UE PL 2034 Strategic Asset Management Plan

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Foreword

I am pleased to present United Energy's (UE) Strategic Asset Management Plan (SAMP).

The SAMP sets out how UE's corporate objectives translate into asset management objectives and plans. It has been prepared to inform stakeholders of UE's asset management approach, programs and strategies adopted for the management of the regulated UE assets over the next 20 years. It outlines our systems and strategies to effectively and efficiently manage the safe and reliable delivery of electricity services to our customers well into the future.

The Australian energy markets are changing at an unprecedented scale. The next decade is likely to see a step change in the adoption of new technologies, including distributed energy resources such as rooftop solar, energy storage and electric vehicles. Transformation will be driven by customers as they embrace the new technologies and take control of their energy use. This will present a significant range of technical, economic and regulatory challenges and opportunities for the industry.

UE's future is impacted by uncertain government policy and regulations, potential soft electricity demand growth, rising prices, a changing generation mix, technology shocks and increased consumer involvement. A well-planned approach to navigate this transformation will be needed to maintain a safe and efficient network to securely integrate the large numbers and diverse range of distributed energy technologies. In a decentralised yet integrated energy future, UE must be responsive to the changing demands for traditional services while enabling new opportunities for energy sharing and balancing to unlock and reveal the true value from the grid.

This SAMP attempts to address for UE key strategic issues facing the electricity supply industry.

I hope you find this SAMP informative and I welcome your comments.

Mark Clarke

General Manager Electricity Network

Table of Contents

Table of Figures

List of Tables

Purpose of this Document

The purpose of this SAMP is to connect UE corporate objectives to our asset management objectives, present the approach for developing asset management plans, and detail the role of the Asset Management System (AMS) in supporting achievement of the asset management objectives. The SAMP supports the overall corporate strategy and the strategic objectives are reflected in our Asset Management Policy. This document also represents an integrated articulation of how the principles of the Asset Management Policy is implemented.

This SAMP addresses key strategic questions facing the electricity supply industry. The future nature of utilities is being considered around the world in the context of potential disruptions from technology, customer behaviours, government policies and legislation.

This document forms part of UE's AMS which is being developed in accordance with the latest standard for asset management (known as the ISO 55000 series and specifically AS ISO 55001: 2014 Asset Management – Management Systems – Requirements).

Executive Summary

United Energy (UE) finds itself at the cusp of a changing energy landscape. Disruptive impacts on the distribution network are wide and varied and include new energy technology, both customer and network driven, political and regulatory uncertainty, extreme weather impacts, changing customer expectations and the rise of data analytics. All of these will change the electricity network as we know it today. UE's challenge as a regulated distribution network service provider is to adopt an approach that is measured yet not risk averse, so as not to fall into the trap of overreaction, complacency or irrelevance as the future arrives.

In preparing the SAMP, UE has developed strategic responses to the identified challenges and opportunities, and is embedding these into our asset and non-asset lifecycle planning activities. Where the future is uncertain, these strategies provide UE options to manage the uncertainty and avoid risks such as investing in long life asset that may not be required in the future.

1. United Energy Overview

United Energy (UE) distributes electricity to approximately 680,000 customers across the east and south-east of Melbourne and the Mornington Peninsula over an area of 1,472 square kilometres. The distribution network we construct, operate and maintain transforms electricity from sub-transmission voltages to distribution voltages for supply to our customers who typically use it at 400/230V in their homes and businesses. Although our service area is only about one per cent of Victoria's land area, it accounts for around one quarter of Victoria's population and one fifth of Victoria's electricity maximum demand.

UE's territory covers the region depicted below. UE is responsible for all the electricity distribution assets within this region, from the sub-transmission network right through to the customer's connection at the house (including the meter). The vast majority of customers are supplied at low-voltage levels.

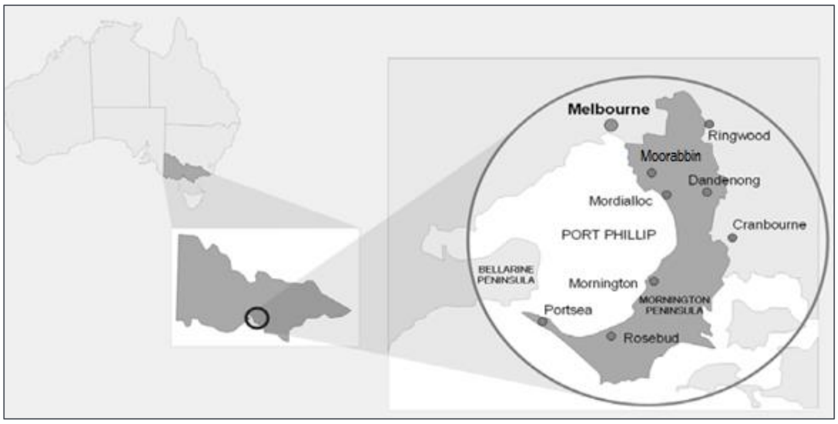


Figure 1 UE Service Area

UE has an electricity licence issued by the Essential Services Commission (ESC). Under the conditions of the licence, UE is required to provide the following functions for stakeholders across the region:

- Distribute the electricity of a retailer to its customers
- Connect a customer's electrical installation to the distribution system
- Connect embedded generating units to the distribution system, and
- Transfer electricity between distribution systems.

UE delivers these services to ensure that the safety, quality, reliability and supply security of the network is maintained in a prudent and operationally efficient manner at least lifecycle cost.

1.1 Asset Portfolio Overview

Assets on the UE network were first installed in Melbourne a hundred years ago, although it wasn't until the late 1930s that network assets were being installed in large numbers and with greater interconnectivity. From the late 1950s the network started growing rapidly, with a large number of new customer connections driven by the economic and population growth in the post-war decades. The capacity of the network continued to grow as air conditioners, computers and other electronic devices drove significant demand growth across the network.

The table below provides a summary of key operating and asset portfolio statistics of UE.

Table 1 Summary Statistics as at December 2017

Network parameter	Statistic
Geographic area	1,472km^2
Number of zone substations	47
Number of distribution substations	13,379
Number of poles	168,842
Overhead distribution lines	4,261 km (high voltage); 5,818 km (low voltage)
Underground distribution cables	1,088 km (high voltage); 1,772 km (low voltage)
Maximum coincident demand	1,858 MW (latest year); 2,084 MW (record year)

UE's primary network assets are distribution lines, cables and substations, approximately 65% of which are under 35 years of age. Projected average remaining asset lives are in excess of 25 years. UE's network is predominantly an overhead, wooden-poled distribution system. The historical operating and asset portfolio statistics are presented below.

Table 2 Historical Distribution Network Statistics

Distribution lines	As at 31 Dec 2017	As at 31 Dec 2016	As at 31 Dec 2015	As at 31 Dec 2014	As at 31 Dec 2013	As at 31 Dec 2012
Total distribution lines (km)	12,939	12,875	12,854	12,823	12,965	12,924
Overhead (km)	10,080	10,041	10,071	10,085	10,280	10,282
Underground (km)	2,859	2,834	2,783	2,738	2,685	2,642
Underground (%)	22.1%	22.0%	21.7%	21.3%	20.7%	20.4%

Table 3 Historical System Demand and Throughput

UE operating statistics	FY2018	FY2017	FY2016	FY2015	FY2014	FY2013	FY2012
Maximum coincident demand (MW)	1,911	1,858	1,963	1,736	2,066	1,982	1,700
Annual energy consumed (GWh)	7,749	7,738	7,825	7,702	7,736	7,977	8,135

The electricity distribution assets owned by UE form the Regulated Asset Base (RAB) which has a value of approximately $2.5 billion.

1.2 Customers

UE's distribution area has a demographically diverse residential population and a broad mix of commerce and industry. Over 90% of our customers are residential and while the demographic profile of our distribution area generally reflects the Victorian average, notable differences compared to other networks include:

- More elderly customers: 17% of our resident population are 65 years of age or older compared to the Victorian average of 14%. This difference may in part be attributed to the attractive retirement lifestyle on the Mornington Peninsula; and
- Greater cultural diversity: 36% of our resident population were born overseas compared to the Victorian average of 28%. The cultural diversity of our distribution area is further highlighted by the 31% of people who speak a language other than English.

In broad terms, the composition and trends in our commercial and industrial customer base are similar to Victoria as a whole. Manufacturing was once the largest employer in our distribution area, but now comprises only 12% of all jobs. In line with trends across Victoria, this reflects a significant reduction in the proportion of manufacturing jobs compared with previous years. Professional, scientific and technical services comprise 9% of all jobs in our distribution area. This is higher than the Victorian average and an increase on previous years. Other significant sources of employment include health care and social assistance as well as retail trade. These two industries represent approximately 12% and 11% of total employment in our area respectively.

Changes over time in the customer profile of our distribution area therefore impact electricity demand on our network.

Table 4 shows that while over 90% of UE's customers are residential, on an energy and revenue basis over 50% of revenue and energy consumption comes from commercial and industrial customers.

Table 4 UE Customer Base

Customer type	By energy volume	By revenue	By number
Residential	36.3%	47.4%	91.0%
Commercial	17.7%	24.5%	8.5%
Industrial	46.0%	28.2%	0.5%

1.3 Corporate Strategy

The new vision for UE and its sister companies CitiPower and Powercor is “We Connect You”. The business is well placed to respond to Australia’s changing energy sector because of its strong track record of delivering balanced and efficient outcomes, the committed and experienced team, and a clear focus on delivering for the customer.

These are upheld by 5 strategic pillars:

Improving stakeholder engagement - Working with communities, government and partners

Optimising regulatory outcomes - Secure the revenue we need to run our business

Driving operational excellence - Be smarter about how we do things

Building a network for the future - Ensure the network remains competitive

Delivering customer outcomes - Make it easy for your customer

Figure 2 Strategic pillars

The strategic pillars are supported by a set of values and behaviours that recognise that how things are done is just as important as what is done. They give focus to how the vision is fulfilled in how customers and stakeholders are connected for a bright future.

Figure 3 Core Values

Live safely - We never compromise health and safety, either at work or at home. We are constantly aware of the risks to ourselves and others and actively manage them.

Improve our business - We drive and lead change to be more efficient and effective for the benefit of our workmates, shareholders and other stakeholders.

Be customer and community minded - We listen to our customer, strive to meet their needs and keep them informed. We make a positive contribution to our communities. We deliver on our promises.

Succeed together - We work together as a team and value the diversity and the contribution of our team members. We always act in a fair and responsible manner and show each other respect. We strive for success as a business while upholding the values that underpin everything we do.

Be the best you can be - We strive for excellence in everything we do and are always accountable for our own performance. We give our best at all times and help our workmates do their best as well.

At the heart of the strategy is people and the business acknowledges that its employees make the difference. UE has a workforce that is committed to 'keeping the lights on' in the communities that it operates in. The staff have a real sense of purpose and this is evident in UE's performance. UE is known for being technically proficient with core competencies in designing, building, operating and maintaining its assets. As customers' needs and market conditions change, UE must continually reassess the capabilities and the culture that is needed to drive the right outcomes. The business understands that the growth and development of its people is critical to its success. UE is committed to supporting all employees to develop their skills, knowledge and expertise and broadening their experience to enable them to be the best they can be. UE values promoting from within and building the capabilities that are needed to achieve its strategy and continue to drive a high performance culture.

2. Asset Management System – Overview and Alignment

2.1 AMS Overview

The key objective of the UE AMS is to maximise value by delivering optimum performance with maximum expenditure efficiency across the combination of CapEx and OpEx. The AMS encompasses a series of interlocking processes that cover most functions across the business and define how the assets are managed over the long, medium and short term.

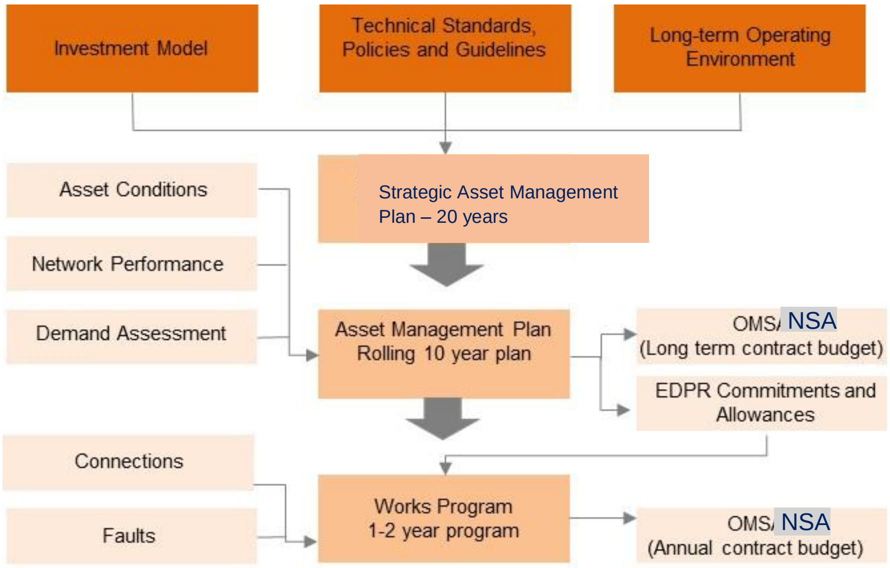


Figure 4 Asset Management System

UE's asset management framework has key asset management processes to manage assets over these distinct time horizons:

- Asset Management Policy, Strategy and Objectives: these provide our approach to prudently manage assets on a whole-of-life basis and define our long term business assumptions. This includes management of external drivers that may influence our asset management approach.
- Asset Management Plan: a rolling ten year plan of the business' priorities, main projects and expenditure as well as the baseline information for the EDPR and NSA. The Asset Management Plan outlines CapEx as well as the associated OpEx over the ten year time horizon.
- Works Program: a one-two year program of work which outlines the specific activities and investments that represent the most cost effective approach for executing the Asset Management Plan.

These asset management strategies and plans seek to optimise the CapEx and OpEx spend within the context of a holistic model that ensures both customer and shareholder outcomes are optimised over the long term.

In addition, there are other business processes, procedures, systems and enablers that complement the AMS, to realise value while optimising cost, opportunity, risk and performance. This includes areas such as information technology, human resources, finance, procurement, facilities and corporate affairs.

This asset management approach integrates planning processes, decision-making and information across UE's assets and activities. It provides a management structure within which stakeholder needs, levels of service, asset information, finance, risk and resources are brought together to enable considered, consistent and high-quality asset management decision-making. These processes enable the delivery of agreed service levels to our customers in the most cost-effective manner and provides proper stewardship of our assets.

Our AMS is a business architecture of key structural elements which are connected through interfaces and processes. These key elements include our people, policies, strategies, plans, business processes, information systems, supporting tools, regulatory environment and commercial environment.

These key elements support the achievement of success criteria for our owners, management, staff, contractors, customers, regulatory bodies and the public. The design brings together the various requirements into a streamlined and efficient management system which drives the realisation of value.

Our AMS structure is in accordance with the high level structure of AS ISO55001.

2.2 AMS Architecture

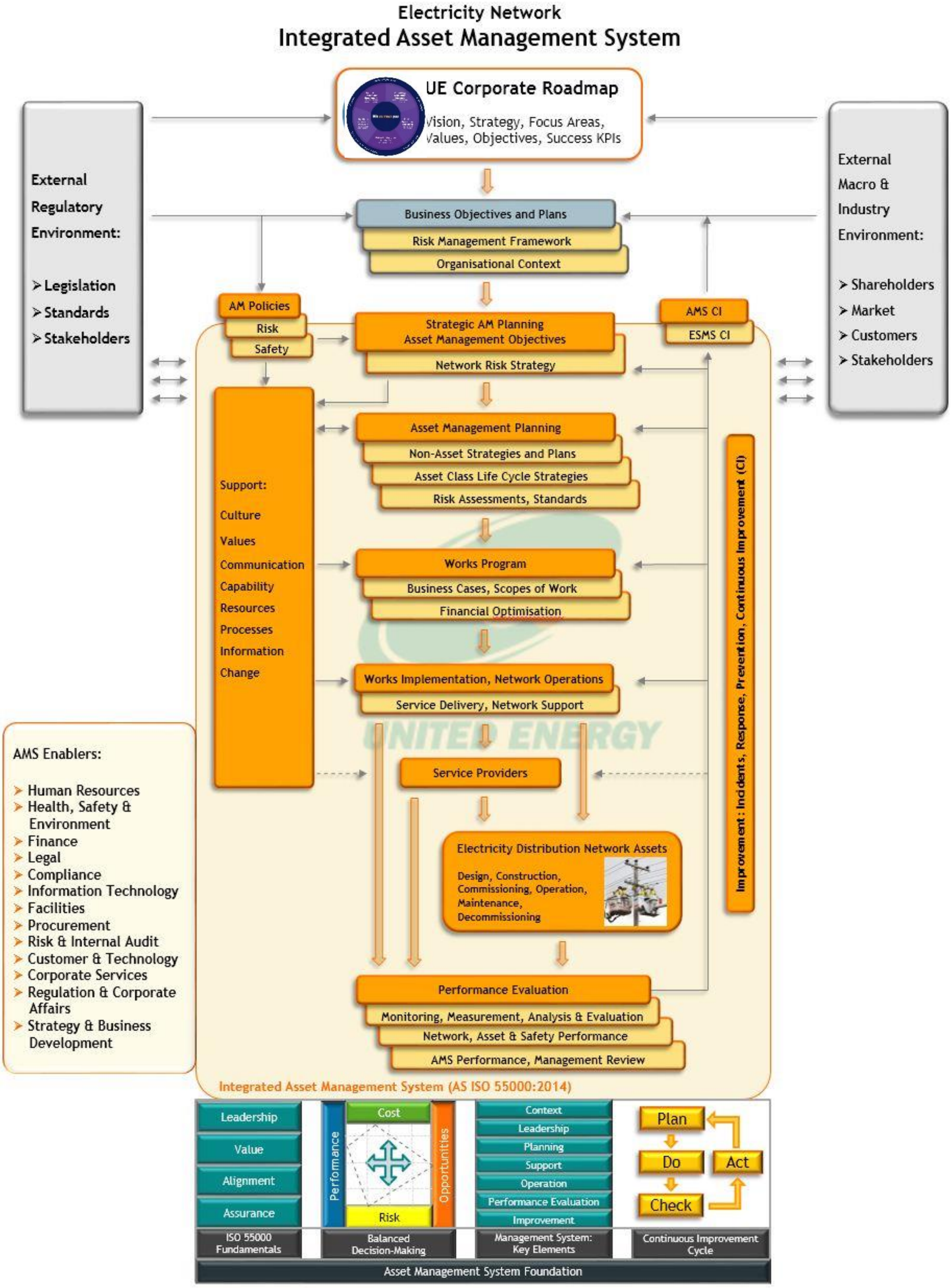


Figure 5 Model of the AMS

The scope of the AMS includes all people, processes, information and assets associated with the design, construction, commissioning, operation, maintenance and decommissioning of the regulated electricity distribution network. This includes lifecycle strategies and plans developed for each asset class which support the high level asset classes covering:

Primary Electrical Assets	Secondary Electrical Assets	Fleet	Metering	Operational Property

Figure 6 Asset Classes

The non-asset class strategies and plans are those which have a strategic impact on the business yet do not fall under an asset classification, rather they are representative of the end-to-end performance of the whole network as a complete system. They typically affect multiple asset classes, to provide network development. The groups for non-asset class strategies and plans include:

Demand	Reliability Performance	Power Quality Performance	Network Asset Safety	Environment	Fire Prevention	Electric Line Clearance	Information and Control Systems

Figure 7 Non-Asset Classes

Our AMS approach translates UE objectives into technical and financial decisions, plans and activities. Alignment of the value chain includes:

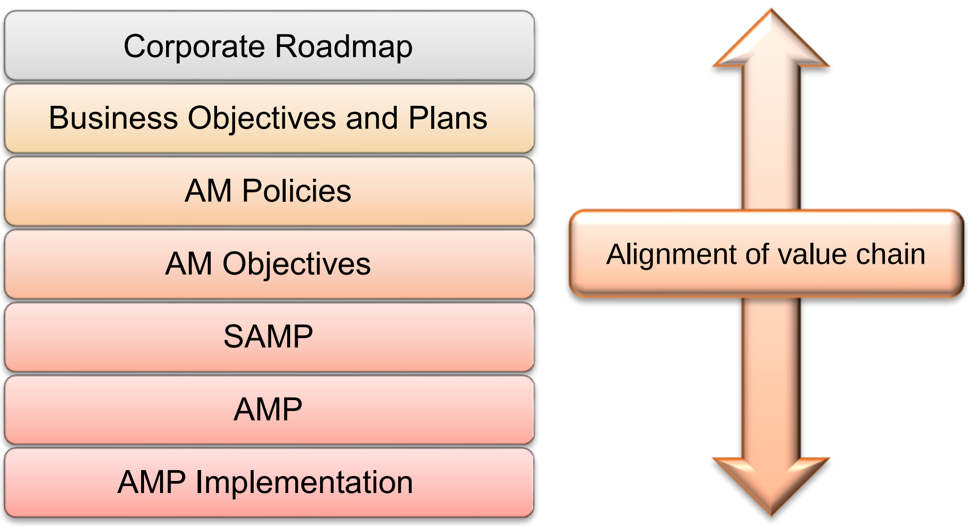


Figure 8 Alignment of Value Chain

2.3 Asset Management Policy and Objectives

The Asset Management Policy sets out asset management activities must meet business objectives and benefit the current and future needs of all customers, stakeholders and employees. UE's AM Policy principles are published in UE PO 2001 Asset Management Policy.

Our asset management objectives generate value from the assets managed in the regulated electricity network portfolio and protect value through effective risk-management. They adhere to the principles outlined in our Asset Management Policy and are aligned with our corporate objectives and allow United Energy to manage its risk in accordance with its corporate risk appetite levels.

United Energy's Asset Management Objectives are published in UE PO 2050 Asset Management Objectives.

2.4 Alignment of AM Policy and AM Objectives with Corporate Strategy

Alignment between Corporate Strategy, AM Policy and AM Objectives is essential for the efficient implementation of Corporate Strategy to achieve corporate objectives and thus meet shareholder and other stakeholder expectations.

Alignment between Corporate Strategy, AM Policy and AM Objectives is demonstrated in Figure 6. The left side of the figure illustrates the alignment of each of the five corporate strategic pillars with individual principles of the AM Policy. The right hand side of the figure illustrates the alignment of each of the six AM Objectives with individual principles of the AM Policy. This alignment demonstrates a clear line of sight between corporate and AM objectives, providing confidence that delivering AM objectives will result in delivery of corporate objectives.

Corporate Strategic Pillars					Asset Management Policy principles	Asset management objectives					
Improve stakeholder engagement	Build a network for the future	Optimise regulatory outcomes	Drive operational excellence	Deliver customer outcomes		Manage and operate the network safely	Meet our network reliability performance targets	Manage our assets on a total life cycle basis at least cost	Manage our compliance obligations	Empower and invest in our employees	Monitor opportunities and drive continuous improvement
			✓	✓	• Minimise safety risks as far as practicable.	✓					
✓				✓	• Enhance our reputation as a trusted service provider through active industry leadership and the delivery of safe and reliable services that meet the needs and expectations of our customers and communities.	✓	✓				
✓			✓	✓	• Focus on maintaining a safe, affordable (least long term cost) and reliable network when devising our plans for the development of our network.	✓	✓	✓			
			✓		• Adopt a risk based approach to managing our network.			✓			
	✓	✓	✓		• Invest in programs that optimise total lifecycle management.			✓			
			✓		• Comply with as a minimum all relevant legislative and regulatory requirements as well as Australian, international and industry standards and any other requirements to which CitiPower and Powercor subscribes.				✓		
	✓		✓		• Develop high performance operations by engaging with our employees and ensuring that they have the right skills and capabilities.					✓	
	✓	✓	✓	✓	• Embrace innovation and technology to continuously improve our asset management framework and activities consistent with recognised asset management standards for the long term benefit of our employees, shareholders, customers and other stakeholders.						✓
✓			✓	✓	• Monitor and evaluate appropriate metrics to effectively manage the network and customer service performance.	✓	✓				✓

Figure 9 Relationships between UE's Corporate Strategic Pillars, AM Policy Principles and AM Objectives

2.5 Integrated Network Management System (INMS)

UE is developing an Integrated Network Management System (INMS) to assist UE to continue to deliver a safe, reliable and affordable supply of electricity. It will also facilitate UE's compliance activities, continual improvement initiatives and ongoing investment in our people.

The INMS enables UE to efficiently meet multiple management system standards. It removes duplication and facilitates both the streamlining of processes and the pursuit of business improvement.

The INMS combines the following management systems into a single Integrated Network Management System:

- Asset Management System (AMS)
- Electricity (Network) Safety Management system (ESMS)
- Occupational Health and Safety Management System (OHSMS)
- Environment Management Framework (EMS)

The scope of the IMS includes areas of the business related to the electricity network (including network data and "operational IT"), but excludes corporate functions such as Finance and Corporate IT.

The scope of the IMS is presented in Figure 11 below.

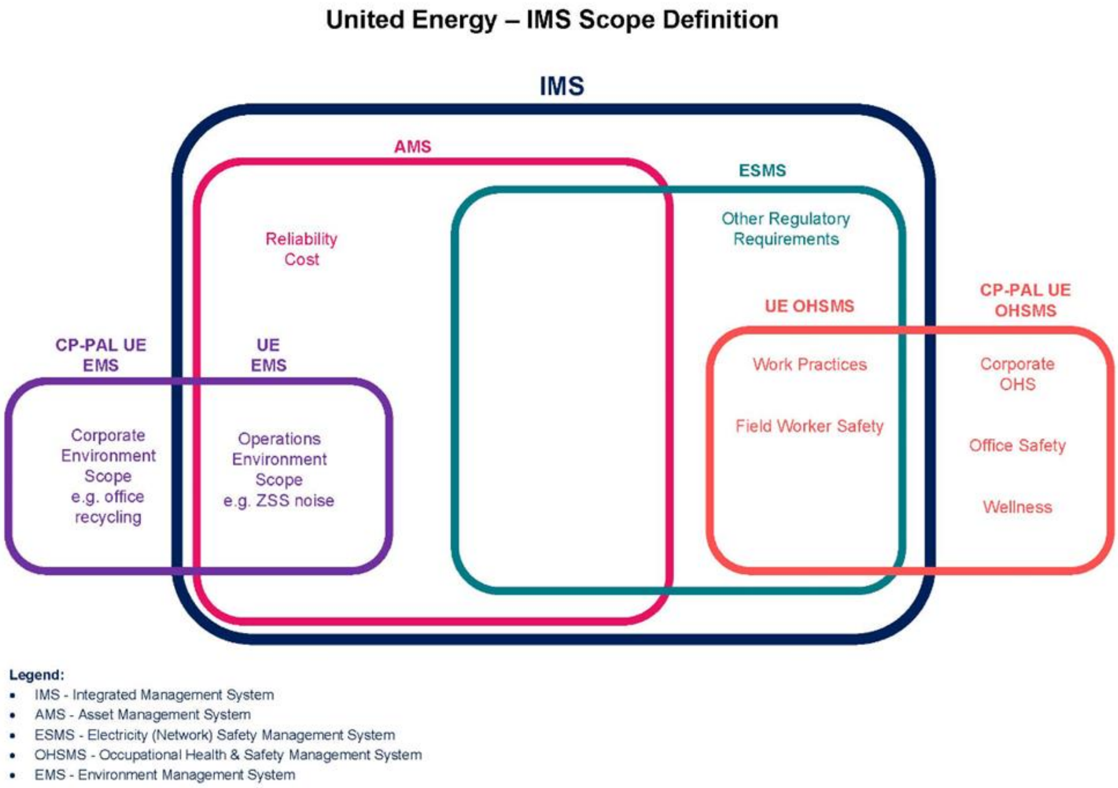


Figure 10 INMS System Scope

2.6 Asset Management Plan

The Asset Management Plan is a rolling ten-year plan that translates the asset strategy and objectives, and asset performance data into a more detailed investment plan. It strikes a balance between efficient and cost-effective investment, the required level of service from the physical assets and an appropriate level of risk to develop a long-term plan for both CapEx and OpEx.

To develop the Asset Management Plan, UE collects and analyses data, determines the necessary modifications to the network that are required, and then produces a capital plan to deliver the network investments with a rolling ten-year view.

When formulating the Asset Management Plan, UE strives to optimise investment across asset replacement, demand and performance CapEx, and OpEx balanced against the following set of requirements:

- **Customer requirements**: analyse customer expectations and current performance in delivering to those requirements
- **Technical requirements**: a range of inputs drive the technical network requirements that need to be adhered to, including:

- **Performance improvement, asset maintenance and replacement programs:** driven by analysis of fault/performance/cost data and based on reliability centred maintenance analysis
- **Safety compliance:** based on UE's ESMS which lays out UE's risk-based approach to managing electrical safety
- **Capacity planning:** based on probabilistic analysis and contingency planning
- **Risk analysis:** performed to ISO31000 for significant asset risks.
- **Economic requirements**: all projects are subject to an appropriate level of economic analysis in accordance with regulatory requirements and prudency investment tests.

2.7 Works Program

The Works Program draws on the Asset Management Plan to develop a more specific one to two year picture. The Works Program details specific planned investments in the network, and is used as an input into project planning (for development of large capital projects), works planning (for development of CapEx and OpEx programs), as well as an input into the annual budgets cycle.

Projects are sequenced in such a way that they are targeted for completion at a time when they will deliver the best outcomes for the business and its customers:

- Programmed asset replacement projects are scheduled to be performed in accordance with replacement policies and as close to, but before, in-service failure, and
- Demand projects are completed to ensure that sufficient network capacity is in place to meet forecast loads immediately prior to the critical summer loading period.

With the investment and asset management plans established, UE must then deliver these plans in the most cost-effective manner. The key elements to achieve this are:

- Competitive tendering for capital work activities,
- Use of approved materials schedules to deliver streamlined purchasing practices, and
- Use of larger longer-term contracts for works involving ongoing programs of a repetitive nature.

UE ensures that its business objectives and asset management requirements are met in the delivery of these plans through the contracts that describe the Service Providers' approach to governance and management to ensure alignment of their service provision with UE's objectives and business requirements.

This is achieved through three mechanisms:

- **Long-term contracts**: UE has a contract (NSA) in place with a service provider: Zinfra. This service provider carries out routine maintenance and small CapEx construction activities under a performance incentive based contract within UE network. The contract is effective from late January 2018 for the next 3 years. It may be extended for 1 year twice after January 2021 at UE's discretion.
- **Projects to tender**: for capital works in addition to the regular contracted work, UE has the ability to access NSA contractor or go to market and ask various parties to tender for the work. This could be either through the existing single service provider, or in some cases new service providers. To help facilitate this process, the Works Program packages up projects to enable benefits to be obtained through tendering significant sized projects. Projects that are suitable to be tendered as turn-key projects are identified at conception stage and a detailed scope of works is prepared as the basis for tender documents.
- **Approved materials schedules**: UE has developed and maintains schedules of materials approved for installation on the network with which all contractors must comply as part of its health, safety and environment systems. This ensures that the integrity of the network assets is maintained and that purchasing and stockholding procedures are stream-lined.

3. Network Performance, Condition, Growth, Expenditure

This chapter describes the current status of UE's network assets along with a description of their recent performance. These elements of a network are an important consideration in the financial aspect of future scenario modelling.

3.1 Network Reliability

Network performance is measured against five reliability indicators, which track the frequency and duration of unplanned and planned outages – these are reported to the ESC and the AER. These metrics are used to determine UE's STPIS for the year that show how service levels have performed. The most important of these measures is SAIDI Unplanned (System Average Interruption Duration Index), which represents the number of minutes per year on average a customer is without electricity due to unplanned network outages. UE's SAIDI Unplanned performance is shown in Figure 13.

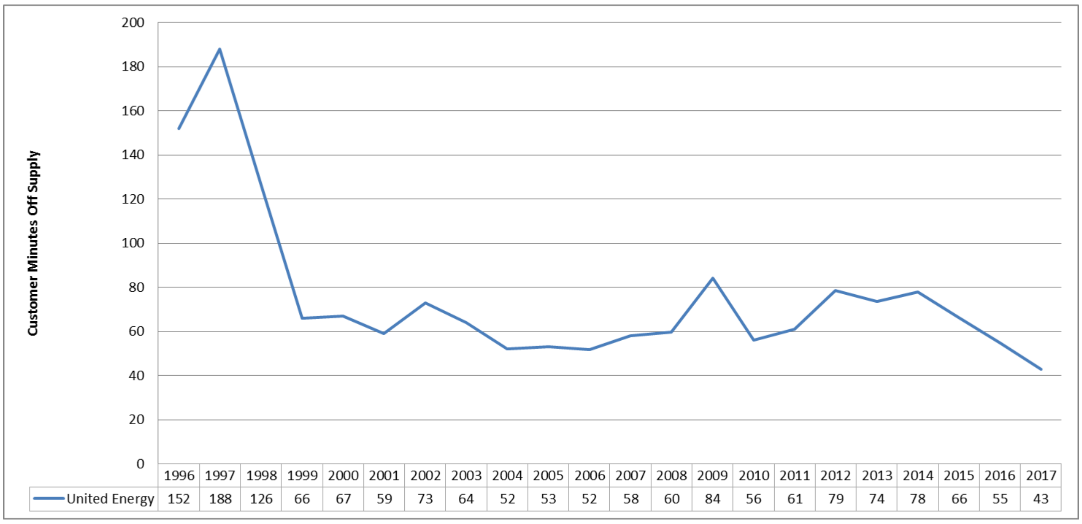


Figure 11 Network Performance (SAIDI Unplanned)

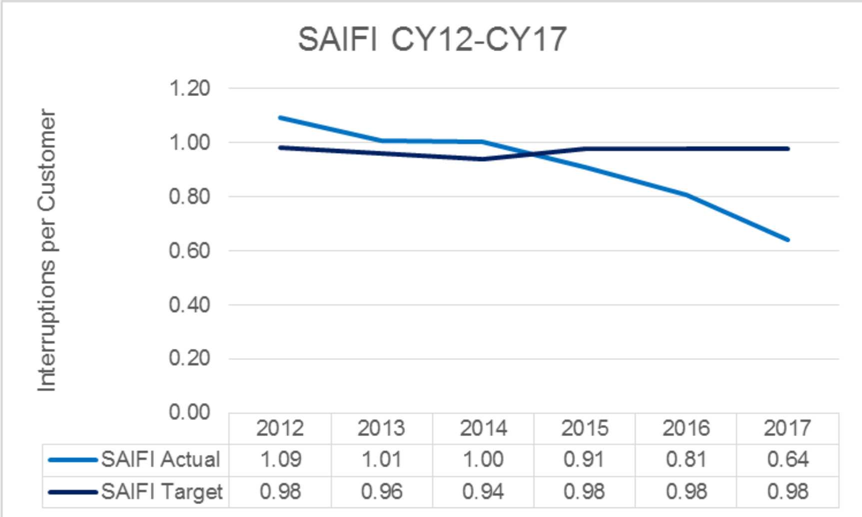
Network performance is driven by a range of factors, including asset failures and external factors such as falling vegetation, third party impacts, as well as interference from animals and birds.

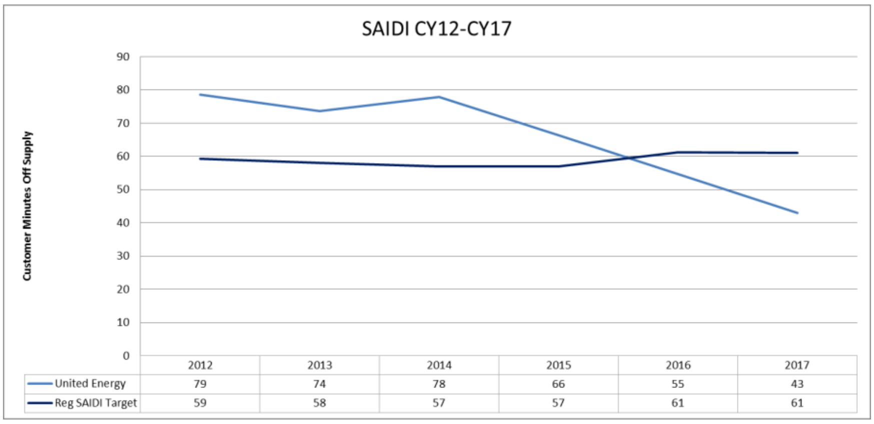
UE's core business is the delivery of an electricity supply with appropriate reliability to our customers. In order to measure UE's effectiveness in achieving this, a number of performance indicators are used. These include:

- SAIDI is the system average interruption duration index and reflects the number of minutes the average customer is without electricity supply during the year.
- SAIFI is the system average interruption frequency index and reflects the number of sustained interruptions that affect the average customer during the year.
- CAIDI is the customer average interruption duration index and reflects the average duration of interruption for customers affected by outages (not all customers are impacted by outages). This reliability performance index indicates the average restoration time for each event and is used as a measure of a utility's response time given adequate levels of redundant capacity to system contingencies.
- MAIFIe is the momentary average interruption frequency index and reflects the number of momentary interruptions the average customer experiences during the year. The small letter "e" stands for "event" where an event consists of one or more momentary interruptions occurring sequentially in response to the same cause that does not result in a sustained loss of supply.

UE’s historical system performance as measured against targets for the last five years is shown below.

Table 5 UE Performance Indicators





UE’s reliability performance targets for the current regulatory period have been set by the Australian Energy Regulatory (AER).[1] These targets are based on the average reliability performance from the preceding regulatory period, adjusted to take into account any reliability improvement initiatives or other factors that have a material impact on the network.

Table 7 below provides UE’s reliability performance targets for the current regulatory period.

[1] The current EDPR period is 2016 to 2020. AER specifies network targets based on both urban and short rural designations for UE. These targets are aggregated based on forecast changes in urban, rural designations over the EDPR period to forecast the reliability targets for the current regulatory period.

Table 6 Reliability Performance Target Levels

	CY16	CY17	CY18	CY19	CY20
SAIFI	0.98	0.98	0.98	0.98	0.98
MAIFI	1.07	1.07	1.07	1.07	1.07
Unplanned SAIDI	67.7	67.7	67.7	67.7	67.7
CAIDI	69	69	69	69	69

3.2 Network Safety

3.2.1 Asset Failures

Over recent years, UE has made a significant capital investment in the network. This investment, supported by improved asset condition assessment, targeted maintenance programs, and milder weather has contributed to the reduction in the number of asset failures, and the number of fire starts.

A significant driver for the reduction of asset failures has been the reduction in pole top failures. This reduction has been driven by increased inspection, vegetation management and cross-arm responses to the high failure numbers in 2013/14. It is noted that abnormal weather conditions pose a risk for pole top fires in any given year and have also been a contributing factor in asset failure numbers.

3.2.2 Fire Starts

The failure of electricity network assets, and contact with the electricity network both have the potential to start a fire. The likelihood and consequence of a fire start is a function of the physical location of the fire source, the surrounding vegetation and the prevailing weather conditions.

The main driver for the reduction in fire starts was the reduction in pole top fires, reduction in LV asset failures and a revision to the vegetation management system in CY15/16.

3.2.3 Incidents Involving the Public

Safety performance, based on the incidents involving the public, has continued to improve. The main reason for the reduction in public incidents was the reduction in shocks due to improved network analytics and reduction in HV injections.

Third party vehicle impact statistics have historically been reported to ESV, but excluded from these statistics on incidents involving the public. Third party impacts have been seen to be declining in line with a general reduction of road accidents in Victoria. UE has implemented a strategy to mitigate the risk of a collision at hazardous sites.

3.2.4 Management of Bushfire Exposure

As UE operates in areas that contain pockets of bushfire risk, UE has a comprehensive bushfire mitigation program borne out of the recommendations put forward following the Royal Commission that was established after the devastating Victorian bushfires of 1983 and 2009. Only 10% of UE's network is located in areas designated as Hazardous Bushfire Risk Areas. Fire risk is a key focus, with vegetation clearance and network maintenance being strictly managed to an approved compliance regime.

The program is approved by the safety regulator, and completed annually prior to the declaration of the fire season. Monthly progress reports are provided to both management, and ESV, leading up to and throughout the fire season. To further reduce the risk of fire starts and bushfire, UE has installed Rapid Earth Fault Current Limiter (REFCL) systems at MTN and DMA zone substations. UE has insurance coverage in respect of liability for bushfire initiation for claims above A$5m per occurrence.

3.3 Asset Condition

The age profile of United Energy's distribution network reflects the large investment that took place in the electricity networks in Victoria with much of the area electrified post-World War. From the late 1950s the network started growing rapidly, with a large number of new customer connections driven by the economic growth in the post-war decades. The present implication is that an increasing number of assets are approaching their end-of-life and require replacement over the current planning period.

This growing proportion of aged assets reflects the uneven historical development of the network, particularly in the 1960s and 1970s. The relationship between asset age and the probability of asset failure varies depending on the asset and failure mode; some equipment types can have a long period of serviceable life with a low failure rate, followed by a period of deterioration leading to increasing failure, while other assets may exhibit a more gradual increase in failure rate. Some assets exhibit a random failure trend throughout their useful life.

The generally accepted principle is that asset failure rates typically increase as assets approach their end of life due to deteriorating condition; the rate of which can vary from asset to asset, and is affected by various factors including operating conditions and the environment. If an increasing proportion of assets are approaching the time where the failure rate starts to increase, the risk of asset failures across the network increases.

Therefore the age profile and deteriorating condition of the network assets will result in more asset failures and pressure to maintain current reliability and network safety levels without unduly increasing investment in end of life replacements. It is expected that more investment will be needed in near real time condition monitoring techniques to better manage these assets to end of life without allowing increases in failure rates to result.

3.4 Network Demand and New Connections

UE's network is designed to facilitate meeting summer maximum demand for the 1-in-10-years hot summer weather condition. The chart below shows both the volatility in actual peak demand due to temperature, with hot summers observed in 2009 and 2014, and mild summers observed in 2012 and 2015, and the forecast growth in peak demand for hot (10%POE), warm (50%POE) and mild (90%POE) summer temperature conditions. Recent hikes in electricity retail prices has resulted in declining demand over the 2013-2017 period. Growth has returned in recent years since the stabilisation of retail electricity prices.

Investment decisions to augment the distribution network to meet forecast maximum demands are based on a least lifecycle-cost technically-acceptable analysis using probabilistic planning techniques. UE, by industry benchmarks, has a very highly utilised and optimised network.

The maturity and cost competitiveness of non-network solutions to defer capital investment in augmentation is improving at a rapid pace. Over the last year, trials in the areas of demand management and solar-storage, and engagement with third-party demand aggregators and generators has led to business-as-usual network support programmes. Our success in this evolving area has led to UE receiving multiple industry awards over recent years, being regarded by the industry as a progressive utility in responding to change and the industry disruptors.

3.5 Network Investment and Benchmarks

United Energy is committed to maximising the long term value of our shareholders' investments through a structured framework for assessing investments to meet business objectives at least long-term lifecycle cost. United Energy recognises that an effective investment framework is necessary to sustain a safe, reliable and compliant network, by embracing the following principles:

- Adopt investment practices in line with good industry practice, compliant with relevant Australian, international and industry standards and all applicable laws;
- Minimise the likelihood of ex-post prudency reviews by ensuring that all network investments are compliant with the National Electricity Rules and all applicable codes and regulations;
- Maintain assets and networks, in a serviceable, safe and environmentally sound condition, contributing positively to business objectives.

United Energy aims to meet these important commitments by conducting the following activities:

- Use effective asset management practices to optimise cash flow and provide the best possible financial return on investment in network assets, recognising funding arrangements and understanding the implications of any deferrals;
- Ensure the best-value long-term decision considers lifecycle costs; regulatory, environmental and safety risks; changing technology and customer requirements; reliability performance and other effects on business goals such as sustainability;
- Evaluate all significant expenditure proposals for shareholder and community benefits, considering all reasonable options including maintain the status quo (do nothing), deferral of expenditure, timing scenarios and sensitivity testing to ensure decisions present the most efficient long- term outcomes;
- Maintain and deliver to forecast by tracking cost and schedule performance of projects and programs to manage variations and minimise their impact, whilst being nimble enough to accommodate the unforeseen.

Network CapEx investment covers all of the activities required to construct, replace, augment, extend, or modify the UE distribution network and associated assets. CapEx is broken up into five categories:

- **Connections CapEx**: covers all new connections to residential premises, most new connections to commercial and industrial premises, and any other modification work requested by customers. Capital growth is based on the number of customer initiated connections. This is strongly correlated (over both the short and long term) with new building construction figures - commercial, industrial and residential.
- **Augmentation CapEx**: covers investment driven by demand and network performance. Demand capital investment expands the network's capacity to deliver electricity. Demand capital is driven by the level of 'peak' electricity use across the network and it reflects the maximum rate of consumption at any point in time. Maximum demand growth rose quite steeply up until 2013 driven by consumer and office consumption behaviours and is expected to continue to grow over the long-term, albeit at a slower rate. While the investment is of a 'lumpy' nature, it is dominated by a small number of large value projects.
- **Replacement CapEx**: the replacement of assets (aged or faulty) in the UE network where it is economic to do so. Replacement capital is driven by the condition of assets and performance of the network. A network that is declining in condition naturally needs more investment to maintain, while regulatory requirements (e.g. bushfire mitigation or health and safety) drive other necessary investments to maintain the network in compliance with safety standards. Replacement CapEx has grown in recent years for UE predominantly associated with increasing volumes of assets reaching the end of their lives. This reflects the expansion of Melbourne during the 1960s and 70s when areas like Doncaster and Box Hill underwent major development. These assets are now reaching end-of-life and will be scheduled for replacement over the coming years.

- **Non-network CapEx**: all non-network assets owned by UE related to the operation of the network. This includes the telecommunications network that sits atop the network, as well as depots, property and major equipment such as fleet. It excludes IT and Advanced Metering Infrastructure (AMI).

Each capital category is driven by a range of factors and expenditure forecasts are been developed by UE after detailed and rigorous analysis of a range of both internal and external data sources. Internal inputs come from various asset information systems, including data collected by the field services teams from their asset inspections (both visual and measured). External data sources include economic growth, regulatory changes, planning information and technical developments.

UE categorises this asset maintenance as operating and maintenance costs, which includes the following primary activities:

- **Maintenance & Asset Inspection**: UE maintains many of its assets to extend the safe operational life of any given asset through both periodic and condition based maintenance on all of its assets. UE has obligations to routinely test and inspect the condition of assets across the network. UE inspects its assets in cycles, including visual and measured inspections of all UE poles and the measured assessments of the zone substations. The data from these inspections is then fed into UE's asset inspection data systems. Variations between years can be predominantly attributed to the cyclic nature of maintenance.
- **Vegetation Management**: UE has regulatory obligations to maintain regulated clearance around its overhead network through vegetation management. These obligations have recently changed as a result of the Victorian Bushfire Royal Commission's finding from its investigation into the Black Saturday bushfires of 2009. The resulting changes have increased UE's compliance costs, due to additional tree clearing and the removal of exemptions that were in place for a transition period. UE continues to monitor its compliance to the vegetation code and is likely to see vegetation costs fall once full compliance is achieved.
- **Fault Response**: UE maintains teams of responders ready to repair network faults. This includes faults right across the network, from the zone substations through to the customer premises.
- **Public Lighting**: UE maintains public lighting assets within its network including the replacement of public lighting lamps.
- **Alternative Control Services**: UE undertakes, at the direction of customers and retailers, a number of services, including new connections, disconnections/re-connections and truck visits.

3.5.1 Benchmarks

The 2017 AER Annual Benchmarking Report for electricity DNSPs is used to review UE's efficiency and productivity. These independent benchmarks demonstrate UE's favourable position in the top quartile according to a variety of measures.

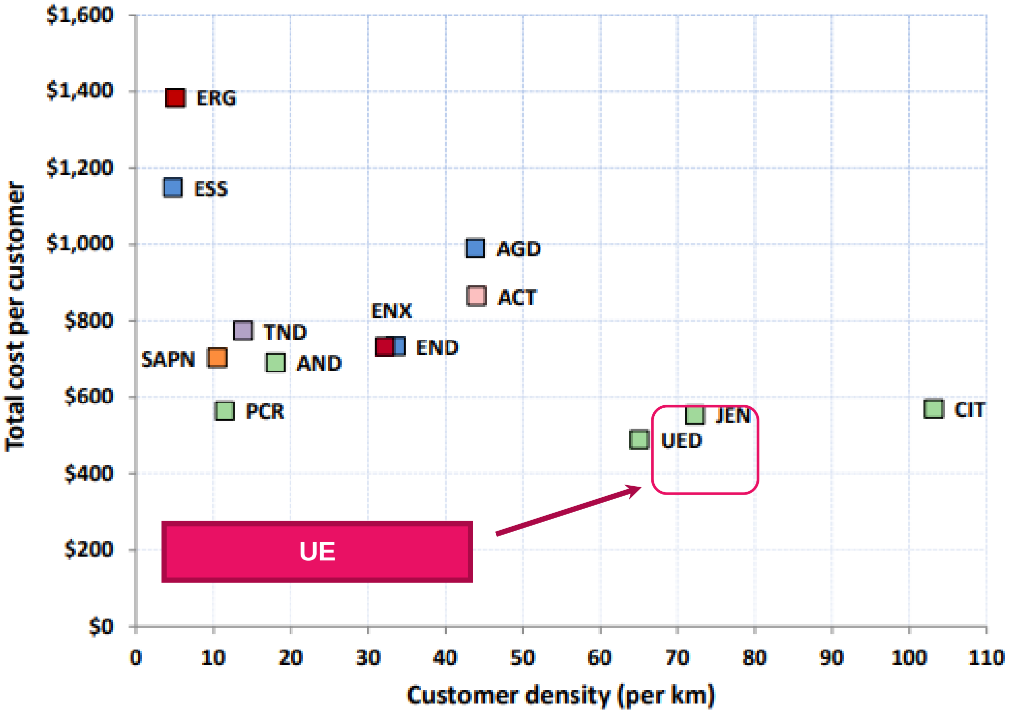


Figure 12 Total Cost per Customer against Customer Density (Average 2012-16)

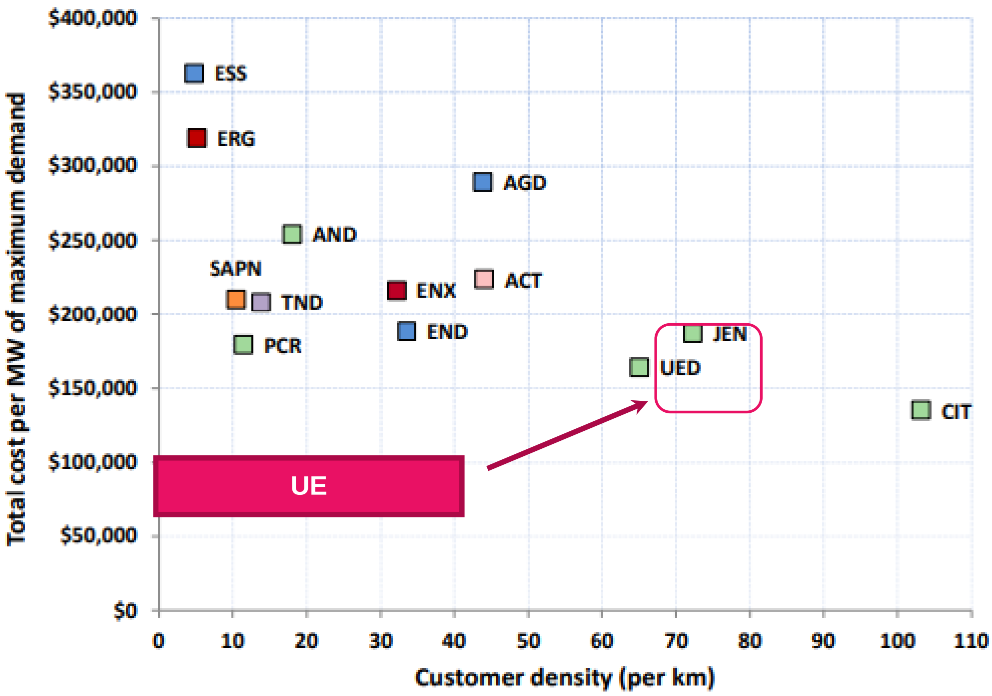


Figure 13 Total Cost per MW of Maximum Demand against Customer Density (Average 2012-16)

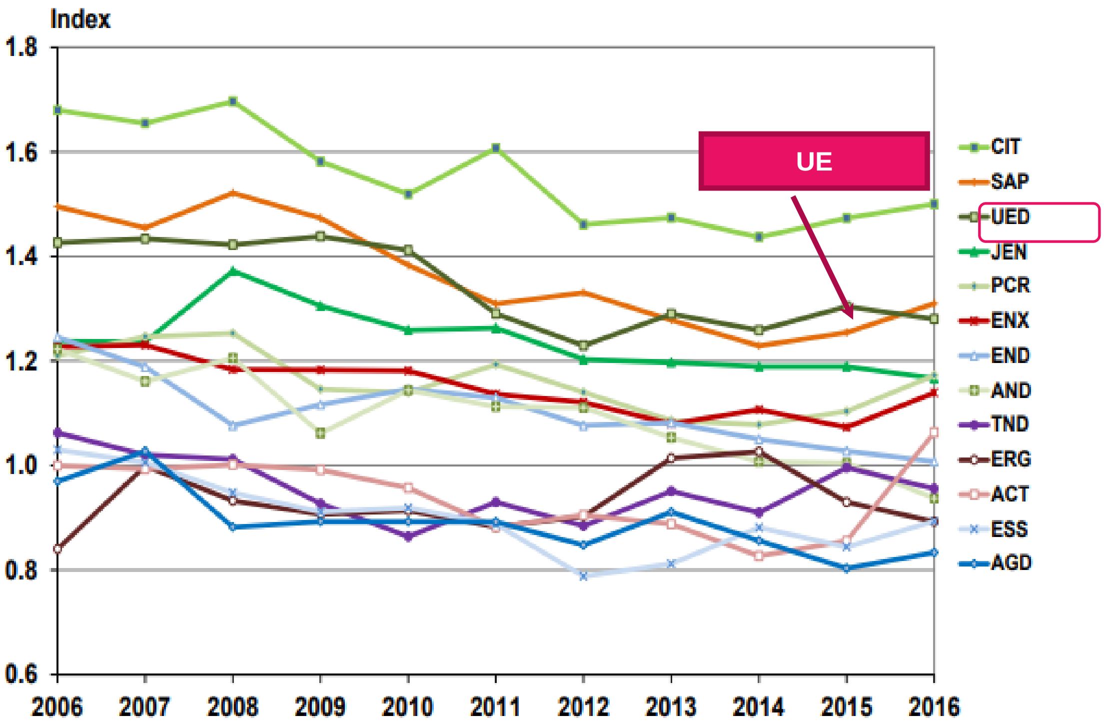


Figure 14 Multilateral Total Factor Productivity by DNSP for 2006-16;

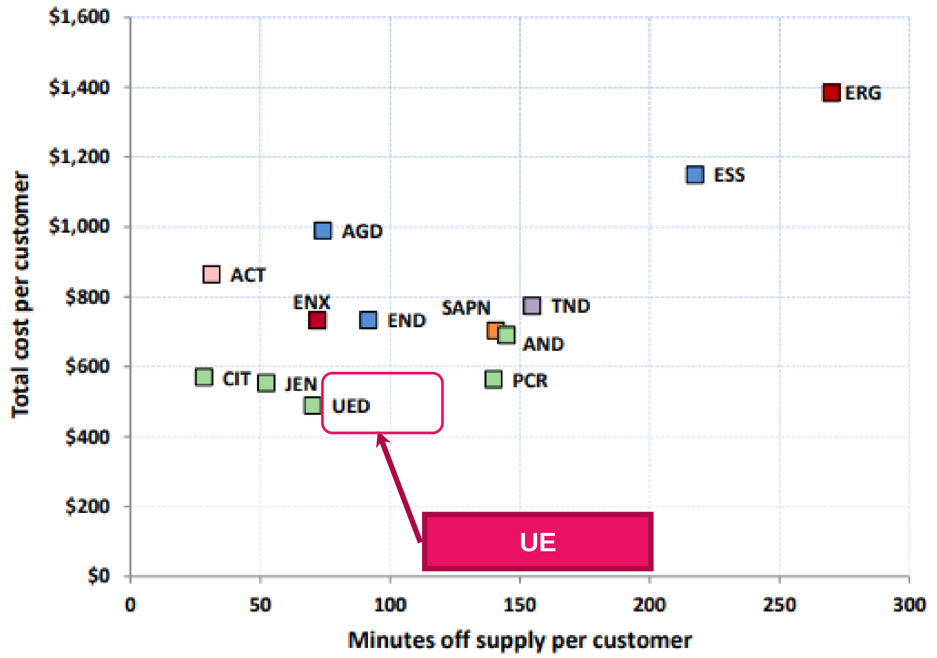


Figure 15 Total Cost per Customer against SAIDI (Unplanned) (Average 2012-16)

4. Strategic Challenges and Opportunities

UE finds itself at the cusp of a changing energy landscape. From management of the electricity network, to the disruptive impacts of solar and storage technology and the future prevalence of new energy platform, the wider industry expects changes to the traditional connection to and usage of the electricity network as we know it today. As a consequence of this occurring change, embedded generation and demand management are being used now more than ever as solutions to manage energy needs, thereby reducing the burden of costs on the consumers. This scenario is a very much a slow burn that is waiting for innovation and affordable technology to accelerate the transition. Electricity industry adaptation is needed to meet these growing challenges.

UE's challenge as a regulated distribution network service provider is to adopt an approach that is measured yet not risk averse, so as not to fall into the trap of overreaction, complacency or irrelevance as the future arrives. In saying that it isn't just UE that understands this future state. Distribution businesses across the country including state and federal agencies are addressing this impending dilemma to some extent through a series of reforms and initiatives. These steps are meant to ease the transition of the businesses into the new age but also afford consumers the opportunity to be more in control of the energy they use and produce, now more than ever.

4.1 Customer and Technology

The forces of disruption are affecting industries everywhere and while technology might be the common enabler, the customer is the root cause. Driven by a lack of customer-centred options, pricing, models and service, customers are causing upheavals in industries that have long been used to the comfort of and their dominance in the traditional business models by choosing new alternatives. It is therefore imperative to understand the customer and the influences that drive their choices and how the customer might transform in the future.

4.1.1 Customer Behaviour

Traditionally customers have perceived electricity to be a basic utility that should be constant and of high quality. Customers were not engaged with the industry and were mainly passive end users.

The digital age has created a new energy consumer who can access a myriad of information online including their own energy usage, energy bills, and pricing information from their own and competitor's retailers. All this leads to a consumer who is engaged in actively seeking out energy services that meet their needs. Now more than ever, customers are aware of electricity prices, including price variance with time and season, and increasingly customers are becoming active in managing their energy use and bills. Customers are aware of energy related issues and are willing to alter their energy usage in response to price and/or incentive schemes such as demand response at peak times. As such the new energy consumer's expectations of their distribution network is one of an engaged utility with seamless customer experience, clear and easy-to-understand pricing information that is relevant to the individual consumer and effortless transactions. This is on top of existing expectations of consistent and reliable power supply.

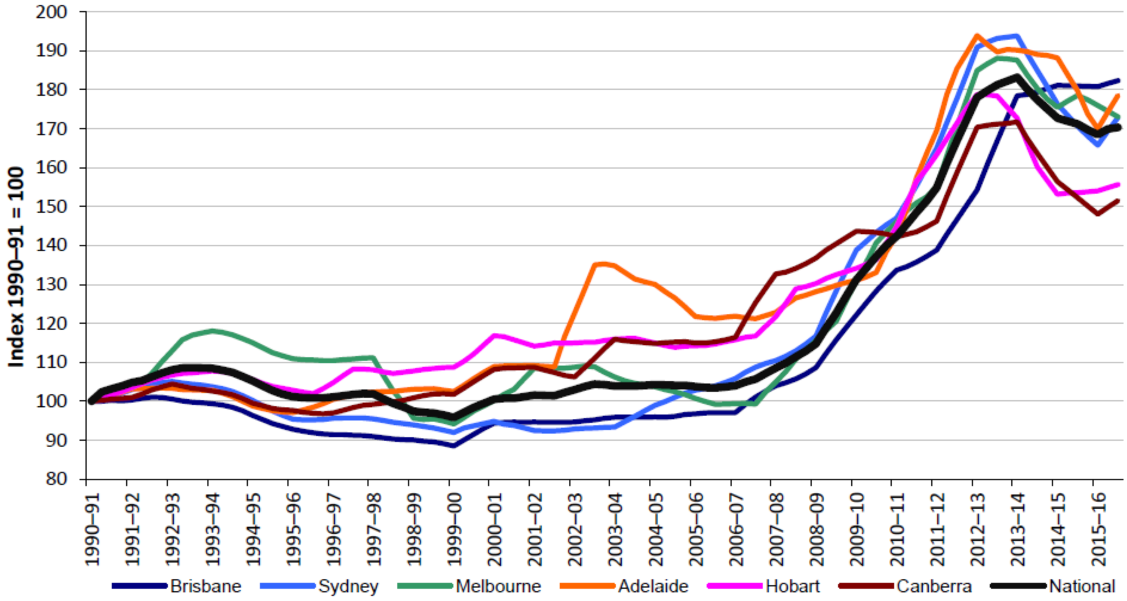
Renewable energy technology is another factor that has altered customer expectations and is driven by Government subsidies and incentives. Roof top solar technology has created the "prosumer" that can generate and also supply power to the grid. This reverse flow of electricity has created issues for distribution networks that were not designed to handle large quantities of distributed energy on the LV network. However the customer expectation is that networks should adapt to enable this change. This leads the way to micro-grids and local area networks that can trade energy between themselves. These disruptive forces are driven by customer's desire to reduce the cost of their energy by controlling their energy sources and use, and be able to trade surplus energy between themselves.

Smart appliances have given customers one more level of control – the ability to remotely control household appliances. Customers now have the ability to cool their homes on hot days before they arrive home or run their washing machine while they're at work. Managed appliances and home energy management systems will become the norm in households of the future and this will alter the residential demand curve that utilities have experienced historically. Residential and commercial customer demand response will become a tool actively used by the system operator to manage peak demand.

This will present opportunities and challenges for UE in the future.

4.1.2 Increasing Electricity Price

Retail electricity prices have increased substantially in all states and territories across Australia over the past decade as the chart below illustrates.



Note: Consumer price index electricity series, deflated by the consumer price index for all groups.

Source: ABS, Consumer Price Index 6401.0, Australia.

Figure 16 Retail electricity price

In the past, energy consumers had no practical alternative but to obtain all of their electrical energy needs from the network, thus the networks were a regulated monopoly with very predictable revenue. However when the sun is shining it is now possible for consumers to generate their own energy using solar PV at lower cost than energy obtained from the network and if the cost of battery storage continues on its downward trajectory it will soon be economic for consumers to store that energy for periods when the sun is not shining, particularly for the residential sector where retail tariffs are the highest.

Thus increasing retail prices coupled with new technologies and targets to reduce greenhouse gas emissions are expected to be the major drivers for change. Network charges are a major component of a retail bill. Operating networks as efficiently as possible while enabling customer technology is crucial to keep the networks competitive against external disruptive technologies.

4.1.3 Customer Driven Technology

A number of potentially significant developments are occurring in the way customers use their electricity. These so-called industry disruptors currently include:

- **Solar PV:** Increased use of distributed embedded generation stimulated through reduced technology cost, subsidies and increased environmental awareness is already being experienced with solar photovoltaic panels being increasingly installed at households and businesses across the UE network since 2009. This is likely to continue to rise into the future as well as the possible emergence of new distributed generation technologies.
- **Electric vehicles:** Plug-in electric vehicles are now commercially available in Australia. While sales volumes are still much less than 1% of total vehicle sales because of the cost and limited range of vehicles, prices are expected to fall as scale of production and competition increase concurrently with falls in battery storage costs.

- **Storage**: Distributed storage applications are also gaining traction with a number of vendors selling products on the market. The Tesla Powerwall is a step change in technological innovation at lower prices to previous offerings. Recent substantial falls in battery prices with increased capacity has put storage one step closer to being viable for householders. Prices are expected to continue to fall for the next several years. Already we are seeing economically viable opportunities for storage on parts of our network.
- **Energy efficiency:** Recent electricity price increases, higher building efficiency standards, government incentives and a greater sensitivity of the community to greenhouse gas emissions has led to customers reducing their overall energy consumption over recent years. Installation of high efficiency air-conditioning, home insulation, standby appliance switches, compact fluorescent and LED lighting are all examples of how customers have achieved greater energy efficiency.
- **Smart appliances and Energy Management Systems:** smart appliances that can be remotely managed are becoming more common in Australian households. Currently several models of popular air conditioner brands have the ability to be managed by the customer or the utility in response to price and/or peak demand signals. In the future the customer, both residential and commercial will have the ability to manage more, if not all of their electric appliances via the internet and thereby shift their load to suit their preferences. In turn, Energy Management Systems for residential and commercial customers are becoming more popular as customers seek the convenience of a “set and forget” lifestyle where there energy usage is managed by a system according to their pre-set preferences.

The combination of rooftop solar generation, household storage units and energy efficient appliances presents a profound challenge to the industry as customers take charge of their power generation and usage. The traditional utility model of bulk centralised generation and transmission will be disrupted in favour of a distributed model. UE must consider and prepare for the impacts that this disruption of potentially lower energy throughput will have on their distribution network.

Electric vehicles pose a different challenge as their increased take up will increase demand on the network when charging. The challenge lies in managing the charging process to avoid simultaneous charging causing peak demands. The network must be prepared to facilitate super charging at residential and public sites.

With signs of the electricity industry already moving towards a more distributed and renewable generation model, the ENA led the development of the Electricity Networks Transformation Roadmap (ENTR) as a joint venture initiative with the CSIRO. The ENTR outlines a set of milestones to be achieved over a 10-year period from 2017-2027 that will enable electricity network businesses to operate within a marketplace experiencing change from new and emerging technologies, business models, government policies and consumer wants and behaviours. The milestones and their associated activities have a broad focus across the wider spectrum of the industry for an electricity system with substantially more distributed energy resources and renewable generation. The major areas of focus are:

- Future structures of tariffs and tariff reform and the impact of new technology;
- Emergence of Distributed System Operators (DSO), home platforms, electric vehicles, micro-grids, and packaged energy services;
- Future system architecture and integrity to cater for this emerging technology;
- Policy and regulation to enable competition and consumer services choices and protection; and
- Ongoing impact of customers’ behaviour to the choice.

4.1.4 Decentralised Energy

The era of the traditional centralised electricity generation model is fading. The traditional model of large clusters of power generation plants supplying large load centres in cities via long transmission networks may not be suited to match the needs of the future customer and their expectations of the network.

As penetrations of distributed energy resources (DER) rapidly increase in the distribution network, the model changes to one of a decentralised network where small generation sources are located near or at the load site. Mircrogrids offer customers autonomy and self-sufficiency as an alternative or back-up to grid connection.

The traditional network approach will become outdated and new network options become available such as microgrids where communities can become self-sufficient. As customers become more self-sufficient and less grid reliant, their expectations and value of network connection change accordingly. As increasing numbers of prosumers trade electricity on the distribution network the value chain and tariff pricing of electricity supply in this non-traditional model will be disrupted.

4.2 Population and Urbanisation

Melbourne's rapidly increasing population is driving a change in the urban landscape of UE's network. The future will see more high density, high-rise housing built throughout UE's metropolitan network. This type of urban landscape requires undergrounding of network infrastructure that is not typical of UE's current network and will need to be carefully planned for. UE's network currently is largely above ground in open spaces and this will be difficult to sustain in highly populated and densely built-up areas.

UE has maintained real estate where it expects to see future demand growth where future large-scale assets can be built. Currently the footprint of network infrastructure has not needed to be minimised in an environment where load growth has occurred in forecast geographical areas where UE holds real estate. Significant growth in population and demand could require additional network infrastructure in geographical locations that UE does not hold real estate or where it is difficult to acquire real estate. Network planners and designers will need to rethink the spacing and be flexible about locations of future networks.

4.3 Government Energy Policy

Government has become serious about tackling climate change through energy policy since one third of Australia's greenhouse gas emissions are related to electricity generation. The Large Scale Renewable Energy Target encourages investment in new large-scale renewable energy and aims to have 33 GWh of additional renewable electricity by 2020. Additionally the Small Scale Renewable Energy Scheme encourages renewable energy systems on a smaller scale to suit households and small businesses in the form of rooftop solar and solar water heaters. As of May 2017, total renewable energy generation capacity was just over 50% of the RET at 17,500GWh, according to the Clean Energy Council.

There are further incentives and rebates all aimed at encouraging customers to take up small scale solar systems, particularly the Victorian Government's Solar Homes rebate programme. These incentives and subsidies along with the decreasing cost of solar PV will continue the rapid uptake of rooftop solar PV. Packaged with storage systems the future distribution network looks certain to contain large quantities of small-scale distributed energy resources. This will have considerable consequences to UE as the traditional distribution network was not designed with a view to enable such large quantities of DER or bi-directional power flows. UE will need to be prepared to enable and manage such a high proliferation of DERs within its network along with finding strategies to proactively manage the resulting network issues.

4.4 Extreme Weather

It would be imprudent for UE not to consider changes in weather and government climate change policy in its preparedness for emergency management of a broad variety of events. Extreme weather and various climate change policy responses are likely to impact how UE's network will evolve over the foreseeable future and affect the costs of providing electricity distribution services.

It is readily apparent that any changes in climate will impact across a wide range of business activities. These are expected to arise from:

- Redistributed and varying rainfall;
- Increased temperatures;
- Increasing incidence of extreme weather events (e.g. Heatwaves, wind-storms, rain-storms, thunderstorms);
- Increased bushfire risks;
- "Greening" of the electricity grid.

The performance of electricity distribution networks can be shown to have a significant dependence on weather, with the effects of wind on overhead lines being the most important. Network equipment failures can also increase during hot weather due to a combination of high ambient temperatures that may stress equipment, and increased temperature dependent loading such as refrigeration and air conditioning. The effect of climate on the operational performance and costs of managing and responding to weather related network outages could increase in the 'future state'. Increasing high wind events can increase network outages resulting from the potential for damage to network assets. Resulting power failures may increase potential claims against UE and STPIS penalties. An increase in the impact of network assets by high winds may also cause a consequential increase in the frequency of damage to third parties, e.g. collapse of poles causing third party damage/injury. The potential for increased liability claims may result in increased control of such risks.

Higher ambient temperatures will affect the accuracy and reliability of electronics in relays, smart meters, ACRs, RCGS thus reducing the data used in analytics and consequently the effectiveness and accuracy of applications like FLISR.

Asset life is dependent upon a complex interaction of factors including materials, design, usage and the operating environment. The effect of changing climate on the life expectancy of distribution assets considers how projected incremental changes in climate variables are likely to influence the rate of deterioration for dominant equipment failure modes that typically define asset life.

All of these climate-related issues will have an impact on the way we run our business as our costs could increase as we strive to maintain network performance, asset life, design standards, network capacity and network resilience under unpredictable weather patterns.

4.5 **Ageing Assets**

The age profile of UE assets is not uniform, with the boom in construction that occurred in the 1960s (and subsequent reduction in asset investment since) means that an increasing proportion of network assets are passing their design life, and entering the 'wear-out' phase of their life cycle. This ratio is expected to significantly increase over the next ten years. Assets operating in this part of their life cycle are increasingly efficient from a life-cycle perspective (as they are continuing to generate business benefit for each year beyond their design life relative to the initial capital outlay), but conversely some assets may have increased likelihood of defects and failures occurring. UE will need to update its asset management and risk management approaches to manage the expected increase in asset failures and defects for affected asset classes.

The potential for a "bow-wave" of replacements in the future (due to stated end of life related failures) should be considered in the context of UE's ability to avoid the risk profile breaching what it deems are acceptable levels. When considering a strategic response, a plan for smoothing out any potential bow-waves (e.g. deferrals and bring-forwards) should be drafted following a robust risk and economic assessment.

The resulting need for asset replacement (or decommissioning if demand slows) presents a challenge for the business. Traditional network assets have a design life of about 30 years however with uncertain demand it is difficult to justify such a capital intensive long term investment. Decommissioned assets must be removed or regularly inspected to ensure they are safe, both of which incur costs.

Any intervention programmes to address the above challenges should be properly assessed to ensure that overall risk is not increased on network as a result of their implementation.

4.6 The Digital Age

4.6.1 Big Data and the Internet of Things (IoT)

The IoT, which is the connectivity of any device through the internet, is forecast to result in an increasing volume of intelligent devices that generate previously unimagined volumes of data. As more network assets become intelligent devices, the data available will provide extensive opportunities to improve network management and operation. The phenomena is also known as “big data”.

The diagram below is an order of magnitude representation of the volume of information that will be available for a network like UE’s. The diagram illustrates that the AMI smart meter roll out is likely only a very small contributor to data volumes. The capture, processing and perhaps storage of data associated with sensors and monitors in the distribution network of the future may be many orders of measure greater.

From the large amount of data available, a key issue will be efficiently assessing which data has the potential to deliver real benefits in network management and operation.

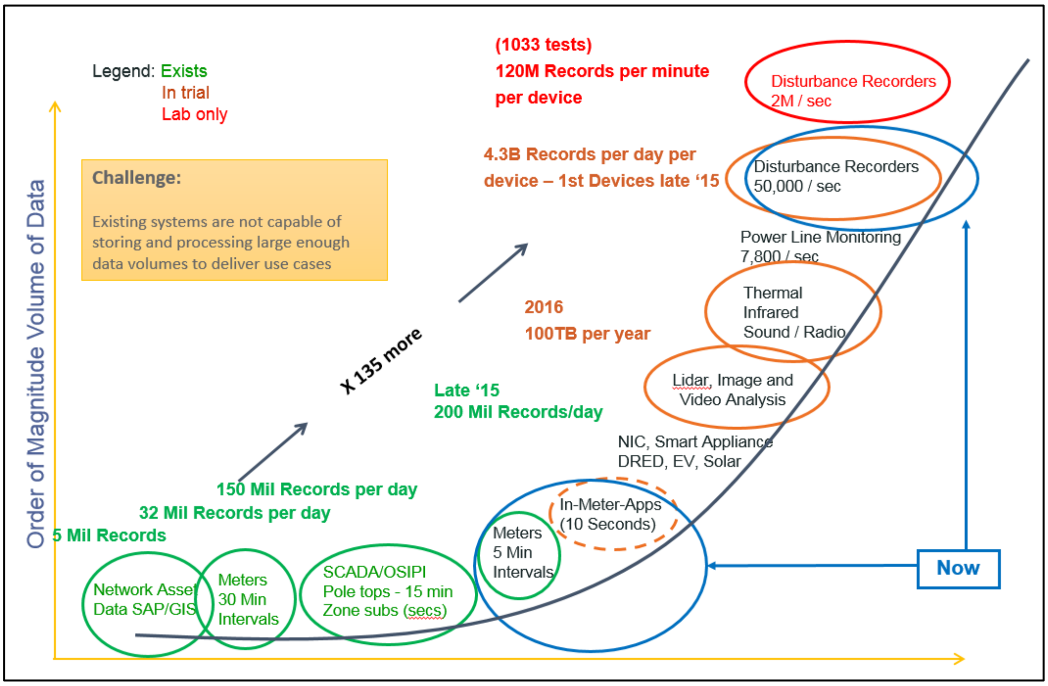


Figure 17 Big Data Availability

4.6.2 Information Management, Security and Access

Suitable underlying infrastructure will be needed to extract value from these vast amounts of data. The communications network must be able handle the quantity of data as it becomes available. Data governance is important as data must be verified for accuracy and completeness before being stored in a system that allows access rights to the appropriate teams. UE’s current systems have duplicated, unauthenticated information and this will need to be addressed in order to make the most of the growing available information.

The influx of data brings a multitude of opportunities, and it is reasonable to expect that third parties will seek regulatory permission to access this anonymised data. Third parties have the potential to provide superior network analytics services developed in conjunction with data from other utilities, local and international. Third parties may also seek to use the data to develop products and services for customers to either create savings or enhance the customer experience through advanced consumption data and personalised information. Information systems will need to manage the privacy obligations related to customer data.

As connectivity and data sources multiply, and third party access is added, so do the avenues for cyber-attacks. Cyber security will become critical to ensure business, network and customer data is protected, and to prevent external sources from gaining access to business systems and control of UE network devices. Cyber risk has been increasing and this is likely to continue, increasing the importance of cyber security.

4.6.3 Analysis, Analytics and Artificial Intelligence

As this "big data" environment evolves and large volumes of data become available, it becomes impossible for human control. Thus, there will be an emerging need for predictive analysis and actions and real-time decision-making.

There are multiple big data maturity, information maturity and utility analytics diagrams that can be sourced via vendor web sites. The diagram below has been assembled to consolidate key themes that are relevant to the UE distribution business.

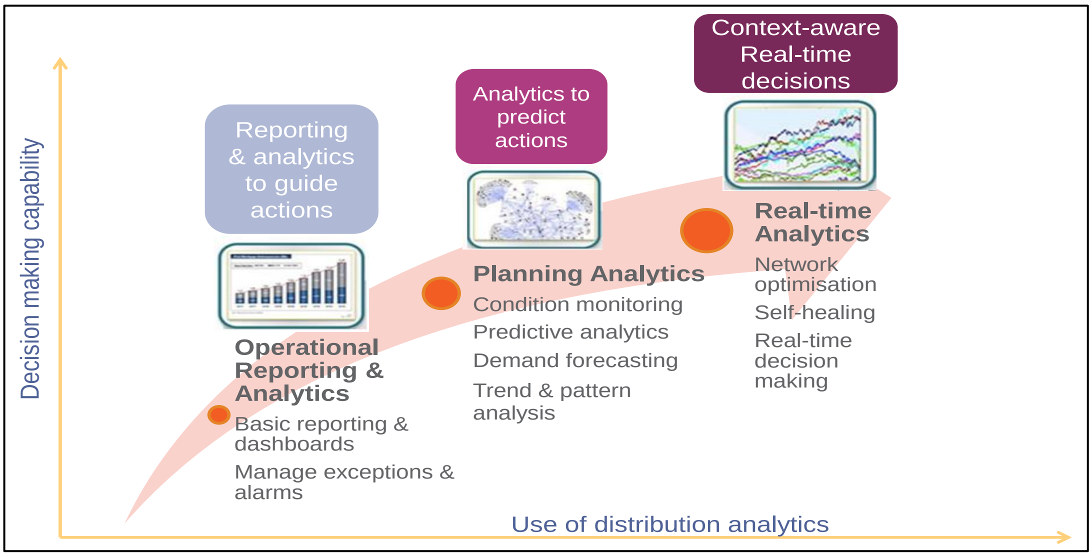


Figure 18 Distribution analytics requirements

Distribution analytics includes all requirements spanning operational reporting and analytics through planning analysis through to real-time analytics. All of these layers combine to provide the analysis services required to support and operate the distribution network in the future.

The iterative nature implied in the diagrams above will be required for UE and will be most relevant since the ability to move through the maturity layers will be a combined dependency on:

- plant and equipment installed on the network;
- application features, functionality and integration;
- information capture and load;
- communications and infrastructure capability; and
- the proven feasibility of the network capability.

Artificial intelligence, or machine learning and 'deep learning' algorithms are set to make the smart grid smarter. By continuously collecting and synthesising vast amounts of data from millions of smart sensors on the grid, it has the potential to make decisions on how to best optimise network operation in a range of applications

4.6.4 Digital Network

At the core of energy industry disruption is transformation away from the traditional centralised load management approach towards a decentralised and flexible grid model that embraces digital technologies, DERs and microgrids and manages these networks in real-time using remote technology solutions.

A digital network will need to provide access to suppliers and consumers of electricity, and provide market services that maintain reliability, quality, safe and secure energy flows. Key to this is to provide access to real time granular data for consumers and energy providers to assist with efficient investment, delivery or consumption of energy. The digital network ideally enables smart decisions on asset investment to optimise asset utilisation and performance.

The Distribution System Operator (DSO) concept is the cornerstone of a digital network, providing visibility of DERs and allowing their inclusion in forecasting and network planning. The DSO platform facilitates setting of network constraints so DERs do not cause networks to operate outside their ratings. DSO platforms will underpin distributed energy markets, which are already being developed to allow DERs to efficiently participate in wholesale market dispatch and provide network and systems services such as frequency control. Distributed energy markets will likely by operated by third parties.

4.7 Workforce

Emerging technologies driving change in the electricity sector are already shifting the profile and skill requirements in the workforce.

Key occupations within the ‘digitally enabled workforce’ have skill sets which will be essential to develop, maintain and complement emerging digitalised technologies which are entering the electricity industry. The skill sets of this workforce will be synonymous with the era of digitalisation and will be in high demand across the majority of industries in Australia. Attracting and retaining this workforce will pose significant challenges. Recruitment of digitally enabled workforce specialists who also have knowledge of the electricity supply industry is already being reported as difficult, and this has potential to increase over time as the demand for these occupations grow.

The ‘traditional network workforce’ includes occupations that have been prominent within DNSP businesses, and such subsequent skill sets are currently critical in the day to day function of UE. This workforce will experience skill, training and personal development opportunities to work with, integrate and compliment emerging technologies. The occupations identified within this cluster which will experience significant impacts on their current role include Electrical Tradespersons[2], Electrical Engineers, Electrical Engineering Technicians and Executive Management.

Throughout the coming decade as new technologies emerge, UE and the rest of the industry will need to understand how these technologies interact with their current systems and business models, and rapidly upskill/re-skill/multi-skill existing workforces to accommodate. Digital and data literacy will not only become a skill set that will become a necessity in specialists but increasingly required within employees from all areas of the business.

Another factor to consider is the age profile of staff within UE’s EN, Service Delivery and NCC departments. A high proportion of staff are likely to retire in the next five to ten years leaving a significant resource and skill gap, which reinforces the need to attract and retain quality staff.

Digitally Enabled Workforce

A workforce that possesses the right skills, to develop, support and maintain digital technologies, as well as providing the required skill sets to complement the additional functionality that such technologies provide, is critical for network operators and supporting industries. The emergence of digitalised technologies and services will require digital literacy and the ability to work with data (skill level will be dependent on position) being a prerequisite for an increasing proportion of the network and electricity supply industries workforces.

[2] For the purpose of this report and to be consistent with the Distribution and Transmission industry terminology Electricians will be referenced as Electrical Tradespersons. These include lines workers, underground electricians, electrical fitter mechanics and electrical contractors.

The challenges that UE and the network industry faces in sourcing workers from the highly skilled digitally enabled workforce are:

- Attracting skilled workers in a market where there is largely an undersupply of such workers
- Making the electricity industry appear an attractive proposition for skilled workers
- Retaining high-quality employees in a competitive market
- Contextualising the needs of the electricity sector and supporting industries for workers with required skill sets and occupations
- Providing appropriate training and training accreditation to meet the diversified skill requirements in this new energy paradigm

The following outlines the digitally enabled occupations that will be critical to the electricity supply industry.

Data Specialists

In recent years the exponential growth of data availability has seen UE become more data-driven, a trend that will continue in the coming decade. The increased volume and availability of data has seen the expansion of existing job roles and creation of new ones that specialise in data science, analysis and visualisation. Data specialists possess the analytical skill sets required to process, extract value from, visualise and communicate with data.

The data specialist occupation cluster includes Big Data[3] Analysts, Data Scientists, Data Architects, Data Analysts and Data Visualisation.

With the introduction of digitalised technologies, UE will be able to utilise data specialist skills to plan, integrate, operate, maintain and leverage business insights from big data management systems. These skills will become essential in assisting UE in understanding a range of businesses insights from consumer needs to energy consumption trends.

ICT Security Specialists

The threats associated with cybercrime will increase as networks including UE become more dependent on digitally connected information systems. The increasing sophistication of cyber-attacks is requiring skill sets of highly trained individuals to protect not only consumers' personal information but also the grid infrastructure.

Whilst a clear need for specialised professionals exists within the cyber security discipline, cyber security fundamentals is another skill that will be required across a number of job roles in order to obtain a deeper level of understanding than currently exists. This is also a skill set that consumer/prosumers will be required to embrace as, after installation, the consumer will be responsible for their networks and will be required to maintain certain security standards.

[3] There are a number of definitions for "Big Data". For the purposes of this report, Oxford English Dictionary defines it as *"data of a very large size, typically to the extent that its manipulation and management present significant logistical challenges"* (OED, 2014).

5. Strategic Response to Challenges and Opportunities

Historically, our asset management planning activities have only considered one possible future, the BAU scenario, which takes into account what we know now, not what we know in the future. We recognise that the future could hold a range of quite different outcomes from the BAU scenario. This SAMP has considered the various disruptive forces and other challenges that can impact UE in the future. This chapter provides the strategic direction on how UE should monitor and respond to the challenges ahead, and incorporate this strategic response into our asset and non-asset class lifecycle strategies.

Continuing to strengthen our proactive monitoring of trends and new developments is crucial to ensure that we can continue to identify issues that can potentially affect our business. Regularly keeping track of customer disruptor technology and understanding their drivers and uptake is one example. Another is monitoring regulatory/government policies which broadly represent customer and external stakeholder expectations both within Australia and overseas. Tracking and modelling these over time with identified trigger points will alert us to change ahead and provide early indications of a trajectory towards a particular scenario. This gives us the opportunity to change tactic in our strategies to manage that particular outcome.

With so much uncertainty in play, the asset management planning today needs to evolve in such a way that it maximises UE's ability to adapt quickly, and provide '*real options*' that allow us to deliver greater flexibility before committing to long-life investment decisions. The core concept of '*real options*' is in delaying long-life or major capital intensive investment decisions with short-term flexible solutions until the uncertainty (and therefore whether the asset is needed) is resolved. This approach usually has an associated cost over the lifecycle, but can minimise the risk in the long term of stranded or obsolete investments.

5.1 Network Safety

As a distribution business, UE is bound by the Electrical Safety Act and Electrical Safety Regulations to manage its assets in compliance with this legislation. The safety objective of UE's Asset Management System is to ensure that the electricity network risks, associated with asset management activities, with the potential to start a bushfire, cause harm to people, or property damage can be demonstrated to be As Low As Reasonably Practicable (ALARP).

Asset stranding becomes a real possibility in the future and UE must prepare to have strategies to manage these assets before their planned decommissioning date. It is important to remember that even decommissioned assets require some ongoing maintenance for safety reasons. The cost to remove and dispose of assets at end-of-life is significant and therefore future design of assets should consider the ease of decommissioning with minimal ongoing safety and environmental risks. Undergrounding future assets is one such option particularly if urbanisation increases as these assets are safely left decommissioned underground.

Innovation and technology advancement can bring about new and improved ways of managing assets and the network. An example of this is the REFCL technology used to detect faults and limit fault current to reduce the risk of powerline-related bushfires.

Data analytics will enable more efficient and smarter asset management decision making. This can take the form of effective asset health assessments that provide indicators on the likelihood of asset failure and provide guidance on asset maintenance and replacement as well as asset availability. Predictive analysis tools will assist in detecting failures before they happen resulting in fewer asset failures.

The key inputs driving a strategic response for network asset safety include:

1. Network technological advancement in managing assets;
2. Stranded assets become a real possibility with a requirement to manage decommissioned assets;

3. Asset data available for analysis;
4. Advancement in predictive analysis technology; and
5. Deteriorating asset condition due to aging

The key strategic responses to these inputs include:

1. Adopt new technologies to manage assets;
2. Future network designs must consider ease and cost of future decommissioning;
3. Develop analytics to assess asset health to enable better asset management decisions; and
4. Utilise predictive analysis to detect failures before they happen.

5.2 Network Reliability

Our asset management objectives are to maintain a balance between cost, reliability and safety. Under some scenarios, in the future customers may be willing to shift this balance by sacrificing reliability for cheaper electricity prices. If this is reflected in relevant regulations, this presents UE an opportunity to re-evaluate our operational and maintenance activities to meet revised requirements. It would be imperative however to understand the impacts on our worst served customers and our risk profile under such a circumstance. Such a scenario is currently underway where UE is consulting with the ESC to amend the Electricity Distribution Code power quality requirements to be aligned with the Australian Standards which is a more practical and achievable standard that results in better electricity cost outcome for customers.

UE should continue to optimise customer reliability and consequential costs through the regulatory STPIS scheme. UE's Network Investment Process is underpinned by a risk-weighted value optimisation tool (i.e. the C55 software), assessing and selecting the optimal mix and timing of investments along with the forecast performance in Network Safety and Reliability at the asset class level. UE's expenditure plans combine to maintain reliability while minimising risk of asset stranding.

UE has a number of initiatives to maintain reliability that includes preventing outages, minimising the number of customers affected by each outage, restoring supply as quickly as possible and managing the experience of individual customers, especially those experiencing poor supply reliability.

The key inputs driving a strategic response for the network reliability include:

1. Uncertainty around reliability expectations from customers given heavy focus on cost of service;
2. Increasing political sensitivity to both reliability of supply and cost of service;
3. Uncertainty around the continued support for renewable energy technologies and targets leading to the inability to appropriately plan for network stability and two way power flows and ultimately reduced reliability; and
4. Deteriorating asset condition due to aging.

The key strategic responses to these inputs include:

1. Monitor likely stakeholder and regulations changes for reliability standards and change operational and maintenance activities in a timely manner;
2. Actively lobby stakeholders to adjust reliability standards and incentive schemes to reflect changing expectations; and
3. Implement short payback investments to maintain reliability whilst extending the life of existing assets to reduce total cost of service.

5.3 Power Quality

In recent years, there has been unprecedented growth in grid-connected solar PV systems on the UE network, particularly in the residential sector. As the penetration of solar PV systems increases, additional efforts are necessary to integrate solar PV generation in an optimal manner on UE's network. Solar PV penetration presents a number of challenges for UE primarily because UE allows automatic connection of inverter-connected generation up to 30kVA (three-phase) and 10kVA single phase without passing through upstream connection costs. This means solar PV systems can suddenly appear anywhere across the network and grow at unconstrained rates to form localised clusters of high penetration which have the potential to impact UE's quality of supply performance by pushing up steady state voltage. Solar PV generation is resulting in new levels of uncertainty for our network regarding longer-term system planning.

The Dynamic Voltage Management System (DVMS) is one of the world-leading solutions that UE has implemented on the network to proactively manage increasing levels of solar PV. This system enables voltage to be managed dynamically in real time and can achieve a step-change improvement in steady-state voltage at times of high solar generation. This solution is a key part of the strategy in managing future DER on the network.

The current Victorian Distribution Code has onerous standards for distributors to manage steady state voltage, harmonics unbalance etc compared with the national rules and standards. UE is working with the ESC to adopt Australian Standards which provides more leeway in managing voltage on the network.

The key inputs driving a strategic response in the area of power quality include:

1. Outdated or non-uniform regulatory obligations not aligned with Australian Standards;
2. Increasing sensitive load and customers awareness of the importance of quality of supply;
3. AMI rollout is identifying customers experiencing steady-state voltage variations outside of the Code limits;
4. Unprecedented growth in grid-connected solar PV systems on the UE network, particularly in the residential sector, has exacerbated steady state voltage variation; and
5. Greater flexibility to control voltage.

The key strategic responses to these inputs include:

1. Proactive measurement, analysis and simulation of PQ disturbances in order to identify existing and emerging compliance issues;
2. Propose PQ improvement and compliance programmes to address PQ disturbances outside the regulatory limits;
3. Trialling of new technologies (such as dynamic voltage management), research and education to better manage the quality of supply levels;
4. Monitor likely stakeholder and regulations changes for safety, power quality and reliability standards and change operational and maintenance activities in a timely manner;
5. Influence regulators to amend power quality compliance limits to align with the latest standards and industry best practice in order to achieve the better cost outcomes for customers;
6. Increase PQ data monitoring capability by installing PQ meters to the transmission connection points;
7. Examine and re-evaluate the role of capacitor banks, reactors and SVCs vs increasing localised generation and its ability to provide voltage support; and
8. Utilise DER inverter capabilities to support power quality.

5.4 Demand, Augmentation and Alternatives

One of the most significant uncertainties at present is electricity peak demand. Until 2013, historical trends have shown demand to continuously grow and thereby justify investment in augmenting and strengthening the electricity network. The scenarios studied have shown that this trend cannot be assumed for the future. There is a possibility that demand will stay stagnant in economically challenging times or demand could decline from high penetrations of renewable and storage technology. Faced with such uncertain demand trends, strategies are being employed that give UE maximum agility in responding to changing demand conditions.

In the short term, this includes looking for opportunities to minimise capital investment in augmenting network capacity and instead focus on managing demand with non-network solutions or ways to increase asset utilisation without compromising reliability. Major network augmentation is being deferred until absolutely necessary under all scenarios by exploring shorter-term investment options with commitment to long life assets only in areas where there is a materialised demand growth trend. Short-term investment options are those that can maintain or reduce the energy-at-risk without necessarily eliminating it. Examples include greater meshing, splitting of buses, improved switching, automation, more optimised decision making with respect to equipment ratings and good data analytics, improved spares inventory and fault repair capabilities, demand management options and solar/storage solutions. With a strategic need to defer long life investment decisions in an uncertain environment, there is a risk that traditional network infrastructure required to respond to a sudden burst in growth may not be completed in time. It therefore remains prudent for UE to adopt short-term solutions even under a high growth scenario (rather than doing nothing) to address the timing gap while longer-term solutions are implemented.

While UE is presently faced with a low demand growth environment, urbanisation of UE's service area is occurring at a rapid rate and this is reflected in the strong customer connections expenditure of recent years. This presents a challenge for timing of real estate investment for location of future network assets. UE has maintained real estate where it expects to see future demand growth where future large scale assets can be built. The possibility exists that future demand does not grow in the expected locations but elsewhere where large pieces of land are difficult to acquire. This is especially so in the high growth scenario where high density, high rise housing is expected to be built throughout UE's metropolitan network. Procuring land and easements early for new zone substation and sub-transmission circuits remains a prudent strategy, but there is a greater need to explore other options for designing the network for non-traditional spaces. This will include substations that can fit into small house sized blocks of land or within a floor of an apartment block and/or promoting the conversion of large customer blocks to a single HV customer. Another outcome of a high density urban landscape is the need to underground assets. With many parts of UE's service area already becoming highly urbanised there is a need to understand the real lifecycle cost differentials between underground and overhead networks and make the right investment choices by incorporating actual lifecycle costs into augmentation business case evaluations.

The growth distributed energy resources presents UE with the opportunity to develop network tariffs and other pricing signals (e.g. demand management rewards) that incentivise customers to shift load and develop programmes that control customer appliances/storage/EVs to better manage network peak loading. A cost reflective tariff and pricing model will ultimately reduce the need for UE to invest as customers will respond to deliver more efficient outcomes. UE should continue to advocate for reforming and mandating network tariffs in the regulatory and political arenas. The promotion of demand management and solar/storage programmes are examples where UE is contributing to the distributed energy resources model by finding smarter ways to manage load locally. The extension of this encompasses utilising generation, storage and inverters at the LV network with localised voltage control. This would facilitate a move towards micro-grid models.

The key inputs driving a strategic response in the area of demand and augmentation include:

1. Uncertain maximum demand trends across the network;
2. Uptake uncertainty and clustering risk of distributed energy resources; and
3. Urbanisation of the UE service area.

The key strategic responses to these inputs include:

1. Minimise capital expenditure on augmentation until localised growth is confirmed;
2. Focus on demand management and non-network solutions;
3. Explore shorter-term investment options including
   - Greater meshing;
   - Splitting of buses with line breakers;
   - Improved switching and network automation;
   - More optimised decision making with respect to equipment ratings and good data analytics;
   - Improved spares inventory;
   - Improved fault repair capabilities;
   - Demand management capabilities; and
   - Solar/storage solutions.
   - HV customers
4. Where high growth is anticipated, continue to procure zone substation land and easements early but balance costs by exploring options for non-traditional spaces;
5. Develop programs to dispatch distributed energy resources including customer-opt-in control of appliances/storage/EVs;
6. Develop cost-reflective network tariffs and other pricing signals that incentivise customers to shift load; and

7. Utilise embedded or mobile generation and/or storage with inverters at the LV network with localised voltage control, procuring these services from third-parties when economically appropriate.

5.5 Customer Connections

In the traditional utility model, the customer relied on the electricity grid as their only source of electric power. Efficient and economical solar and storage technology is changing that model and making it viable for customers to generate and store their own electricity. The scenario assessments have shown that this could result in high numbers of customer disconnections. This outcome is reflective of customers' belief that they are self-sufficient and they see no benefit in remaining connected to the grid.

It is important to understand the drivers for customer disconnections so UE can find ways to bring value to customers remaining connected to the grid. Many customers believe they are/can be self-sufficient with a standard solar and storage system and they believe it gives them cheaper power than traditional generation.

Most customers may not be aware that a standard solar/storage system may not be sufficient to power their needs 100% of the time (hot but cloudy, long period of rain). They may also not be aware of the value of having the grid as a backup when there is a failure or scheduled maintenance on their solar/storage system. This presents UE with the opportunity to engage with these customers and provide clear and concise information to them on the reality of their demand and benefits of remaining grid connected. It is an opportunity to add value to our service and improve customer relations.

UE must proactively market to and attract new business customers into our network and with that will naturally follow increased residential connections as more jobs are created within the service area.

Distributed energy resources, such as solar, storage and EV, do not have their economic value maximised if operating as stand-alone resources. Remaining connected to the grid, it creates the opportunity for two-way energy flow to allow customers to share resources. Once the energy from these distributed energy resources can be measured and traded with appropriate value between customers, the hidden value of the current distribution network will be revealed. While markets which accommodate this do not exist at scale currently, it is foreseeable that they may emerge - this is the Distribution System Operator (DSO) model.

Opportunities to continue to minimise Customer Connections capital expenditure should be pursued through proactive management of low voltage network planning processes. This will assist the business to remain competitive against external competitive disruptors.

Key to all of these strategies is excellent customer engagement and continued focus on low cost so that customers clearly understand the value proposition in remaining connected to the grid.

The key inputs driving a strategic response in the area of customer connections and CIC include:

1. Customers disconnect as self-sufficiency becomes viable;
2. Customers want to reduce electricity bills by generating and storing electricity; and
3. Customers want to trade electricity they produce (i.e. they are "Prosumers").

The key strategic responses to these inputs include:

1. Minimise capital expenditure in CIC by looking for further efficiencies;
2. Provide clear and concise information to customers on benefits of remaining connected to grid;
3. Encourage businesses into our service area; and
4. Enable DSO and micro-grid services to unlock the value of the grid for customers including greater use of DER inverter control to reduce generation export constraints.

5.6 Asset Lifecycle Management and Replacement

In response to future uncertainty, UE is evolving its asset management approach to manage the network more efficiently and stretch existing assets to their full capability. This means we strive to utilise preventative or sometimes even reactive maintenance approaches to keep assets running for longer while still achieving our asset management objectives. Predictive data analysis is being employed to identify early indicators of failure to better manage end-of-life risk. Asset health information is becoming central in asset management and replacement strategies with early works already underway in some asset classes. Strengthening our response to critical asset failures will become even more important as we have a potentially greater dependence on our existing fleet of assets.

This approach is currently being demonstrated by our management of zone substation equipment, with replacement starting to be delivered one asset at a time rather than in bulk, until such time the demand justifies replacement of subsequent parallel assets. Further opportunities exist including reassessing the rating requirements of the asset instead of automatically upgrading to the standard size or replacing like-for-like, or options to replace assets on the network with cheaper and/or shorter life assets. As we move to more Zone substations with old and new transformers, consideration should be given to implementing an automated system to reduce load on the old transformer if the new transformer trips off.

Asset lives are being extended to cope with uncertain demand trends through refurbishment and life extension programs. In some cases the least cost approach will be to run assets to failure, provided safety is not compromised.

If utilisation decreases, it is worth investigating the benefits of placing some under-utilised assets at their end-of-life on “stand-by” while transferring load to surrounding assets to increase their utilisation. This gives UE the option of re-enabling these assets in the future if demand grows or if required for emergencies. Designing future networks with the ability to easily put them on “stand-by” at their end-of-life further enhances UE’s options in managing demand at least cost.

Lean design practices have already been employed and this should be extended further as it will continue to play an important role in minimising costs and maintaining our cost competiveness against external disruptors.

Non-traditional methods are becoming necessary in managing such future uncertainty in the network. Keeping any future stranded assets as spares in a mobile fleet gives UE operational agility to deal with demand and outage situations quickly. This gives potentially stranded assets a second life while enabling a wider range of fixes and capabilities to be reactive to future network scenarios.

Improved methods to reduce repair times will allow UE to increase utilisation on its existing fleet of assets without increasing risk. For operational flexibility and adaptability, UE must maintain a larger quantity and range of spares, and where possible recycle or repurpose parts as this will give UE options to manage demand in the high growth scenario if traditional infrastructure is not built in time.

Some future scenarios experience less reliance on the HV network, therefore investment in a meshed LV network with smart technology and greater automation further enhances UE’s operational flexibility for future scenarios. Expenditure on the network will trend towards LV rather than the HV network over time as ageing LV network assets begin to impact reliability outcomes for customers in scenarios developing micro-grids.

The key inputs and strategic responses on each of the major asset classes is now presented.

5.6.1 Zone substation Transformers

The key inputs driving a strategic response for the zone substation transformer asset class include:

1. The asset class is aging, with many transformers reaching the end of their technical life over the next 20 years;
2. Under some scenarios we have demand growth, under other scenarios this asset class becomes mostly stranded; and
3. UE have redundancy for zone substation transformers, that is, there is only a network reliability impact if multiple zone substation transformers fail.

The key strategic responses to these inputs include:

1. If assets are at risk of stranding, replacement is deferred if practically possible while managing the increased risk with strengthened risk controls;
2. Transformer components (such as bushings and tap changers) are condition-assessed and replaced if required to keep the transformer operating reliably, rather than replacing the whole transformer;

3. Where we have ageing transformers at a substation, one can be replaced first to reduce the risk of transformers failing at once;
4. In zone substations with old and new transformers, consideration should be given to implementing an automated system to reduce load on the old transformer if the new transformer trips off;
5. having a mobile transformers and associated contingency plans, to restore system security more rapidly following a transformer major failure more rapidly; and
6. An increase in spares holdings for tap changers etc. to repair minor failures more rapidly.

5.6.2 Zone substation Switchgear

The key inputs driving a strategic response for the zone substation switchgear asset class include:

1. The asset class is aging, with many switchboards reaching end of life over the next 20 years;
2. There is less risk of stranding than with power transformers as they influence the number of HV feeders which are the primary contributor of unreliability on the network; and
3. Reductions in customer numbers and value of energy.

The key strategic responses to these inputs include:

1. Additional condition monitoring (maintenance and on-line technology installations) is required to manage risks where replacement is deferred;
2. Increase in spares holdings including retention of decommissioned switchgear for spare parts or customisation of modern plant to act as immediate spares with a minimum of swap-over effort; and
3. Economic deferral of CapEx replacements as a response to dwindling customer numbers.

5.6.3 Distribution Transformers

The key inputs driving a strategic response for the distribution transformer asset class include:

1. The asset class has extreme range of utilisations across the fleet;
2. Tapping range on transformers may not be appropriate in future (due to higher voltages caused by high concentrations of PV generation and the subsequent inability to keep voltage levels to the distribution code); and
3. Less risk of stranding than power transformers as they do not have redundancy.

Possible strategic responses to these inputs include:

1. Re-assess assigned transformer ratings where more granular operating data is available;
2. Review tapping range of distribution transformers;
3. Only augment or implement non-network solutions at sites operating above their short-term overload ratings;
4. Minimise the number of new distribution substations installed under CIC to keep utilisation high; and
5. Reviewing the effects of reverse power flow more closely

5.6.4 Distribution Switchgear

Analysis and specific responses for this asset class has not yet been developed.

5.6.5 Conductors, Connectors and Cables

Analysis and specific responses for this asset class has not yet been developed. However, there is considered to be minimal risk of stranding as they do not have redundancy. As noted below though, potentially higher ambient temperatures will affect capability and ratings of this network equipment.

5.6.6 Poles and Pole-top structures

Analysis and specific responses for this asset class has not yet been developed. However, there is considered to be minimal risk of stranding as they do not have redundancy.

5.6.7 Protection

The role of network protection will not change. It will remain necessary to have equipment designed to detect faults to protect the network, protect individual plant on the network and to ensure the network remains safe. Nonetheless protection will not be immune to change. Change will be required to support increased levels of distributed energy resources (DER) and bi-directional power flow, possible operation of micro-grids with low fault levels, increased obligations in regards to bushfire mitigation (only an issue in rural or semi-rural areas) and changes in technology such as IEC61850. Hence the complexity of protection is likely to increase.

High penetrations of distributed generation is already having an impact on voltage and fault levels on the distribution network. DER to a degree are beneficial to a distribution network but above a certain level they can contribute to degradation of feeder voltages, feeder and substation loading and protection issues due to reverse power flow. To embrace this future scenario, UE is adapting its practices to safely enable high levels of DER on the network. This includes conducting impact studies to determine the levels of DER than can be safely hosted on the network, strategies to manage protection systems and power quality, standards by which the connecting devices must operate and incentives to encourage take up in constrained areas.

Design standards for protection must be upgraded in line with anticipated levels of DER. It is imperative that UE manages DER connection on the network to levels that sustain network performance and safety. As a variety of products and installers flood the market, UE must be proactive in setting standards to which connecting equipment must comply and operate. New technology is being developed such as four-quadrant inverters that allow utilities to control reactive power and better manage voltage. UE should be proactive in utilising this technology.

The key inputs driving a strategic response for the area of protection include:

1. Increase in the amount of DER;
2. Increased safety requirements (eg. for bushfire mitigation such as rollout of REFCLs and other protection systems);
3. New technology such as IEC61850;
4. Internal drivers or external pressure to support micro-grid and islanding operations; and
5. Increased data requirements from IEDs to support network analytics.

The key strategic responses to these inputs include:

1. Develop standard designs for systems to accommodate high penetration of DERs including consideration of reverse power flow and multiple sources of infeed of short-circuit current;
2. Develop standard designs for systems to support micro-grid and islanded operations;
3. Maintain accurate registers of all DER including capacity, type and location to allow protection systems to be correctly operated;
4. Only change standards, such as adaption of IEC61850, where there is a performance or economic benefit;
5. Pursue resourcing options for REFCL deployments and grow knowledge base in this area;
6. Support competition to put downward pressure on costs and to encourage innovation; and
7. Identify opportunities to use the full suite of data and functionality available from IEDs.

5.7 Information & Operational Technology, Monitoring and Control, Metering and Communications

5.7.1 IT, OT and Information Management

With large amounts of data forecast to become available from network devices and other sources, suitable underlying infrastructure will be needed to extract value. Data governance will become increasingly important. UE's current systems have duplicated, unauthenticated information, and this will need to be addressed in order to make the most of the growing available information.

Further, data privacy, data access, and cyber security are all likely to increase in importance.

The key inputs driving a strategic response in the area of information management include:

1. A lot more data will be available, and will need to be managed effectively;
2. UE’s current systems have duplicated, unauthenticated, difficult to access data;
3. Obligations for data privacy and data access are already significant considerations; and
4. Cyber security threats are likely to increase.

The key strategic response is to establish and progressively implement an IT/OT architectural / systems strategy and plan to address current and emerging requirements, including:

1. Determine the data capacity requirements of the system by assessing the ability of the data to deliver tangible benefits, both now and in the future;
2. Develop an integrated system with improved data governance and data model, and data accessibility and usability for staff;
3. Provide access to data and ensure data privacy to meet our obligations; and
4. Manage the cyber security threat, through sound design, testing and upgrades.

5.7.2 IT, OT and Monitoring and Control

Currently, monitoring and control on the HV network is performed locally at a zone substation and remotely via SCADA and DMS systems. Automation is increasing and includes fault location isolation and service restoration system (FLISR), bus tie open schemes (BTOS), automatic reclose, automatic voltage regulation, automatic bus tie close scheme to restore supply following loss of a transformer, and load shedding.

AMI provides the opportunity to introduce remote monitoring and control of the LV network. As DER penetrations increase, this will become more important, to understand when and where network constraints due to DER operation are being approached.

Network analytics utilising AMI and other data can be developed for network/asset fault detection, asset condition monitoring, automatic control, and other applications. As real time applications increase, automation will be required for efficiency and to avoid overwhelming network operators.

Consumers are likely to adopt smart internet connected appliances. This will potentially enable networks to gain some load control of certain appliances.

Micro-grids will require local decentralised control systems to maintain a stable micro-grid, with some coordination with the distribution network control systems.

The Distribution System Operator (DSO) platforms may ultimately provide visibility of DERs, enable the setting of network constraints so DERs do not cause networks to operate outside their ratings, and mediate DER operations where constraints are encountered.

DSO platforms will underpin Distributed Market Operator (DMO) platforms, which are already being developed to allow DERs to efficiently participate in wholesale market dispatch and provide network and systems services such as frequency control.

The key inputs driving a strategic response in the area of monitoring and control include:

1. DERs are likely increase in number to ultimately become a crucial element of the power system providing a significant portion of the total installed capacity;
2. LV network operation will become increasingly complex with more DERs;
3. AMI data facilitates the use of network analytics for a broad range of applications to improve network operations; and
4. Smart home appliances will increase, enabling remote monitoring and control.

The key strategic responses to these inputs include:

1. Develop network analytics based on AMI and other data, where there is a demonstrated cost benefit. Applications may include network/asset fault detection, asset conditions monitoring, and automatic control, and can be in real time or for planning purposes. Real time applications will ultimately need to be automated;
2. Develop LV network management functionality using AMI data and network analytics, for monitoring and control in real time, and for planning purposes;

3. Pursue demand management utilising direct control of customer smart appliances;
4. Pilot microgrids and develop where there is a cost benefit; and
5. Participate in the development of DSO and DMO models and systems, and accommodate these in future plans.

5.7.3 Metering and Network Safety Devices

AMI smart meters are a rich source of data and provide a digital interface with the customer.

The key inputs driving a strategic response in the area of metering include:

1. AMI smart meters provide a rich source of valuable data, and a control interface with the customer;
2. Contestable metering; and
3. The introduction of 5 minute settlement.

The key strategic responses to these inputs include:

1. Liaise with the Victorian Government on metering contestability;
2. Manage the meter fleet tightly, minimising stock levels and matching depreciation rates with likely meter in-service life;
3. Avoid development of in-meter analytics that may be lost as a result of smart meter contestability, and instead focus local processing in the network interface card.

5.7.4 Communications Systems

Current UE communications infrastructure includes the fibre optic cables used for protection and data, the TRIO radio network used for wireless remote control and monitoring, some direct point to point radio, and the AMI mesh network used for metering and data provision for network analytics. In addition, Telstra ADSL, 3/4G and landline services are also used for SCADA, generator remote trip and wireless monitoring and control of devices without TRIO radio coverage or that are mobile.

In the future, the capacity requirements for UE's communications systems will likely increase significantly as more data becomes available. Fortunately, the rapid development in communication systems capability is also likely to continue as demand for data increases. UE will need to develop a strategy and plan for the progressive retirement of communications systems and the transition to new communications infrastructure to meet increasing capacity requirements. This strategy and transition plan must include scoping adequate capacity to accommodate future growth from new devices and applications. In the near future, this includes having the capacity to enable data capture for 5 minute settlement.

The key inputs driving a strategic response in the area of communications include:

1. Rapid development in communications systems capability; and
2. Increasing volumes of data traffic.

The key strategic responses to these inputs include:

1. Develop a strategy and plan for the progressive retirement of discontinued communications technologies and the transition to new communications infrastructure to meet increasing capacity requirements; and
2. Adopt the inter Control Centre Protocol (ICCP) to allow exchange of control and monitoring with AusNet Services and AEMO. The immediate application will be for load shedding but numerous other benefits will be realised into the future with the ability to share real time data and allow control between networks and the market operator (AEMO).

5.8 Network Operations

5.8.1 Fault and Emergency Management

Traffic congestion continues to affect UE's CAIDI due to deteriorating fault response times. This could lead to hiring more distributed fault crews and invest in more efficient fault dispatching tools. Drones may become prevalent in fault patrols and this will require investment in this technology as well as fault responders to be trained in this technology. Fault location technology will need to be relied on to reduce patrol requirements.

Potentially higher ambient temperatures will affect the accuracy and life of electronics in relays, smart meters, ACRs, RCGS thus reducing the availability of data used in analytics and consequently the effectiveness and accuracy of applications like FLISR. More rugged technology will need to be updated to overcome this barrier or use of air-conditioning in control buildings.

5.8.2 Electric Line Clearance

With more frequent and extreme weather patterns possible, UE must be prepared for more faults and damage caused by wind-blown or drought affected branches and debris falling on lines. Tree clearing becomes critical to managing this situation along with working closely with councils and land owners on their tree health policy and vegetation clearing obligations. Some councils resist tree clearing as this reduces the amenity of properties and in such instances further strategies must be employed. This includes using aerial-bundled conductor to make the network more robust or covered conductors that can operate for a period of time with a branch resting on it. The ESV favour covered conductors in high bush fire risk areas and this could become mandated in future along with undergrounding of new and replacement assets.

5.8.3 Fire Prevention

Extreme heat and drought conditions also present challenges for fire prevention. Vegetation management and asset condition monitoring are critical components of the fire prevention strategy. Investment in new electrical asset protection and control equipment that can detect and prevent fires will be required along with continuous improvement in cost-effective risk reduction technologies and procedures. Network analytics could assist in identifying assets at risk of fire before the start of high risk periods.

The key inputs driving a strategic response for the network operations include:

1. Potentially more frequent and severe weather induced faults and damage; and
2. Potentially higher ambient temperatures will affect availability, capability, failure rate and life of network equipment.

The key strategic responses to these inputs include:

1. Hazardous tree clearing will need an increased focus;
2. In heavily vegetated areas, make the network more resilient to vegetation faults with aerial bundled cable, covered conductor or underground cables;
3. Update pole top standard designs and clearance requirements;
4. Deploy robust technology to cope with higher ambient temperatures;
5. Investigate the use of drone technology for fault patrol and fault location technology to reduce patrol requirements.
6. Investigate and invest in asset protection and control equipment with fault location technology;
7. Continue to investigate and develop network analytics to monitor the condition of assets to allow their replacement before they fail, and detect (and where possible) isolate faults and determine the fault location; and
8. Invest in an automated fault dispatch system to reduce fault restoration times and improve operations efficiency.

5.9 **Workforce**

Significant proportions of traditional occupations throughout UE and the broader electricity supply industry will be impacted in varying ways and by various levels from emerging technologies and services. Workers employed within this specialised industry including ICT, engineering and tradespeople will need to embrace ongoing professional development to keep learning about emerging technologies that enter the market.

UE as a business is continuing to invest in the workforce to upskill and diversify the skillset available to deal with the various scenarios that could occur. Furthermore UE must have good succession planning in place to transfer skills and knowledge of older and more experienced staff to prepare for a large number of staff retirements in the near future.

Electrical engineers must upskill to be proficient in technologies such as battery storage and electric vehicles which will enable the two-way flow of energy into a grid that was designed for a one-way flow. They are needing to understand the integration of renewable energy into networks and the systems that monitor and manage micro-grids. In particular a solid understanding of system stability will be needed to manage micro-grids. The ability to work with, manipulate and understand big data and supporting software will be essential including the ability to manage risk driven by systems integration complexities. It is of utmost importance that industry and education continue to work together on researching the future needs of electrical engineers and develop future curriculum content around this information. It is therefore expected that a graduate recruitment program of typically 2 per year complemented by targeted hiring of other skills and replacement of a typical staff attrition of around 7% per annum will be required to maintain a suitable workforce

Electrical engineering technicians will be impacted by digitisation, automation, and the introduction of advanced electronic protection relays and telecommunication protocols. The proliferation of intelligent electronic devices and the requirement to create an intelligent network whilst managing the lifecycle of these assets is problematic. Enterprise and ICT skills are key skill changes for the future electrical engineering technician. The future worker will need to be proficient in taking a systems approach to working. This is increasingly important as old and new technologies are integrated and require different approaches to repair and maintenance. Testing and maintenance of systems will progressively be performed digitally with less reliance on physical tools. Complex problem solving skills is needed to create models which are more sophisticated and digitally enabled. Digital literacy is needed for analysis and fault finding using data networks and telecommunications products and services. Maintenance of new technology is likely to see subject matter expert/niche workers in the short term, however it is anticipated the engineering professional will absorb these into their role through ongoing professional development activities.

Electrical tradesperson will be the primary installer/maintainer of emerging technologies such as battery storage systems. Technologies entering the market in the coming decade will have advanced componentry enabling the interconnectivity of these devices to the internet. As such, the electrical tradesperson will be required to obtain the necessary ICT and cabling skills to install, configure, connect and fault find, both onsite and through remote commissioning. There will be a number of new skill sets required by electrical tradespersons for a safe and reliable transition to a changing electricity sector - these skill sets will be required to be learnt in the short to medium terms. Proficiency in working with direct current systems is essential as new standards for these areas need to be written and embedded in vocational education and training, as well as ongoing professional development for existing workers. The creation of a specialist license may be required to address skill shortages of the current workforce in the interim. Embedding and connecting the IT components of emergent technologies will be necessary. This is expected to be at its highest and most significant as technologies emerge. As technologies evolve the complexities are expected to decrease and potentially become ‘plug and play’, although the interconnectivity of smart technology will need to be understood to ensure the equipment is configured correctly and correctly interconnected. Electrical tradespersons are needing to embrace ongoing professional development and acquire consumer education skill sets. The maintainer/installer of this equipment will be the primary source of knowledge for the consumer at the point of installation. Due to the complexities and varying nature of how these systems work e.g. customer and network interaction, the maintainer/installer will be the conduit between the manufacturer and the end user.

Executive management is already playing a critical role within the transformation period. The convergence of digitalisation, new technologies and increasing customer demands will require that business models adapt to accommodate such changing consumer behaviours through the integration of new services and technologies.

Expert business acumen will be required to position companies strategically; a fundamental aspect of this is ensuring that the businesses have a workforce that has the necessary skills to succeed in the changing environment. Executive Management is responsible for the formation and the development of strategic pathways that businesses follow to ensure future viability. In an environment in which the traditional delivery of products and services to consumers is in a rapid state of change, such strategic plans and ability to change and predict and understand future environments is essential. This is not only essential to the businesses future but also the workforce that is employed within them. Thought leadership and a strong commitment to embracing change were identified as key risk areas for company board members, CEO's and general manager's working in the electricity industry. Specifically, leadership in the network operators and electrical contractors will continue to be risk areas driven by the complex and rapidly changing business models, and the safety risks associated with incorrectly or insufficiently skilled workers carrying out high-risk work. The education process will need to be ongoing with board members, CEOs, and executive managers required to have a deep understanding of industry trends and emergent technologies.

The key inputs driving a strategic response for workforce planning include:

1. Rapid advancements in new technologies;
2. Complex interconnectivity of smart technologies; and
3. Requirement to integrate high levels of DER into a network that wasn't designed for it.

The key strategic responses to these inputs include:

1. Invest in the workforce to upskill and diversify the skillset;
2. Manage risk and formulate strategies to navigate the business through changing external environment to ensure future viability;
3. Form working groups to act on and adopt new technologies;
4. Continue to work with universities on researching the future needs of electrical engineers and develop future curriculum content; and
5. Graduate recruitment of 2% per year along with targeted hiring of other skills and succession planning will be required to maintain a suitable workforce.

5.10 Environment Driven Expenditure

UE is committed to reducing the impact of our business operations on the environment, in accordance with legislated requirements. Key areas of focus for UE include noise emissions, oil leak containment, asbestos removal, and remediation of contaminated land. Obligations in this area are well developed, and the likelihood of radical change is considered low.

The main environmental challenge facing the electricity supply industry is climate change. The production of electricity is the single largest global contributor to greenhouse gas emissions. UE's direct contribution is modest by comparison, via energy losses on the network, emission of SF6 gas and through its activities to operate the network (such as vehicle emissions, energy use and indirectly via the procurement of materials). It is likely governments will continue to focus on greenhouse gas reduction in industries and sectors that contribute the most, although some legislative changes may drive further emissions reductions within UE. UE should review its continued use of SF6 switchgear against new technology developments.

The key inputs driving a strategic response in the area of environment driven expenditure include:

1. Climate change causing more extreme weather; and
2. Government policy changes to drive further emissions reductions.

The key strategic responses to these inputs include:

1. Update UE's climate resilience strategy, and apply to applicable asset and non-asset class strategies; and
2. Review UE's strategy of managing equipment with SF6 gas.

6. Definitions

Term	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AMI	Advanced Metering Infrastructure
AMS	Asset Management System
ANZSCO	Australia and New Zealand standard codes for organisations
API	Australian Power Institute
ARENA	Australian Renewable Energy Agency
AS	Australian Standard
AugEx	Augmentation Expenditure
BAU	Business As Usual
CAIDI	Customer Average Interruption Duration Index
CBRM	Condition Based Risk Management
CEO	Chief Executive Officer
CESS	Capital Efficiency Sharing Scheme
CIC	Customer Initiated CapEx
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CY	Calendar Year
DC	Direct Current
DER	Distributed Energy Resource

Term	Definition
DMIA	Demand Management Innovation Allowance
DMIS	Demand Management Incentive Scheme
DMS	Distribution Network Management System
DNSP	Distribution Network Service Provider
DSO	Distributed System Operator
DUOS	Distribution Use of System
EBSS	Efficiency Benefit Sharing Scheme
EDPR	Electricity Distribution Price Review
EN	Electricity Network group within UE
ENA	Energy Networks Australia
ENTR	Electricity Networks Transformation Roadmap
ESC	Essential Services Commission
ESMS	Electricity Safety Management Scheme
ESV	Energy Safe Victoria
EV	Electric Vehicle
FLISR	Fault Location Isolation Supply Restoration
FY	Financial Year
HBRA	Hazardous Bushfire Risk Area
HV	High Voltage
ICT	Information and Communications Technology
IMS	Integrated Management System

Term	Definition
IoT	Internet of Things
ISO	International Standards Organisation
IT	Information Technology
LBRA	Low Bushfire Risk Area
LV	Low Voltage
MAIFI	Momentary Average Interruption Frequency Index
NEM	National Electricity Market
N-1	For plant operating in parallel, this represents one plant item out of service
NSA	Network Services Agreement
OPEX	Operational Expenditure
POE	Probability of Exceedance
PV	Photovoltaic
RAB	Regulated Asset Base
REFCL	Rapid Earth Fault Current Limiters
REPEX	Replacement Expenditure
RIIO	Revenue = Incentives + Innovation + Outputs
RIN	Regulatory Information Notice
RIT-D	Regulatory Investment Test for Distribution
SAIDI	System Average Interruption Duration Index
SAIFI	Sustained Average Interruption Frequency Index
SAMP	Strategic Asset Management Plan

Term	Definition
SCADA	Supervisory Control and Data Acquisition
SECV	State Electricity Commission of Victoria
STPIS	Service Target Performance Incentive Scheme
TOTEX	Total expenditure (OpEx and CapEx)
UE	United Energy
VCR	Value of Customer Reliability
WACC	Weighted Average Cost of Capital
WH&S	Workplace Health and Safety