In the transition, it is important for a transmission company to stay involved, considering the role of transmission and how this can deliver overall least cost solutions to customers.

Thirdly, potential opportunities exist to use DER capacity to find innovative ways in which to manage network constraints and outages. This can only be achieved with partnerships, e.g. in collaboration with key industry bodies such as existing distribution networks, and future third party aggregators or distribution system operators.

DER will have the ability to be potentially controlled and orchestrated and optimised, or it could exacerbate the peak demand while reducing the overall usage of the grid. There is a risk that those who do not have the financial or logistical opportunity to get a DER will be left to pay for the network.

To support long-term planning and asset management decisions it is important to understand the potential for network rationalisation where the usage of the network is decreasing and not cost effective to supply these regions.

## Network design and operations

This is a broad driver which considers both the operation and asset management decisions of the network.

Firstly, it looks at how data can be used for a wide range of purposes including supporting automation of systems, and how dynamic signalling can be incorporated into incentives to influence demand response and support network operations.

Secondly, it touches on climate change and the potential increase of demand on our network but also the potential need to change network design parameters based on increased temperatures, flood risks and prevalence of bushfires.

Thirdly, it considers the variability of generation and demand that is reliant on weather. This impacts the accuracy of forecasts and the need to be more agile when scheduling outages.

Lastly, it considers the increase of asynchronous generation connection to the network and how this could impact on system strength. This will drive consideration for a transmission company's network planning, design and procurement of the protection and systems and equipment used for voltage control and protection. Also, as traditional synchronous plant retires, decreasing levels of system strength will necessitate additional infrastructure (e.g. synchronous condensers) and fast controls which will need to be considered as part of network planning.

## Large scale generation

This driver focuses on the future connection of large scale solar and wind generation to the network.

A range of energy policies anchor an objective to reach a 50% renewable energy target by 2030 and zero net emissions by 2050.

The future retirement of existing coal fired plant creates significant network operational challenges. Even with the recent rule change requiring three years notice of a planned intention to retire a scheduled generator, the potential for an aged power station to become financially unviable or experience an equipment failure that would be expensive or time-consuming to repair may still lead to sudden unplanned retirements.

The heart of the future transmission network will be about how the transmission company can continue to connect asynchronous generation and operate the network with lower system strength.

High radiance or good wind resource maybe located in remote regions away from main load centres, which is likely to increase congestion on networks.

When combined with controllable demand and fast communications, there is the potential to use solar generation to cost effectively release additional capacity on the transmission network.

## End use customer expectations

Traditionally electricity was provided on a one-size-fits-all basis. Customers have rejected the 'one size' model in every other aspect of their lives and inevitably this will continue to filter through to the electricity sector.

It is important to note that end user customers are not just residential households, but anyone who has historically received electricity through connection to the distribution network, like education and health services, and businesses small and large. These customers will not always make choices based on financial cost and it is important to gather information on their expectations from them and not make assumptions.

The continuing uptake of DER and batteries, will give users more choice and control, opening up opportunities to supply their energy needs at an individual or community level. These technologies will also give more customers protection from short-term outages, which could provide opportunities to change the way the network is operated and maintained. In the future there may be opportunities to reduce both reliability and cost, or provide differentiated service levels, with no impact to customer experience. This would require effective partnerships between all participants in the electricity supply chain.

Further, the uptake of smart home automation systems will provide a role for third party providers to enter into the industry, giving users more control and flexibility over their use of electricity, whilst maintaining simplicity, allowing them to just get on with their lives.

## Signposts

Signposts have been developed to help identify critical shifts over time and monitor changes to the uncertainties, network impacts, insights and opportunities.

These were developed to provide an ongoing mechanism to assess the likelihood of a scenario eventuating, identify when critical implications may occur and attractiveness of potential opportunities for a transmission company.

Both qualitative and quantitative measures were utilised to provide meaningful and practical signposts across the different time horizons. These will inform Powerlink's strategic processes, Revenue Determination process and future network design.

Examples of a signpost are the Uptake of Electric Vehicles (for the Mobility driver) and Uptake of Rooftop Solar (for Distributed Energy Resources driver).

## CONTACT US


**Registered office**
33 Harold St Virginia
Queensland 4014 Australia
ABN 82 078 849 233

**Postal address**
PO Box 1193 Virginia
Queensland 4014 Australia

**Telephone**
+61 7 3860 2111
(during business hours)

**Email**
pqenquiries@powerlink.com.au

**Website**
www.powerlink.com.au