Future Network Strategy

March 2018

Asset Standards and Design

Endeavour Energy

CONTENTS

1. EXECUTIVE SUMMARY

Australian electricity networks are undergoing a significant technological and low emission driven transformation. Endeavour Energy is actively involved in navigating these changes by maintaining value to its customers and supporting technology initiatives that complement and maximise the utilisation of the Endeavour Energy electricity distribution network.

The emergence of new technologies presents challenges and opportunities for electricity distributors.

Energy efficiency and sustainability is changing the way Australians consume energy. Customers are increasingly aware of technology and its impact on energy delivery. Australians have strongly embraced new technology on a national scale where the service offers cost savings, government financial incentives and aligns with their broader environmental philosophy.

The challenge for Endeavour Energy is to manage the impact of each wave of technology rollouts on a network traditionally designed for one-way energy flow from large-scale centralised generation via a bulk transmission and distribution network.

By 2050, it is estimated that customer owned small-scale generation would supply 45% of Australia's electricity needs.

Endeavour Energy will need to embrace new methods of supplying, incentivising and facilitating customer demand such that the aggregated cost to serve customers is minimised, reducing cross subsidies. A framework supporting new customer services and the necessary technologies that support them, is also required.

CSIRO analysis modelling indicates that almost $1trillion could be spent by all parties in Australia's electricity system by 2050, however, the benefits achieved will depend greatly on decisions made early in our energy transition.

The role of the traditional electricity grid is evolving to enable customer driven take up of new services such as renewable energy based generation, battery storage, electric vehicles and home automation, and also services not yet known but expected to be disruptive and displace existing services.

These changes, combined with price signal impacts and energy efficiency improvements, mean that customer usage patterns continue to change, with the network functions transitioning from a traditional 'bulk supply to customer' model to a 'connection sharing' model, similar to the way the internet functions.

Without an innovative approach to navigate this transformation, Australia's traditional energy networks will be unable to efficiently and securely integrate the diverse technologies, large-scale renewable energy generation sources and small-scale customer owned renewable energy generation resources. This may result in customers choosing to opt-out by going 'off-grid' or choose to partner or aggregate with other 'off-grid' customers and alternative networks.

This strategy, the Future Network Strategy, comprises one of the company's three key strategic initiatives to achieve the objectives of the Network Strategy in the period 2017/18 to 2023/24, which will enable Endeavour Energy to be prepared and respond commercially to the future grid through the efficient provision of network-connected energy services.

As part of this plan, Endeavour Energy will develop internal and external capabilities through development work on existing systems, and pilots and trials of new technologies, in conjunction with industry, customers and academia to determine how technologies and standards should be developed to support this grid transformation.

Additionally, pilots and trials will need to be carefully selected and timed to allow for customers and technologies to be sufficiently mature and widespread to effectively and efficiently test, but not so mature and widespread that trial learnings are unable to be integrated into standard industry and customer practice.

The development of technologies (and capabilities) will be achieved through two key streams:

- Optimisation of existing network and capabilities (capacity, reliability, staff, resourcing, maintenance etc.); and
- Facilitating customer opportunities.

Endeavour Energy will continue to develop solutions that optimise the use of our existing network and capabilities through the continuation of technology pilots and Demand Management Innovation Allowance (DMIA) programs, mobility and workforce management systems, and asset management and information systems.

The development of these programs contributes to maintained network reliability, cost savings and safety improvements for customers and the business.

1.1 Optimisation of the Existing Electricity Distribution Network

The existing electricity distribution network has developed as a legacy of customer demand, technology and standards relevant at the time of construction. It is not possible to upgrade many legacy assets to support current network functional requirements.

Network augmentation initiatives have progressively replaced or upgraded legacy network assets and some modern equivalent components do support current network functional requirements.

Modern equivalent technologies provide significant advantages as they generally support condition monitoring (real time and long term) of the asset. This allows Endeavour Energy to tailor a maintenance regime driven by asset condition rather than traditional routine maintenance.

It is rarely cost justified to retrofit technologies on all assets of a particular asset class and the proportion that has unsatisfactory reliability or require higher capacity is not of a sufficient volume to justify complete asset replacement. Improved data and analytical processes to target low reliability assets or assets with limited spare capacity can be used to determine which assets are best suited for technology augmentation to improve reliability or capacity.

This allows for a low risk and low cost implementation of technology at locations where the return for the technology investment is justified. Additionally, this process may be carried out at multiple levels such that low risk assets have little to no technology or monitoring and some high risk assets may have multiple technologies deployed to control this risk. This approach targets replacement and growth capital to areas with the greatest effectiveness, and also allows for a reduction in risk profile, particularly in electrical shock, arc risk and bushfire risks.

Endeavour Energy has and will continue to implement technologies that maintain reliability and increase the capacity of the network, and extend effective asset life through our existing process of piloting and trialling untested or technologies with uncertain benefits, and the rollout of proven technology in locations that are cost effective.

1.2 Optimisation of Existing Capabilities (People and Systems)

In addition to the physical network assets, Endeavour Energy is the custodian of a significant asset base of network staff and supporting systems that allow Endeavour Energy to operate its network. These staff and supporting systems are geared towards two main tasks:

- Responding to network incidents to restore supply; and
- Development of the network to meet existing and new customer requirements.

The efficiency of management of the network is increased through using integrated management systems. This assists in the accuracy and timeliness of asset data, the use of this data within analytics to determine optimal management strategies and the availability of this data to multiple users to provide insights.

The use of optimised scheduling will enable Endeavour Energy to utilise our resources more efficiently. Additionally, the continuation of the project to implement a Distribution Management System (DMS) will have significant customer, safety, efficiency improvements and enable the maintenance of our reliability performance through greater understanding of the new network paradigm of increasingly active sources and consumers of energy.

These systems allow Endeavour Energy to optimise the resources required to expand, maintain, respond and repair the network.

1.3 Facilitating Customer Opportunities

Endeavour Energy will pursue technologies, platforms, standards and information systems that allow customers to take advantage of the existing grid capacity, as well as provide incentives for customers to play a part in increasing the efficiency of the grid, and avoidance of costly and disruptive capital works.

These systems will allow for an increasing level of distributed energy resources and significant customer opportunities to not just supply their own energy requirements, but also play a part in being an energy solutions provider within their local area.

This vision of significant distributed energy provision and customer opportunities will require significant changes in regulatory settings, centralised technology platforms, distributed technologies and significant customer engagement. It is not expected that this vision will be realised within the next five years, however progress will need to be made to develop these systems. Customer engagement and technology trials will need to occur to determine the most efficient way to enable opportunities for customers that wish to take these up whilst embedding protections for customers that do not or are unable to actively participate in these opportunities.

2. KEY POTENTIAL IMPACTS OF CUSTOMER LED TECHNOLOGIES

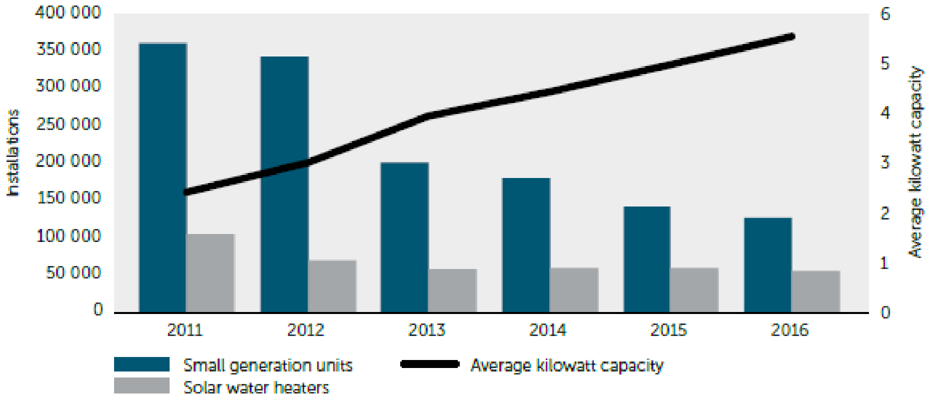
2.1 Technology Impacts

2.1.1 Solar PV

The increasing penetration of solar generation has not yet presented any material issues for Endeavour Energy's network. However, other jurisdictions around Australia and the world have been required to conduct relatively significant works due to high penetration of solar photovoltaic (PV).

The number of solar PV installations rose dramatically with the Solar Bonus Scheme in 2010 and slowed with its cessation in 2011. Although the number of solar PV installations has reduced, since the average PV size has increased, the amount of PV being installed, as measured in total power output, has remained relatively consistent since this time. Endeavour Energy's current PV penetration rate is 12% and is increasing between 1-2% per year.

Figure 1 - Number of small-scale system installations since 2011



The nature of the rooftop PV has changed from small customer installations to larger customer installations and commercial installations. Subsequently, the opportunities to engage these resources are greater due to the more informed nature of the customer, systems with greater capabilities and the ability for the customer to generate a greater return for a similar action.

Additionally, the impacts of residential solar PV in new build (predominantly underground) areas are minimal at current penetration levels due to the characteristically high capacity, low impedance network found in new residential estates. It is anticipated that in modern underground networks, significantly higher solar PV penetration levels can be accommodated with appropriate distribution tap selection. However, in legacy areas and areas with significantly greater than average distributed generation, work will be required to orchestrate the distributed generation such that the total hosting capacity of the network is maximised.

Even in areas not expected to experience a constraint in the short to medium term, there is value in enabling provision for orchestration of the distributed generation such that when constraints occur, a viable solution to enable greater customer opportunities exist rather than customers being locked out due to their lack of first mover status. Endeavour Energy has been active in the development of the AS4777 and AS4755 standards, which provide provision for orchestration of distributed energy resources.

The industry has developed additional remote management protocols for distributed energy resources, which Endeavour Energy can further investigate to potentially curtail any the long-term impacts of solar PV. SunSpec is an open source protocol offering control and monitoring capabilities of compliant equipment. SunSpec has been included as a requirement for renewable energy installations greater than 5kW on the Horizon Power network, providing a provision for remote feed-in and reactive power management of distributed inverters via SCADA.

2.1.2 Micro-Grids/Virtual Neural Networks/Virtual Micro-Grids

Micro-grids provide both a threat and opportunity. They pose a threat to the regulated business through the potential reduction in new growth but also provide an opportunity to supply customers in a more economic manner than via connection to traditional networks, particularly in fringe of grid areas.

The role of the network is changing to become a ‘neural network’ rather than a supply network, ensuring that the various distributed generation and supply functions operate in an integrated way. This will drive advanced connectivity, metering and operational control requirements, integrated with telecommunications requirements.

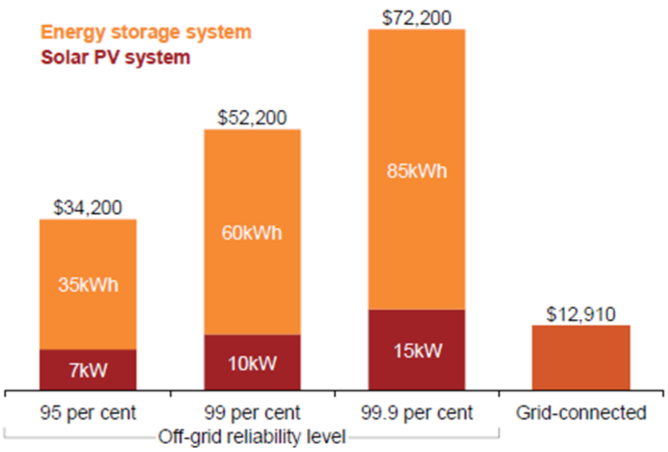
2.1.3 Battery Storage

Battery storage is an opportunity to improve our load profile, increase utilisation and provide a strong value proposition for our customers.

There is minimal risk of individual customers going off-grid, as costs are currently five times more than staying on-grid and an average urban roof cannot support sufficient solar generation.

However, some customers may elect to install excess storage, which in the absence of a mechanism to utilise this storage, such as time variable pricing or congestion variable pricing, will render this investment inefficient. Further, prolonged periods of low solar irradiance or ‘solar droughts’ are a barrier to any customer severing their physical connection to the grid. This includes residential customers with different consumption profiles to our illustrative customer, as well as commercial customers. The frequency and duration of these solar droughts in both the Ausgrid and Endeavour Energy networks is sufficiently high, to make physical disconnection unlikely for the vast majority of customers in these networks. A system that would allow customers to make it through a typical wet winter week needs about $58,000 worth of solar and storage[1].

Figure 2 - Upfront cost of an off-grid system by reliability levels vs net present cost of remaining connected (2015) [2]



Further, lowering of battery costs will increase affordability of electric vehicles, bringing new regulated revenue with low marginal cost due to the ability to charge them outside peak hours. A key element of enabling this revenue is engaging with electric vehicle and charger providers to ensure that charging is not coincident with peak demand times.

[1] https://grattan.edu.au/wp-content/uploads/2015/05/822-sundown-sunrise5.pdf
[2] https://grattan.edu.au/wp-content/uploads/2015/05/822-sundown-sunrise5.pdf - Figure 17

Energy storage can provide an alternative to network augmentation through the provision of energy during periods of peak demand, which will allow existing network infrastructure to stay within its allowed limits. Energy storage can be implemented both in a centralised utility scale installation and distributed at customer installations. The availability of space for the installation of the system is the dominant constraint for the solution to be implemented.

The substantial hurdles that exist in Australia appear to make it unlikely that electric vehicles will attract high uptake rates in the near future. However, the advent of battery storage may reinvigorate interest in electric vehicles. In particular, households looking to invest in batteries may consider purchasing an electric vehicle, which serves the dual purpose of providing storage and a means of transport.

In the event that electric vehicles were widely adopted, the potential implications for the network could be significant. In particular, charging electric vehicles adds to energy demand and may increase peak demand levels if users were to charge their vehicles at similar times during peak periods.

At the end of 2012, the AEMC finalised a review of the energy market arrangements for electric vehicles and natural gas vehicles. The AEMC found that the Australian energy market arrangements are generally robust to cater for the efficient uptake of electric vehicles. However, it recommended that measures be put in place to facilitate efficient investment for both consumers and service providers in the long term. Such measures include changes to electricity tariff structures to provide appropriate pricing signals to facilitate efficient charging behaviour and the provision of metering installations with interval read capability to allow consumers to manage their electricity consumption.

2.1.3.1 Challenges Arising From Electric Vehicles

Global electric vehicle stock is continuing to increase, rising from about 180,000[3] electric cars on the road in late 2012 to over 665,000 on the road at the end of 2014. Approximately two-thirds of global electric vehicle stock is located in just three countries, the United States (39%), Japan (16%) and China (12%).

In July 2017, there were only a total of 3,000 registered electric vehicles across Australia[4]. There are only five electric vehicle models[5] locally available to purchase due to negligible federal and state government incentives and punitive car taxes including the luxury car tax, which typically adds $76,292[6] to the Tesla Model X priced at $300,000, although the electric vehicles luxury car tax (LCT) threshold is set to $75,526 rather than $65,094 for other vehicles. The LCT rate remains at 33% for all cars. A trend in Australia to favour less fuel-efficient SUV vehicles[7] can be counteracted with an electric vehicle take up only if charging infrastructure is rolled out, incentives are provided and battery life is extended to meet Australian road conditions.

Electric vehicle sales in Australia in 2014 totalled 948[8] but in 2016 fell to only 219[9] electric cars. Despite Australia's current out-of-step behaviour, a widespread uptake of electric vehicles across Australia is expected with recent global trends of future imposed bans on solely internal combustion engine vehicles and increased development in Vehicle to Grid (V2G) technology by a number of prominent vehicle manufacturers.

Endeavour Energy expects two different effects on electricity demand:

- **Increase** total consumption of electricity, as the vehicles draw additional energy from the power system; and
- **Reduce** the peak energy demand (or more accurately to increase supply) by feeding energy to the grid from stored energy in the electric vehicle's battery.

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[3] International Energy Agency 2015
[4] http://www.afr.com/lifestyle/cars-bikes-and-boats/cars/teslas-model-3-to-take-electric-cars-to-mass-market-but-australians-must-wait-20170726-gxjjaf
[5] https://myelectriccar.com.au/evs-in-australia/
[6] http://www.executivestyle.com.au/the-australian-government-just-made-it-harder-to-buy-luxury-cars-gw26ut
[7] http://www.theaustralian.com.au/national-affairs/electric-car-plans-spark-showdown/news-tory/e7f060f5b2a4371a4e0b202a5c61ab06?login=1
[8] National Transport Commission 2015
[9] Herald Sun 16 Jan 2017; National Motoring Editor, News Corp Australia

These two effects have significant implications for network operation and investment decisions including:

- Rising energy throughput across the grid;
- Increased off-take and injection capacity requirements;
- Substantial network augmentation (moderated by the take up of demand response facilities) coupled with technology necessary to support the intermittent nature of energy usage;
- Increased two-way energy flow;
- More complex network modelling requirements and a need for more accurate forecasting; and
- Development of potential non-network solutions to support network management.

2.1.4 Smart Meters and Third Party Load Control

An area of new technology that has potential significant implications for network businesses is increased installation of smart metering technology and other technologies that facilitate the remote control of appliances – such as the Google's Nest thermostat[10] and Planet Innovation's Zen thermostat[11].

Many of the smart meters currently available are capable of providing a number of new services.

With the emergence of smart metering technology, customers can now make more informed choices about energy usage and become energy producers and storers themselves – known as 'prosumers' resulting in two-way directional energy management.

The first emergence of this collective group typically includes educational campuses, military bases, hospitals, commercial buildings, factories, residential homes – even whole city districts, who attempt to trim business operating costs by better managing their energy consumption.

With the increased availability and accessibility of intelligence, customers now have the tools and understanding to take control of their energy consumption.

True 'prosumers' are also investing in onsite energy production. This may include solar panels, wind turbines, combined-heat-and-power systems, or diesel or gas engine-generators.

This load control capability raises opportunities for network businesses since it provides an additional tool to address peak demand on the network, which could potentially avoid more expensive network investment. However, it also presents operational challenges since it could result in relatively large blocks of load under control that is being activated according to prosumers' commercial incentives, with potentially limited visibility to the network business.

2.1.4.1 AEMC Rule Change – Metering Services

On 26 November 2015, the AEMC made a final rule[12] that has opened up competition in metering services and will give customers more opportunities to access a wider range of services.

The rule change provides Endeavour Energy with several potential opportunities, most notably including:

- Continued benefits of "network devices" installed at customers' premises to monitor, operate or control our network for the purpose of providing network services;

[10] https://nest.com/
[11] https://planetinnovation.com.au/
[12] http://www.aemc.gov.au/Rule-Changes/Expanding-competition-in-metering-and-related-serv

- Investigate means to improve power quality by phasing out Audio Frequency Injection Control (AFIC) as controlled load functionality can be delivered by the appropriate Metering Coordinators/Retailers; and,
- Engaging with the appropriate Metering Coordinators/Retailers to achieve cost effective end-of-grid voltage monitoring utilising deployed smart metering devices.

2.1.5 Cyber Security

As the electricity network integrates new technologies, employs greater connectivity and deploys automation solutions, corresponding complexity and cyber security risks emerge.

The addition of large numbers of distributed energy resources, aggregation and control systems, and the requirement to connect these systems together, creates cyber security risks as well as provides resilience against cyber security issues.

Endeavour Energy's licence conditions will also require a significant investment in the security and management of the Operational Technology (OT) and the IT systems that operate the network. In particular, the requirement to maintain good industry practice has meant that Endeavour Energy will be progressing towards ISO27001/19 compliance to demonstrate this requirement.

Traditional electricity network control and monitoring systems located in OT environments are firewalled from corporate IT environments. Data collected by these systems are accessible to corporate and external users via servers located in demilitarised zones to prevent unauthorised users from accessing the OT network.

A 'defence in depth' architecture strategy is adopted for the control systems to further protect its integrity where access to high security zones requires transitioning through several less secure zones.

Strict adherence to standard communication protocols, data security and data classification is required for information exchange between the electricity network control system and external network automation systems, intelligent monitoring devices and customer automation systems.

Control systems will need to be appropriately secured depending on their level of impact to the network, be appropriately segregated and fail safe to enable independent operation, and that compromise of one system does not compromise another system. However, the provision of data from these control systems will need to be facilitated to enable safety, efficiency and reliability benefits from the provision of this information to asset managers and operational staff.

In particular, the development of Endeavour Energy's DMS and demand response systems will need to incorporate security and resilience as a foundation for their architectural design.

3. OPTIMISATION OF EXISTING NETWORK AND CAPABILITIES

Endeavour Energy will continue to develop solutions that optimise the use of our existing network and capabilities through the continuation of technology pilots, DMIA programs, mobility and workforce management systems, and asset management and information systems.

The development of these programs will improve customer experience through maintained reliability performance, lower cost to serve and increased safety of customers, Endeavour Energy staff and service providers.

3.1 Optimisation of Existing Network

Endeavour Energy has and will continue to implement technologies that maintain asset reliability and improve network capacity through our existing process of piloting and trialling untested or technologies with uncertain benefits and the rollout of proven technology in locations where cost benefit can be demonstrated.

It is rarely cost justified to retrofit technologies on all assets of a particular asset class and the proportion that has unsatisfactory reliability or require higher capacity is not of a sufficient volume to justify complete asset replacement. Improved data and analytical processes to target low reliability assets or assets with limited spare capacity can be used to determine which assets are best suited for technology augmentation to improve reliability or capacity.

This allows for a low risk and low cost implementation of technology at locations where the return for the technology implemented is the greatest. Additionally, this process may be carried out at multiple levels such that low risk assets have little to no technology or monitoring and some high risk assets may have multiple technologies deployed to control this risk. This approach targets replacement and augmentation capital to areas with greatest effectiveness.

Initiatives are examined against our key strategic goals of safety, reliability and sustainability (cost), to determine if these initiatives are likely in the case of a successful trial to provide a cost justified rollout.

3.1.1 Increase of Operating Capacity

Increasing the allowable operating capacity of the network asset is achieved by providing more information regarding the loading or true capacity of the asset. This is generally done through various levels of asset condition monitoring.

As an example, remote interval distribution substation monitoring is applied to the asset when the loading is estimated or manually read as being near the asset's limits.

This provides load profiles that can tell if an asset exceeds its rating for significant lengths of time. At this point, thermal monitoring and modelling can be applied to the asset to determine if the loading present is causing the asset to experience heating that may damage or prematurely age the asset (see section 3.3.4.2).

3.1.2 Optimised asset management

Optimised management of our network asset base is achieved through real time condition monitoring combined with practical knowledge of the various failure modes of the asset class. A reliability index can be created based on asset condition, age, information collected from a high volume of similar assets and from manufacturer's advice.

Endeavour Energy will use technologies (neutral integrity metering, voltage surveys etc.) to understand the condition of the network and repair the network before an outage can occur, and use asset management and information technologies to understand optimum maintenance practices for efficiency and reliability.

The addition of advanced analytical processes can target assets for deployment of technology solutions for direct monitoring. Targeted monitoring on low reliability assets provides Endeavour Energy with a powerful tool to improve customer safety via functional failure anticipation of specific assets, and offer an efficient replacement strategy for wholesale asset replacement programs (see section 3.3.4.3).

3.2 Optimisation of Existing Capabilities (People and Systems)

In addition to the physical network assets, Endeavour Energy is the custodian of a significant asset base of network staff and supporting systems that allow Endeavour Energy to respond to network incidents and to develop the network. Supporting systems comprise a network-wide OMS integrated with SCADA, an IVR, a Power Outages website, Lightning Tracker system, RequestIT and SwitchIt applications, mobility tools, ClickSoftware Scheduling tools, MySafe and a Call-Taking application. These support systems are currently planned to be replaced by a DMS solution.

Network staff comprises of Customer Service Providers responsible for call taking, senior system operators and system operators responsible for safe switching and monitoring of the sub-transmission and HV networks, EMSO or a Rapid Response crew to make safe and District Operators (LV/HV) and authorised switching officers (LV) to conduct local switching and restoration.

Use of technologies such as efficient scheduling and provision of visibility of all staff resources available to resolve an issue can reduce the duration of the outage, as well as outage location detection systems such as feeder automation, fault location sensing and through information technologies such as the DMS and mobility systems to get staff to site quicker when an issue occurs.

3.3 Initiatives for the Optimisation of Existing Network

The following initiatives will be pursued by Endeavour Energy to optimise the use of the existing network to provide a safer, more reliable and more efficient network at rollout stage if the pilot or trial of these technologies proves to be successful. A short description of each project is detailed below with a fuller case for each of these initiatives contained in Appendix A – Project Summaries.

3.3.1 Edge of Grid Monitoring and Smart Meter Integration

The introduction of the Power of Choice metering reforms has provided Endeavour Energy with an opportunity to derive business benefits utilising 'Network' data from retailer installed smart meters. The market driven delivery of smart metering provides a low cost solution for edge of grid network data acquisition without any asset management requirements or capital investment for the smart meter deployment.

There are two primary sets of network data Endeavour Energy can use and acquire from retailers or metering coordinators:

- Energy consumption interval data (this data is already available to Endeavour Energy); and
- Additional Power Quality (PQ) data (this may require commercial agreements with retailers or metering coordinators.

This data may provide Endeavour Energy with a low cost avenue to determine in near real time the last mile and local network conditions with greater certainty compared to traditional practices. This will allow for greater hosting capacity of distributed generation while avoiding unnecessary network investment, potential reduction in preventative maintenance of specific low voltage assets to safely reduce Endeavour Energy's operating costs and maintain a high reliability of supply to deliver a continued positive experience to customers.

There are additional services which retailers or metering coordinators may offer Endeavour Energy to directly improve resource efficiency and customer experience through reduced outage times and real time fault finding. See Appendix 6.1.1 for more information.

3.3.2 Grid Battery Systems

Endeavour Energy is piloting a centralised utility scale system to be installed at Endeavour Energy's future West Dapto Zone Substation site where the installation will be used to determine load management benefits, as well as examining the feasibility of using a battery to supply a small section of network during unplanned outages. If this pilot is successful, the battery will be deployed to growth sites across the network to defer the construction of up to four zone substations to 2024.

In addition to peak lopping applications, battery storage is suitable for reliability support applications. Reductions in the price of battery storage make it feasible to use for edge of grid back-up supply. Sites already exist on Endeavour Energy's network that present a positive case for concentrated deployment of Battery Energy Storage Systems (BESS) for reliability support. This application should be piloted and if successful, will present an alternative to conventional means of reliability improvement that is, reclosers, covered conductor, network undergrounding etc.

A pilot project is proposed to install island capable BESS to provide back-up supply to customers on rural feeders during outages. Three systems are proposed. See Appendix 6.1.2 for more information.

3.3.3 Feeder and Network Automation

Feeder automation schemes provide reliability by automatically isolating faulted line segments and restoring supply to customers not connected to the isolated segment. These schemes aim to complete all actions within the momentary interruption definition time, avoiding a sustained interruption for customers on the unfaulted network segments. Endeavour Energy has deployed feeder automation on a small subset of poor performing feeders that were non-compliant to the NSW reliability licence conditions (individual performance standard), as an alternative to more costly network strengthening options.

Two forms of feeder automation have been deployed:

- Loop automation which is low cost, highly reliable and does not rely on communications but is generally only suitable for simple two-feeder schemes; and
- Centralised automation which allows for significantly increased complexity, scope and flexibility but has a higher cost to implement.

The automation scheme trials were deployed in Springwood (Loop) and the Hawkesbury (Centralised) in 2011 and 2012. Following these trials, loop schemes at West Wollongong and Bomaderry, and centralised schemes at Wentworth Falls, Kangaroo Valley, Wisemans Ferry, Appin and Bowral were commissioned. Endeavour Energy intends to further leverage the targeted development of automation schemes, where suitable, as a cost effective way to address licence compliance obligations.

3.3.4 Expansion of Network Connected Monitoring Devices

Endeavour Energy has deployed several monitoring technologies in the 2014-19 regulatory period to derive varying benefits from improved customer and employee safety to improved asset management practices.

Below are three examples of network connected monitoring currently being deployed.

See Appendix 6.1.3 for more information on potential future monitoring device projects.

3.3.4.1 Various Distributed Feeder Monitoring Technologies

There are several initiatives for deployment of medium voltage (MV) feeder level equipment which will provide as a secondary benefit, real time MV network level load and voltage data.

Endeavour Energy is currently rolling out advanced feeder protection relays over a period of seven years to deliver a significant safety benefit to Endeavour Energy staff, contractors and the public through the reduction of arc flash and increased sensitivity to earth faults. These devices also provide improved monitoring to allow for detection of two-way power flows to future proof against embedded generation and use IEC 61850 communications to the SCADA RTU to provide a migration path for broader application of this technology.

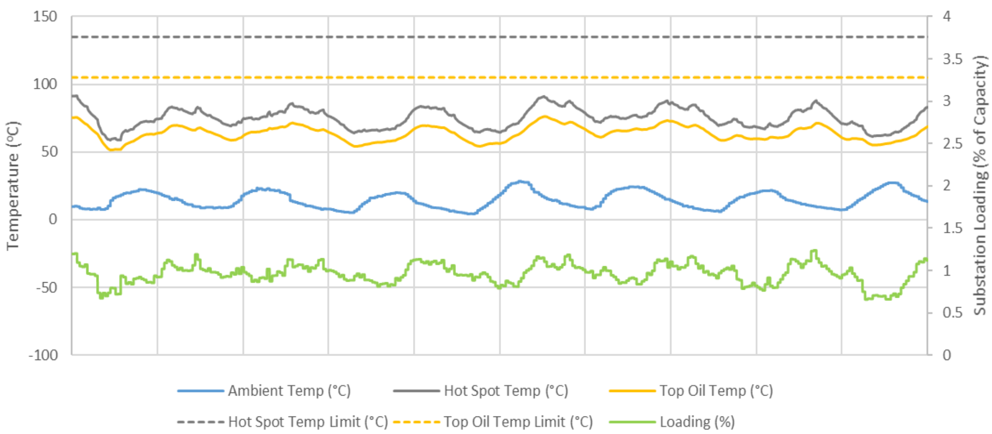
Endeavour Energy is rolling out more SCADA connected field devices such as line fault indicators, reclosers and load break switches across the network to maintain network reliability and to increase the coverage of automatable switches for potential future distribution feeder automation schemes. These field devices, which are installed under reliability programs, also deliver real time voltage and load data through SCADA, which is available in Historian and provide coverage of the MV distribution network utilisation.

3.3.4.2 Distribution Substation Real Time Monitoring

To assist with planning of the MV/LV network, including identifying capacity constraints, Endeavour Energy manually collects maximum MW demand readings from maximum demand indicators (MDI) every three years. The MDI reading process is time consuming and provides limited historic data to assist the business with operational and planning activities.

With the emergence of low cost smart meters with embedded meter functionality and extensive third party 3G/4G telecommunications coverage, an opportunity to cost effectively deliver remote monitoring of selected distribution substations and transformers has been realised. Utilising ambient temperature and load data, thermal modelling on transformers can be conducted in accordance to AS/NZS60076.7:2013 to identify the level of thermal loading on transformers to determine asset loss of life, and remaining life of the asset.

Figure 3 - Thermal model of distribution substation (AS/NZS60076.7:2013)



The resultant improved accuracy, timeliness and granularity of the measured data has facilitated a significant reduction in capital expenditure by deferring the need to increase the capacity of distribution substations approaching capacity limits and conversely, determine areas where under-utilisation of assets is occurring.

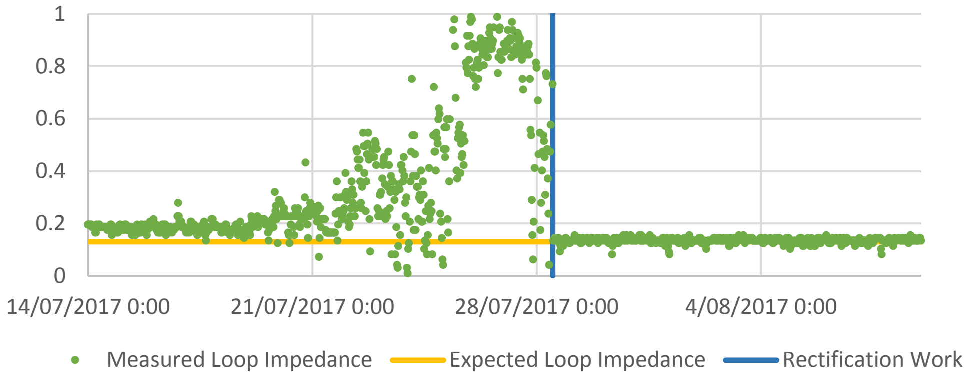
3.3.4.3 Neutral Integrity Metering

After a successful trial of 200 devices, Endeavour Energy has now deployed approximately 2,000 devices to the ends of low voltage feeders containing Consac cable to monitor the overall and localised condition of the asset population. Consac cables incorporate paper insulation and are covered with bitumen corrosion proof coating and a PVC over sheath.

Due to the aging condition, inherent safety risk and unacceptable operating reliability of the cable, the Consac replacement program was established in 2003. The systematic replacement of Consac has required significant capital investment and has addressed approximately 2% of the total risk profile on Consac each year. By utilising improved real time monitoring on almost 100% of the Consac network, the safety risk profile has been almost completely addressed, and the targeting strategy of the replacement program has ensured that capital expenditure is appropriately invested in areas where replacement is required to address the high risk sections of the network, whilst reducing the OPEX risk of ongoing F&E activities.

Shown below, is the loop impedance characteristics of a developing hot joint resulting in loss of supply to the affected customer. The development of real time and post analytics can be implemented to flag developing functional failures before they develop into a potential hazard or an outage to Endeavour Energy customers.

Figure 4 - Loop impedance of developing functional failure



It is envisaged that with the retailer-led deployment of smart metering there will be further opportunities to use meters to better manage our assets and risk without the need for substantial Endeavour Energy investment in deployment of devices.

3.3.5 Protection Projects

Electricity protection systems are among the most critical systems on any electricity network. In recent years, Endeavour Energy have begun developing and implementing more advanced protection systems to reduce fault clearance times and improve safety to Endeavour Energy customers and staff.

3.3.5.1 Distribution Feeder Modernisation (PS012)

The PS012 program is a refurbishment program to upgrade old technology relays on distribution feeders to newer ones in order improve fault sensitivity and allow for reduced protection clearance times.

The reduction in fault clearance times will reduce the likelihood and/or severity of injuries in relation to arc flash events and reduces the likelihood of fire ignition. The program will result in an upgrade of approximately 600 distribution feeder bays. Typical fault clearance times for old and new relays are as shown in the figure below.

Figure 5 – Typical fault clearance times

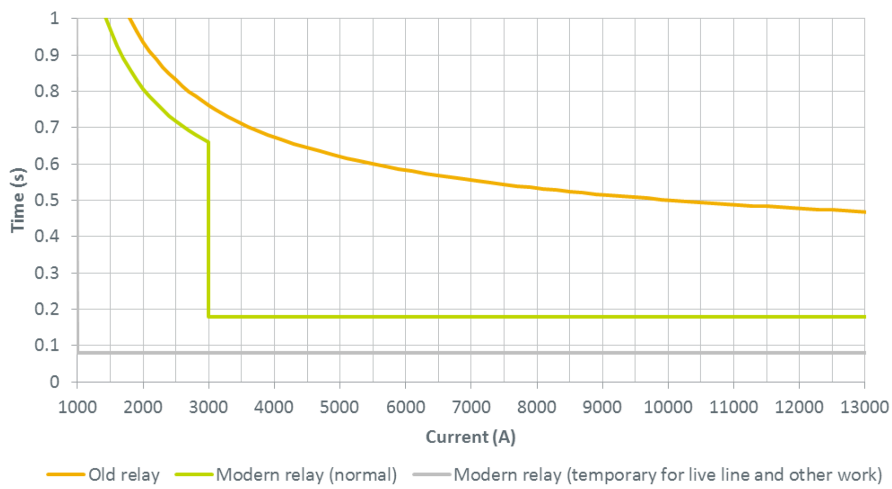
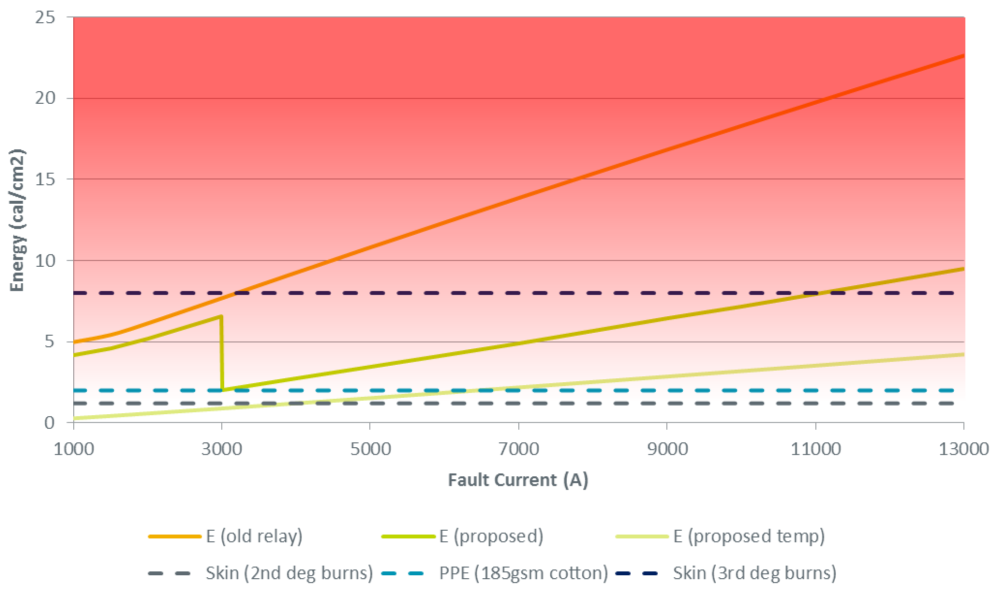


Figure 6 – Typical arc flash energy levels at 0.5m (IEEE 1584)



The PS012 program is expected to be completed in around 2020.

3.3.5.2 Distribution Fault Anticipation

Distribution fault anticipation (DFA) is a standalone monitoring device installed on feeder bays at the substation, which supplies medium voltage distribution lines. It provides direct, real time line condition information to aid field maintenance, refurbishment and replacement decision-making, safety and bushfire risk assessment.

DFA is a new technology with the potential to offer significant benefits in reducing operating cost and risk while improving safety of distribution networks.

DFA uses pattern analysis of current and voltage waveforms to identify abnormal events indicating failing line components and downed lines, reporting in plain English directly to the mobile devices of operations or maintenance team members.

Rather than traditional, expensive and slow physical line inspection work processes to detect line component failure, improved line condition information can be achieved using DFA, providing condition information directly in real time with less field resources than conventional physical inspection processes.

DFA provides improved information on the real time health of the asset and the root causes of component failures. Line rectification works, refurbishment decisions and condition-based maintenance can be better informed using the information provided by the DFA system. This information can assist in improving investment decisions including deferral of capital expenditure, providing major commercial benefit for the utility. Improved condition information provided by DFA enables improved operational efficiency and effectiveness for field crews, enhanced safety and real operational expenditure savings.

DFA may be utilised in detecting a range of bushfire-inducing line conditions before they become apparent by other means. Arising from an Industry requirement in bushfire mitigation and now with a long experience and capability in this field, DFA can be used to assess the maintenance condition of a feeder prior to bushfire season. DFA is a low cost technical solution compared to other methods, and can significantly reduce the risk of fire starts and a major fire with a consequent commercial, social and community benefit.

Implementation requires minimum changes to the existing substation to monitor the associated feeder. Using standard voltage and current signals, one unit is required for each 3-phase feeder. A simple web interface enables direct communication to field crews.

3.3.6 Telecommunications and Information Technology

The Endeavour Energy telecommunications network is required to support a large range of business and operational functions. No single technology can deliver all functionality required across the entire franchise area.

Smart grid telecommunication requirements encompass the transmission and distribution network to the customer's premises. The number of communication connection points is potentially in the millions, so an integrated communication networks management system for the re-configuration, self-monitoring and self-healing capabilities is required.

Where it is not possible or economically feasible for Endeavour Energy to provide the necessary last mile communication coverage, in fill communication coverage by third party communication services is required along with the necessary security and performance requirements fit for purpose for each application.

Endeavour Energy has successfully rolled out a Multiprotocol Label Switching (MPLS) telecommunication network leveraging off the fibre network to provide high-speed communications to over 50% of our substations and the majority of field service centres. This deployment is progressing through the normal growth and renewal of assets. The MPLS network design incorporates a scalable architecture to accommodate integration of fibre optic cable connections to new zone substations. UHF 'last-mile' access then interconnect the rural substations and field devices with mountain top MPLS aggregation points. This provides SCADA connectivity to satisfy present operational needs.

The fibre network is complimented with communication sites with microwave and UHF radio links suitable for low cost long distance links where fibre is not currently available. The Point to Multipoint UHF bases connect to substations that are not on the fibre network and to field-based devices such as reclosers, switches, voltage regulators, capacitor banks and DC monitoring systems. Through this extensive fibre and radio network, Endeavour Energy has implemented automation to all our substations and over 800 field devices.

This growth of the MPLS network using fibre or microwave links will progress in line with feeder, RTU and substation refurbishment programs.

Technologies incorporated into this network in the future include:

- DWDM implementation for inter data centre links that are fibre constrained;
- Upgrade of core MPLS routers including 10Gb/s NNI links;
- Encryption of SCADA and corporate services in the WAN; and
- Synchronisation and timing enhancements through the IEEE1588.

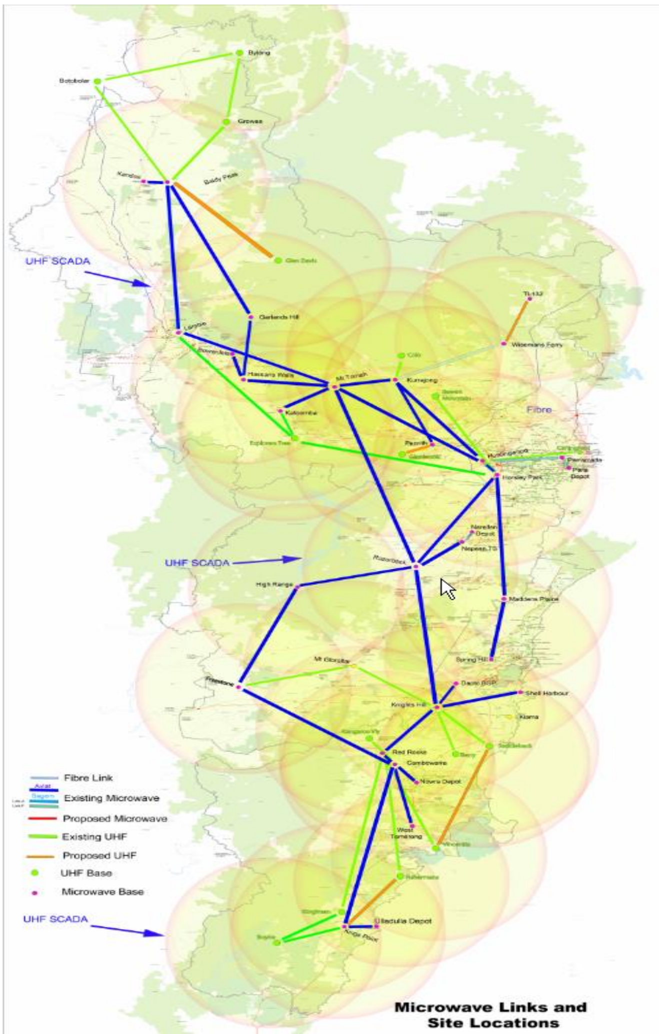
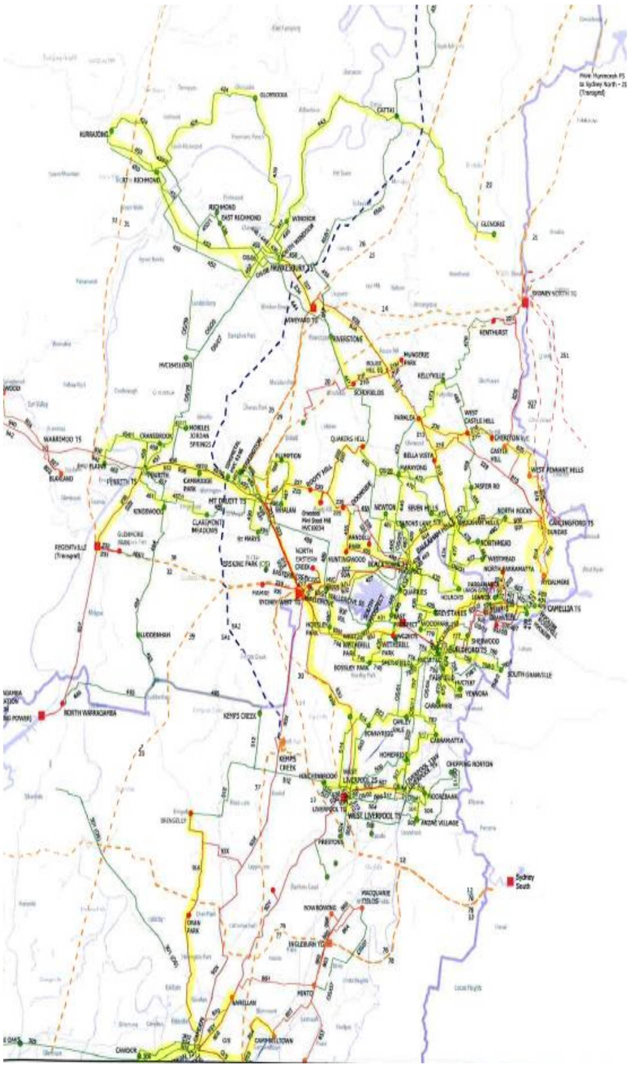


Figure 7 - Existing microwave and fibre networks



Endeavour Energy has also successfully implemented a trial of IP communications over legacy pilot networks, allowing for medium speed communications that can support SCADA and ancillary functions such as IP telephony and security cameras. This also has the capacity to support protection communications over MPLS, which can separate the renewal tasks of communications paths and protection relays.

See Appendix 6.1.5 for more information.

3.3.6.1 Cost Effective Last Mile Communication Network

The internet is increasingly being delivered wirelessly. With state-of-the-art wireless communication already operating close to the Shannon capacity, the next increase in data rates will be delivered in a similar manner to the transition that wired Ethernet has had to a fully switched network.

The future wireless networks will consist of many channels for communication between access points and end devices. Already 4G telephone networks using LTE-Advanced Carrier Aggregation are in service, allowing mobile phones to use parallel 4G channels. 5G mobile networks are due for deployment in Australia by 2020 with speeds expected to be 50 times 4G speed, although standards are still being finalised.

Endeavour Energy has trialled proprietary mesh radio technologies for two-way communications with feeder automation with mixed results. Mesh networks can be more reliable than other kinds of communication networks because if a single node goes down, other nodes are available. Their future success is governed by vendor acceptance of standardisation and possible limited convergence with fully switched carrier networks.

Recent changes in telecommunication spectrum allocation has allowed Endeavour Energy to license lower frequency bands, providing expanded and deeper network coverage for rural areas.

Endeavour Energy owned and operated rural last mile communication networks are more likely to be adjoined by urban third party operated last mile communication networks.

3.3.6.2 Low Energy Last Mile Communication Network based on the NB-IoT Standard

Rapid progress is occurring in the standards around the 'Internet of Things' or NB-IoT. The first reference to the term 'Internet of Things' (IoT) was coined over 30 years ago. IoT fundamentally involves the principle of remotely collecting and identifying collections of devices. Interest in IoT has increased in recent years due to the ready availability of cost effective communications and back office systems able to handle high data volumes.

Initially built around a concept of devices connected by communications protocols, it has evolved into physical devices with embedded technology which interact with each other and the external environment.

An appropriate IoT definition as offered by European Research Cluster (IERC) is as follows: "A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies."

Ecosystems have been formed based on a wide range of factors but the IoT's key focus is:

- Connectivity – low cost, simple to use, Machine-to-Machine (M2M), interoperable, mobility, secure, globally sourced, long range;
- Low Energy – end point devices delivering efficient communications methods using minimal energy; and
- Value – IoT-enabled applications delivering value.

The relative success of the IoT Ecosystem depends on the development of key components including:

- Technical reference architecture;
- A set of consistent standards; and
- Sustainable standardisation processes.

In general, the recent 3GPP standard approval represents a positive move with architecture and sustainability to be further developed over time.

3.3.6.3 Wireless Enabled Streetlight

Endeavour Energy maintains a large distribution network for the purpose of electrical distribution. This network is also currently used to provide public street lighting. The distribution network may be further utilised to provide additional services through Endeavour Energy streetlight assets to deliver Wireless (Wi-Fi) Enabled poles and lights as an additional last mile communications network option. By leveraging Endeavour Energy's communications network, strategic distribution of Wi-Fi enabled poles and lights can provide a number of improved network operating efficiencies by providing high speed internet access for Endeavour Energy staff and contractors as well as providing an additional communications channel for distributed monitoring of assets.

A deployed Wi-Fi network provides high-speed internet access for Endeavour Energy staff, reducing mobile broadband usage and remote access to corporate services.

Wi-Fi enabled streetlights offer additional monitoring of streetlight assets, which have traditionally required public and council feedback to address streetlight failure. Wi-Fi streetlights deployed in high traffic areas, blackspot locations and over pedestrian crossings will notify Endeavour Energy as soon as a streetlight has failed to ensure that they are replaced as soon as possible to address any risk arising from reduced visibility.

3.3.6.4 Fast and Secure Core Communications Network

A fast and secure core communications network's primary purpose is to support the protection systems used to protect the energy transmission and distribution assets, and operate within statutory and regulatory limits.

The core communications network supports links for SCADA, inter-data centre communication links, links to maintenance depots and other critical and non-critical business support functions. Utilisation of the core communication networks reduces reliance on third party communication services.

The core communication network capacity is continuously enhanced and expanded by technology improvements in the interface equipment.

In line with privatised transmission and distribution utilities across Australia, there is increasing interest in offering communication services associated with fibre optic networks broadly outside the business. The AER has advised methods for managing shared assets including communication services, via a set of 'Shared Asset Guidelines'[13].

Communication services may include the following typical offerings:

- Dark fibre;
- Fibre swap;
- Shared DWDM circuits; or
- Fully managed IP services, Layer 2 and Layer 3 VPN.

The ability to leverage communications assets allows a return to shareholders, better utilisation of the existing skilled workforce, and specialised test and diagnostic tools.

3.3.7 Substation Automation Systems

Endeavour Energy has developed a suite of substation automation applications used in zone substations. The SAS applications embedded in local RTUs comprise the following typical functions:

- Transformer auto standby;
- Bus restoration;
- No Volt restoration;
- CB auto reclose;
- Capacitor bank voltage control;
- Miscellaneous interlocks; and
- Summations and calculated values for SCADA and the Historian.

Introduction of high-speed communications within the substation LAN between the RTU and distributed intelligent electronic devices (IED), including Ethernet connected protection relays, have provided improved data latency resulting in reduced timing of automation routine operations, as well as a number of additional improvements within the potential installation practices of SCADA connected transducers and protection equipment. Development within this space has also required a review of the cyber security philosophy with the wider adoption of IP connected SCADA equipment.

Further development of the SAS in line with industry movements will ensure Endeavour Energy is in a position to maintain and further improve service conditions within the license agreements.

See Appendix 6.1.6 for more information.

3.3.8 Supporting Infrastructure

Endeavour Energy maintains OT supporting infrastructure in the form of a high availability (HA) data centre and medium scale desktop computing platform.

[13] http://www.aer.gov.au/node/18878

The supporting infrastructure is primarily used for the operation of Endeavour Energy's mission critical operational systems, which includes the MOSAIC SCADA system, and supporting smart grid applications such as the Distribution Feeder Automation (DFA), Data Historian and others. This data centre will be upgraded to host the future Advanced Distribution Management System (ADMS).

OT desktop computing platform is primarily to support SCADA operations in the control room.

See Appendix 6.1.7 for more information.

3.3.8.1 Operational Technology (OT) Data Centre

The OT data centre is physically and logically isolated from the corporate IT infrastructure and is located in separate data centres.

The OT data centre environment incorporates its own security systems comprising firewall, intrusion detection systems and end-point protection systems. These systems enable Endeavour Energy to meet its licence conditions on cyber security

The OT data centre was specifically designed and built to host a number of Endeavour Energy's high-availability, mission critical operational systems including MOSAIC SCADA, Distribution Feeder Automation (DFA), and supporting smart grid applications and the Data Historian. The data centre operates in a highly virtualised environment and utilises commodity infrastructure that allows increased flexibility and reliability.

The majority of the hardware infrastructure is more than three years old and is at end-of-life. An augmentation project was initiated in 2016-17 to provide additional capacity to meet increased demand, data growth and provide sufficient capacity for the next three years, at which point a full data centre is planned. A separate project will be initiated to replace end-of-life hardware, and update firmware and software.

The program of work for the OT data centre is aimed at ensuring the availability and reliability of Endeavour Energy's SCADA and other mission critical systems. The program of work is focused on the following:

- Replacement of aging data centre hardware to manage failure points and reduce the risk of operating system failure, which includes the phase out of end of support assets by ensuring technical currency;
- Increase data centre server and storage capacity to meet increased network operational control and data growth;
- Implement solutions that address multiple requirements, replication, de-duplication, NAS, SAN and reference architecture, resulting in reduced cost in maintenance and support;
- Purchase of commodity hardware-based appliances and licensing a virtualisation product that allows Endeavour Energy to take full advantage of its high availability data centre architectures, flexibility and operational requirements;
- Take advantage of technology innovations and developments in the IT and OT marketplace to deliver significantly improved performance, availability, reliability and scalability. Technology innovations contribute to the reduction in the overall capital and operational cost of providing infrastructure frameworks; and
- Support business continuity by taking advantage of high availability architectures enabled by existing connectivity between primary and secondary data centres. Consideration to be given to cloud services for the provision of third tier disaster recovery where technically and commercially viable.

3.3.8.2 OT Desktop Platform

Endeavour Energy's current Windows 7 desktop platform was introduced in 2012 in order to reduce the operational risk of Microsoft no longer supporting Windows XP and the lack of support for applications based on the XP operating system. A similar situation is now at hand, as Microsoft phases out Windows 7 support in favour of Windows 10 and future desktop operating systems.

This program of work will ensure the technical currency of Endeavour Energy's desktop operating systems, as well as interoperability between Endeavour Energy's desktop platform and its core infrastructure and application architectures.

The primary costs associated with this program of work include the purchase of upgraded software licences, the configuration of a new operating environment and its roll-out. The trigger for implementation will be the risk of reduced interoperability between desktop applications.

These costs have been derived using the rationale that software licence costs will be in line with previous upgrade costs per desktop and additional hardware will be required. Configuration and implementation costs have been estimated using a standard estimation model applied to all projects and confirmed as reasonable against historical projects.

Expected benefits from undertaking this program of work is a reduction in costs due to technical currency, a reduction in annual support and maintenance costs, and reduced points of failure to desktops through maintenance of technical currency.

3.3.8.3 SCADA Software Development

The SCADA system is the primary tool for the monitoring and control of transmission substations, zone substations and field assets such as reclosers and load break switches through the Endeavour's Electricity Network

Increasingly, the SCADA system is also being used as the data acquisition system for future grid applications such as distribution feeder automation schemes and distribution substation monitoring

Further the implementation of optical fibre communications has allowed for greater data capacity and improved reliability of communications between substation RTUs and the master station SCADA system.

To meet the increased data and demand for additional functionality to meet business requirements, the SCADA system needs to be continually developed and supported

The SCADA system therefore need to be continually developed and supported to meet the increased demand for data and functionality required by the changing needs of the business. The primary costs of this program Is around software and systems development, environment support and development of functionality as required by the business.

3.4 Initiatives for the Optimisation of Existing Capabilities and Systems

3.4.1 Field Force Automation and Scheduling

Endeavour Energy has a suite of asset management systems that are fit for purpose, highly integrated, and suitable for recording and accessing the information required for efficient and effective asset management. There is however, an opportunity for improvement in the data quality contained in these systems through robust input validation at the point of entry to ensure accuracy and completeness. This will further enhance the current investment decision-making process for asset maintenance and renewal.

To facilitate this, information technologies that allow for the provision and collection of asset information data by field staff are being progressively deployed. This will facilitate field staff being able to receive work requests in the field and the recording of asset information at the time the work is performed.

To date, Endeavour Energy has implemented field force data systems in business areas with high data volumes and where a positive business case could be made. This includes activities such as overhead and ground line inspections of transmission and distribution lines, service mains renewal scoping assessments, emergency service dispatch, street light replacement, and column and pillar inspections.

With the ongoing reductions in technology deployment costs, there is increasing business justification to broaden the deployment of field-force mobility solutions to other field-based asset maintenance and inspection processes. Smart tablets including iPads, are currently being deployed. The mobility roll-out is expected to provide benefits in asset management through improved data collection (such as better RCM and FMECA analysis), as well as improved efficiency in the field processes themselves, particularly when combined with improved work scheduling required as part of the Network Services Strategy.

The iPad deployment program in 2016 had initially covered timesheets, leave applications, worksite hazard and risk assessments, safety documentation, network loading history access and heavy vehicle documentation. Further applications to be progressively deployed include maintenance activity recording systems for different asset classes.

See Appendix 6.2.1 for more information.

3.4.2 Distribution Management System (DMS)

Endeavour Energy's Outage Management System (OMS) is the main system by which customer outages are monitored, reported and managed on a real time basis. The system is critical to the operation of the business, especially during times of large scale incidents such as storms.

Automated systems such as OMS are the only way that large scale incidents can be efficiently managed to minimise customer impact and maintain visibility of the status of the network in real time. The current OMS was installed in 2007 to assist Endeavour Energy to efficiently manage the planned and unplanned network outage process. The system provides efficiency benefits through automation of previously manual processes, the scalability of the system and the effective provision of information to the business and customers.

The existing OMS system is comprised of a bespoke system of software interfaces and systems. The majority of these systems are now at end of life from both a platform and software perspective, and have experienced declining levels of stability during 2016.

The implementation of an integrated DMS system is expected to provide the greatest benefits to Endeavour Energy through the significant risk management, safety, efficiency and maintenance of our network reliability. The adoption of an integrated DMS system is critical to managing the highly decentralised future electricity grid.

The option will allow ongoing accurate real time monitoring and control of customer outages. It will also facilitate the ongoing critical operation of the business, especially during times of large scale incidents such as storms. The use of a DMS automated system is the only way that large scale incidents can be efficiently managed to minimise customer impact and maintain visibility and control of the status of the network in real time.

The successful completion of this project allows the business to realise the benefits identified, including but not limited to:

- Replace the out of support OMS with a fit for purpose OMS product;
- Full screen-based geo-schematic, geographic, schematic network views to fully replace pin-board paper based drawings for real time system status representation;
- Multiple points of control with full control room functionality;
- Collection of distribution network snapshots;
- Switch planning with selectable optimisation;
- Mobile switching as part of a suite of field force mobility tools and services; and
- Advanced network applications including load flow, state estimation, short circuit analysis etc.

See Appendix 6.2.2 for more information.

3.4.3 Efficient Distributed Database to Determine Local Network Conditions

Setting up peer-to-peer energy markets using microgrids will enable neighbours to buy and sell energy within their community. Microgrids are possible using technologies such as batteries (for storage) and solar panels (for electricity generation).

These options enable a consumer to either sell their produced energy to their peers in the microgrid, store the energy in a battery located on their site/their peer's site or continue to use the produced energy to offset their consumption.

The buying, selling and distribution of electricity among peers within these microgrids requires local collection, analysis and computation of data as it is not feasible to send and compute this amount of data to in a centralised location. As such a distributed database systems will be utilised to provide this capability

Distributed database systems utilise local CPU and storage resources at the consumer site to analyse and store local energy production and consumption data.

These type of microgrid setups not only provide opportunities for Endeavour Energy to reduce peak demand but also provides cost savings to consumers by relying more on their local peer-to-peer markets for energy.

See Appendix 6.2.3 for more information.

3.4.4 Analytics and Distribution State Estimation

Endeavour Energy maintains a large distribution network for the purpose of electrical distribution. The Endeavour Energy network at times is required to be reconfigured or switched in order to maintain or restore supply during maintenance or equipment failure scenarios. Due to the complexity of the network, it is not always known what the effects of various switching configurations could have on the network in regard to power load flows, load estimations during high network demand, network and feeder losses etc.

Development of advanced analytics utilising data from distributed monitoring technologies, customer interval metering and SCADA systems for distribution state estimation will deliver improved asset management, drive further operating efficiency initiatives and reduce risk of system instability impact on customer supply.

See Appendix 6.2.4 for more information.

3.4.5 Drone Line Inspections

Manually piloted drones for close inspection of conductors and conductor hardware is already common practice, however the use is typically reserved non-distribution voltages (33kV to 132kV). Endeavour Energy already utilises drones for this purpose. There are also external companies that offer this service.

Automated drones could provide automatic post fault line inspection of affected high voltage assets to reduce investigation duration and deliver a cost-effective alternative for routine visual inspection of overhead lines.

Manually piloted drones could also provide more detailed inspection, which could assist in identifying failures such as insulators cracks, conductor damage and cross arm deterioration, and reduced inspection times by avoiding the need to transverse difficult terrain.

See Appendix 6.2.5 for more information.

3.4.6 iPad Forms Rollout

The scope of the project will include, but is not limited to:

- Developing maintenance forms and ensuring accurate collection of asset information and failure data;
- Liaising with the appropriate staff to ensure terminology and formatting are aligned with the current operating practices of the organisation; and
- Facilitating the appropriate level of change management to ensure field staff understand their responsibilities and benefits of the new maintenance forms.

Current data capture methodology does not allow asset data to be analysed efficiently and effectively. Some of the deficiencies include:

- Manufacturer and models are often incorrectly or inconsistently recorded;
- Corrective tasks carried out during planned maintenance activities are generally not captured, as current data capture methodology is too onerous; and

- Defects data recording largely relies on free text comments, which leads to inconsistent or incomplete records.

See Appendix 6.2.6 for more information.

3.4.7 Non-destructive Pole Inspection

Endeavour Energy currently perform destructive inspection techniques on timber poles, which involves drilling holes in the pole below ground line. This practice accelerates fungal decay and reduces the functional service life of the asset.

Endeavour Energy plan to investigate non-destruction internal inspection techniques for timber poles, improving asset functional service life reliability, deferring pole replacement requirements and reducing the risk of functional failures, which can have high consequences, including public safety and bushfire ignition.

See Appendix 6.2.7 for more information.

4. FACILITATING CUSTOMER OPPORTUNITIES

Endeavour Energy will pursue technologies, platforms, standards and information systems that allow customers to take advantage of the existing grid capacity, as well as provide incentives for customers to play a part in increasing the efficiency of the grid, and avoidance of costly and disruptive capital works.

These systems will allow for an increasing level of distributed energy resources and significant customer opportunities to not just supply their own energy requirements, but also play a part in being an energy solutions provider within their local area.

This vision of significant distributed energy provision and customer opportunities will require significant changes in regulatory settings, centralised technology platforms, distributed technologies and significant customer engagement. It is not expected that this vision will be realised within the next five years, however progress will need to be made to develop these systems.

Customer engagement and technology trials will need to occur to determine the most efficient way to enable opportunities for customers that wish to take these up whilst embedding protections for customers that do not or are unable to actively participate in these opportunities.

To this end, Endeavour Energy is proposing a staged implementation of technologies and trials that develop:

- Centralised technology platforms;
- Distributed technologies; and
- Customer engagement trials.

The fundamental requirement to allow for customer opportunities is the provision of information to customers to allow them to make informed decisions including but not limited to:

- Tariffs that charge customers for their contribution to peak or their support of the peak (or dynamic time and location congestion charging);
- Facilitating improved export capacity for distribution networks (customer side and network side changes);
- Location specific pricing;
- Remaining capacity in network provision to customers;
- Customer islanding and microgrid operation and supervision;
- Electric vehicle charging;
- Customer secondary markets;
- Reduction of going off-grid due to revenue positive access;
- Enabling direct participation by customers in their network management;
- Ability to know what customers' requirements and preferences are;
- Improved access to network data;
- Direct participation by customers;
- Accommodating all generation and storage options;
- Enabling new products, services and markets;
- Providing PQ and reliability; and
- Anticipating and respond to system disturbances.

4.1 Initiatives to Facilitate Customer Opportunities

Traditionally Endeavour Energy has provided customer opportunities within the latent capacity of the network to allow for the integration of distributed energy resources and the use of demand management schemes to allow customers to exploit opportunistic synergies in their load to achieve a better network outcome. Endeavour Energy has utilised and developed demand management technologies to further enable this through schemes that have been trialled and are now being implemented at a production level, including:

- Peak time consumption reduction rebates;
- Control of customer air-conditioners; and

- Control of customer swimming pool pumps.

PV systems, batteries, smart grid technologies and the use of electric vehicles are potentially disruptive for the electricity supply network, but also have potential as future solutions to network constraints. These technologies provide new tools to improve the performance of the network and to defer future network augmentation investment.

Endeavour Energy will need to work with customers further in the future to identify technologies and potential issues to ensure that customer opportunities are maximised while the requirement to incur network augmentation costs to allow these opportunities are minimised

4.1.1 Demand Response (AS4755) Trial

Australian Standard AS/NZS4755 defines the framework for demand response capabilities and supporting technologies for electrical products. This standard creates a framework that will allow off-the-shelf equipment, communication technologies and electrical products to be integrated and adapted so that demand management solutions may be developed and deployed in a timely and economical fashion.

The availability of electrical products that are AS4755 compliant provides an opportunity for Endeavour Energy to reduce peak demand. During critical peak demand days, a demand response signal is sent to a Demand Response Enabling Device (DRED) to limit the amount of power that a DRED-enabled electrical product such as air conditioners, swimming pool pumps, electric storage water heaters, electric vehicle chargers and electrical energy storage systems, can consume in comparison to its nominal full load power consumption. The aim is to reduce overall demand to the supply network at times of critical peak load.

Home automation technology will also be integrated into the system in order to connect to smart appliances like thermostats for heating and cooling, fridges, washing machines and other appliances. These smart appliances are able to communicate using the home Wi-Fi, which makes it capable of being remotely controlled and monitored.

In this scenario, Endeavour Energy will send a demand response signal to the customer at times of critical peak demand. When the customer agrees to participate in the demand response event, Endeavour Energy will send a signal to the connected appliances in order to limit the demand from the premises for that period. Customers will be incentivised for participating in the event.

See Appendix 6.3.1 for more information.

4.1.2 Residential Battery System

The Endeavour Energy *Solar*Saver program is underway. Customers were incentivised to install battery storage and in exchange would allow Endeavour Energy to discharge the battery during peak demand periods. The trial aims to identify customer uptake levels and quantify network demand reduction.

An expanded pilot is proposed for the North-West sector of Sydney where significant load growth associated with the North-West Rail Link is forecast. This pilot will incentivise customers with existing battery storage to join the program and allow use of the battery for peak lopping. The pilot will determine what incentives and control issues are associated with batteries installed within customers' residential dwellings.

If successful, this pilot will form part of Endeavour Energy's suite of demand management solutions, which include air conditioning and pool pump control moving forward.

See Appendix 6.3.2 for more information.

4.1.3 Smart Inverter

Strategic integration with new inverters offering remote generation management capabilities such as the SunSpec protocol or AS4777.2:2015 compliant equipment with AS4755 capabilities could be enabled by advanced analytics for the efficient operation of the electricity network to support localised system stability, increased hosting capacity and assist in spot price stability. Improved market spot and dispatch price stability will provide financial benefits to all participants in the electricity market, including customer consumers and prosumers.

SunSpec is an open standard protocol facilitating the interoperability of distributed energy resources. The inclusion of Section 6 – 'Operational Modes and Multiple Mode Inverters' within AS4777.2:2015 provides Endeavour Energy with an opportunity to strategically utilise:

- DRM modes on AS4755.3 compliant inverters to improve local network utilisation; and
- Improved PQ responses.

See Appendix 6.3.3 for more information.

4.1.4 DRMS 2.0 - Signalling to Customers

The Demand Response Management System (DRMS) was developed and deployed as part of the Smart Grid initiative for trialling various demand response initiatives. To date, it has been employed for the *PeakSaver*, *CoolSaver* and Endeavour Energy *SolarSaver* demand response programs.

The DRMS has the following capabilities:

- Creation and management of demand response programs;
- Enrolment and management of customers who are participating in programs;
- Scheduling and initiating ad hoc demand response events;
- Provision of notifications and feedback to enrolled customers about the demand response event;
- Forecasting customers' demand (when there is a planned demand response event) and then afterwards calculating whether they are entitled to an incentive payment for reducing their energy usage; and
- Interfacing with the metering database to validate customer data and usage.

See Appendix 6.3.4 for more information.

4.1.5 LV STATCOMs

A Static Synchronous Compensation (STATCOM) is a voltage regulating device based on a power electronics voltage-source converter. It can act as either a source or sink of reactive AC power, allowing management of voltage fluctuations or flicker, and control over power factor. When installed on the LV network, STATCOMs are an effective tool to manage PQ issues introduced by PV, such as high volts and flicker.

Endeavour Energy will investigate the efficacy of LV STATCOMs to address PQ issues on the network. As LV STATCOMs can control voltage rises, they have potential to enable more customers to utilise the grid for distributed generation export. It is envisaged the LV STATCOMs will be pole-mounted units capable of correcting PQ issues on medium to heavily loaded LV feeders.

See Appendix 6.3.5 for more information.

4.1.6 Electric Vehicle V2G, Charging Infrastructure and Transport Electrification

With the lowering cost of battery technology, electric vehicles (EV) are expected to become increasingly affordable, therefore the uptake rate of EVs is expected to increase in the coming decade. Recent global trends are seeing large international markets being imposed with future jurisdictional bans on solely internal combustion propelled vehicles in the coming decades, making transport electrification an inevitable prospect.

Numerous independent studies have indicated varying uptake rates for EVs; however they have also indicated that if deployment of EV charging infrastructure (public and private) remains unmanaged as the penetration of EVs approach certain volumes for given local networks, significant Power Quality issues to the electricity grid will arise, impacting on Endeavour Energy's customers' electricity supply. It is therefore essential that Endeavour Energy stay abreast of the technology, and contribute to the development of future standards and installation practices to ensure minimal impact on the customer experience, whilst providing a platform to ensure Endeavour Energy is in the right stead to leverage the technology for improved network utilisation.

Customers may also wish to leverage the storage within the EV battery to trade on the electricity wholesale market. Trialling Vehicle to Grid (V2G) technology will provide Endeavour Energy with insight into the potential impacts of this technology on the Network and AEMO market prices, and develop strategies to integrate it with other initiatives to improve network operation (that is, smart inverter integration, advanced analytics etc.). Additionally, V2G technology could provide future avenues for Endeavour Energy to improve transmission of electricity as a non-network means to strategically improve network capacity.

See Appendix 6.3.6 for more information.

5. SUMMARY

Endeavour Energy is a commercially successful, customer-focused business. Our vision over the next five years is to create a business that thrives with the opportunities that will emerge as the Australian energy industry transforms. By the year 2021, we intend to be known for our benchmarked safety excellence, efficiency and reliability performance.

Endeavour Energy has been successful in applying proven technology cost effectively and at the right time when and where it is supported by a strong business case. Our culture is flexible and keen to adopt new technologies when the technology reaches the right price or maturity and we have proven capability to introduce technologies quickly.

Key threats or risks associated with new and emerging technologies include:

- Cyber security;
- Revenue reductions and network impacts from embedded generation;
- Loss of customers or reduction in customer growth through storage or micro-grids;
- Electric vehicle uptake; and
- Regulatory risks due to prohibitions on technology or technology use.

Cyber security is managed through application of defence in depth, isolation of the operational technology from the corporate network, monitoring for intrusion, regular penetration testing and private ownership of the fibre, microwave and UHF networks.

As mentioned above, the current and future expected revenue and network impacts from embedded generation is low. This is further mitigated through strong customer growth in the Endeavour Energy network area, tariff reform being implemented as well as the efficiency programs which seek to keep prices low and therefore maintain electricity's competitiveness with alternate technologies.

Micro-grids may become viable in the medium term. A defensive strategy open to Endeavour Energy is to change the capital contribution policy around new developments to significantly reduce the value proposition of micro-grids (by Endeavour Energy funding the distribution reticulation).

Considered application of new technologies will allow Endeavour Energy to serve our customers more efficiently through better asset management practices (operating closer to real limits, only replacing when failed or near failure, optimal maintenance scheduling), better data inputs to align with RCM and FMECA processes, and more efficient workforce scheduling and management.

Technology will also allow Endeavour Energy to be more flexible in the connection of new customers and load such that customers are able to access the existing capacity in the network through flexible connection options and contracts rather than prescriptive connection rules. It will also enable fringe of grid connections to be supplied via islanded systems where the cost of network renewal is higher.

The risks associated with new technologies to Endeavour Energy's revenue and network are expected to be manageable and the opportunities for efficiencies will continue to enable Endeavour Energy to be a commercially successful, customer-focused business.

6. APPENDIX A – PROJECT SUMMARIES

6.1 Initiatives for the Optimisation of Existing Network

6.1.1 Edge of Grid Monitoring and Smart Meter Integration

6.1.1.1 Introduction

The introduction of the Power of Choice metering reforms has provided Endeavour Energy with an opportunity to derive business benefits utilising “Network” data from retailer installed smart meters. The market driven delivery of smart metering provides a low cost solution for edge of grid network data acquisition without any asset management requirements or capital investment for the smart meter deployment.

There are two primary sets of network data Endeavour can use and acquire from Retailers/Meter Coordinators:

- Energy consumption interval data (this data is already available to Endeavour Energy), and
- Additional Power Quality data (this may require commercial agreements with Retailers or Meter Coordinators)

Network data is inclusive, but not limited to:

- Consumption Data (kWh)
- 10-minute average Voltage Data
- 10-minute average THD
- Power (kW, kVAr, kVA)
- Neutral Integrity/Loop Impedance (Ω)

The above Network data will directly improve existing Endeavour Energy monitoring, fault finding and asset maintenance activities, as well as assist in bolstering reliable low voltage connection data in the Endeavour Energy GIS systems, reducing the risk of unnotified customer disconnections with scheduled field work.

Consumption Data is already utilised for the Endeavour Energy Load Estimator which will improve in accuracy with the increasing volume of retailer deployed smart meters.

This data will provide Endeavour Energy a low-cost avenue to determine in near real time the last mile and local network conditions with greater certainty compared to traditional practices. This will allow for greater hosting capacity of distributed generation while avoiding unnecessary network investment, potential reduction in preventative maintenance of specific low voltage assets to safely reduce Endeavour Energy’s operating costs, and maintain a high reliability of supply to deliver a continued positive experience to the customers.

There are additional services which retailers or meter coordinators may offer Endeavour Energy to directly improve resource efficiency and customer experience through reduced outage times and real time fault finding.

Several meter coordinators are offering additional services for DNSPs including, but not limited to:

- Real time meter ping
- Last Gasp

With the introduction of the real-time meter ping coupled with Last Gasp functionality, Endeavour Energy can improve resource efficiency by determining the scale of localised outages at a low voltage network level to direct the correct field resources directly to the source of any network issues.

6.1.1.2 Scope

The scope of this project will include, but is not limited to:

- Engage Meter Coordinators to include PQ measurements within their Smart Meter fleet
- Development of B2B standard/interface for new data

- Further development of analytics utilising interval data
- Improved Load Estimation
- Improved voltage management (i.e. Confirmation of distribution substation tap positions etc.)
- LV asset monitoring to improve maintenance practices/schedules
- Improve connectivity data
- Improved resource efficiency
- Training of rapid response dispatch staff
- Advanced analytics including real-time inputs from SCADA/DMS and AEMO market data to assist in efficient strategic operation of the Electricity Network to assist in spot price stability

It is projected that at least 80% of all customer meters on the Endeavour Energy will be smart meters within the next 10 years. This level of penetration will enable improved LV asset and resource management when compared to traditional methods.

By improving the level of Edge of Grid data from retailer deployed smart metering provides qualitative financial benefits derived from:

- Ensuring compliance of LV voltage management within license conditions
- Reduced investigation times for Endeavour Energy rapid response, increased time on tools
- Reduced maintenance cycles and improve service life reliability off certain LV asset classes
- Improved LV asset replacement strategy for certain LV asset classes
- Reduced liability risk and improved customer safety through functional failure anticipation
- Potential to improved wholesale market spot price stability through efficient real time network operation

6.1.1.3 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Edge of Grid Monitoring	0	100k	350k	400k	350k

6.1.2 Grid Battery Systems Back-up Supply BESS

Endeavour Energy is piloting a centralised utility scale system which is to be installed at Endeavour Energy's future West Dapto Zone Substation site. The installation will be used to determine peak load management benefits as well as examining the feasibility of using a battery to supply a small section of network as an island during an outage. If this pilot is successful, the battery will be deployed to growth sites across the networks to defer the construction of up to four zone substations to 2024.

6.1.2.1 Introduction

Ongoing reductions in the price of battery storage present an opportunity for the application of this technology for grid back-up supply to the poorest served customers either individually or as a microgrid at the edge of grid. Diesel generation has previously been utilised, however it suffers from ongoing refuelling and operational maintenance costs as well as unreliable operation in the presence of unbalanced loading which is typical on the edge of grid.

6.1.2.1 Scope

A pilot project is proposed to install island capable BESS systems to provide back-up supply to customers on rural feeders during outages. Three systems are proposed:

Island Capable RESS: 9 customers targeted for install at premises

Grid BESS: Pole or skid mount solution to supply a distribution feeder of ~50kW load
Scope

Generation Support Battery: backup in existing generation plant to support the transition from grid supply to generator supply.

The project will cover the procurement, install and testing of the two Back-up Power BESS solutions. The pilot test period will run for a year following installation.

6.1.2.2 Justification

Once proven, incentivising behind the meter RESS or deployment of back-up BESS maybe deployed where justified to improve performance for the worst served customers or worst performing segments of feeders which are non-compliant to NSW reliability licence conditions..

6.1.2.1 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Back up BESS	0	0	500k	750k	725k

6.1.3 Expansion of Network Connected Monitoring Devices

6.1.3.1 Introduction

Endeavour Energy have deployed several monitoring technologies in the 2014/19 regulatory period to derive varying benefits from improved customer and employee safety to better asset management. As further monitoring technologies mature and positive business case applications arise, additional network connected monitoring devices will be trialled on the Endeavour Energy network to determine validity in additional monitoring technology.

6.1.3.2 Scope

The scope of this project will be to determine if further monitoring can materially improve any existing maintenance or replacement programs (reduce OPEX) and/or improve customer safety on the Endeavour Energy network, and deliver them in a technology trial.

Potential projects could include:

- Additional substation asset condition monitoring
- Additional low voltage asset capacity and condition monitoring
- Partial Discharge/Corona detection
- Dynamic cable rating

Qualitative financial benefits will be be derived from:

- Reduced investigation times for rapid response, increased time on tools
- Reduced maintenance cycles on certain substation and low voltage assets
- Improved LV asset replacement strategy for certain programs
- Reduce unnecessary capital investment where possible
- Reduced liability risk, Improved customer safety

6.1.3.3 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Network Connected Monitoring	50k	50k	75k	110k	115k

6.1.4 Protection

6.1.4.1 Distribution Feeder Modernisation & Safety Program

Introduction

The Distribution Feeder Modernisation program is a refurbishment program to upgrade old technology relays on distribution feeders to newer ones in order improve fault sensitivity and allow for reduced protection clearance times. Advantages include the introduction of Ethernet based IEC 61850 compliant communications, and in many cases relays which also include voltage as well as current measurement. This means that information and speed of communications is improved which allows for voltage, Watts and Vars to be measured close to real time and allows for the communication of detailed fault records which can be reviewed remote from site within minutes of a fault occurring.

Scope

To continue the delivery of the distribution feeder modernisation program.

Budget and Timeline

Project funding will be covered under the Protection projects (PS012).

6.1.4.2 Distribution Fault Anticipation (DFA)

Introduction

Distribution Fault Anticipation (DFA) is a standalone monitoring device installed in the feeder substations of medium voltage distribution lines and designed to provide direct, real-time line condition information to aid field maintenance, refurbishment and replacement decision-making, safety and bushfire risk assessment.

Several Australian utilities have deployed DFA technology relying on either:

- Vendor supplied and operated analytic engines to report; or
- Utility-developed analytics integrated in corporate historian analytic engines.

Scope

The scope of this project will be to conduct a proof of concept trial, focusing the trial in geographic areas which may derive benefits by:

- Reducing bushfire risk in high risk areas of the network, and
- Improved asset management of aging network assets on the oldest parts of the network.

Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Distribution Fault Anticipation	0	0	300k	130k	100k

6.1.5 Telecommunications

The Endeavour Energy telecommunications network is required to support a large range of business and operational functions. No single technology can deliver all functionality required across the entire franchise area.

Smart Grid telecommunication requirements encompass the transmission and distribution network to the customer premises. The number of communication connection points is potentially in the millions, so an integrated communication networks management system for the re-configuration, self-monitoring and self-healing capabilities is required.

Where it is not possible or economically feasible for Endeavour Energy to provide the necessary last mile communication coverage, in fill communication coverage by 3rd party communication services is required along with the necessary security and performance requirements fit for purpose for each application.

Endeavour Energy has successfully rolled out a Multiprotocol Label Switching (MPLS) telecommunication network leveraging off the fibre network to provide high-speed communications to over 50% of our substations and the majority of field service centres. This deployment is progressing through the normal growth and renewal of assets. The MPLS network design incorporates a scalable architecture to accommodate integration of fibre optic cable connections to new zone substations. UHF “last–mile” access then interconnect the rural substations/field devices with the mountain top MPLS aggregation points. This provides SCADA connectivity to satisfy present operational needs.

The fibre network is complimented with communication sites with microwave and UHF radio links suitable for low-cost long-distance links where fibre is not currently available. The Point to Multipoint UHF bases connect to substations that are not on the fibre network and to field-based devices, such as reclosers, switches, voltage regulators, capacitor banks and DC monitoring Systems. Through this extensive fibre and radio network, Endeavour has implemented automation to all our substations and over 800 field devices.

6.1.5.1 Cost Effective Last Mile Communication Network (including Low Energy IoT)

Introduction

Endeavour Energy has trialled proprietary mesh radio technologies for two way communications with feeder automation with mixed results. Mesh networks can be more reliable than other kinds of communication networks, because if a single node goes down, other nodes are available. Their future success is governed by vendor acceptance of standardisation and possible limited convergence with fully switched carrier networks.

Rapid progress is occurring in the standards around the ‘Internet of Things’ or NB-IoT. IoT fundamentally involves the principle of remotely collecting and identifying collections of devices. Interest in IoT has increased in recent years due to the ready availability of cost effective communications and back office systems able to handle high data volumes. End user devices include utility meters (water, electricity and gas) street light control, car park sensors, security sensors and cameras, fire sensing, vehicles tablets and phones and tracking of any geographically-dispersed high-volume assets.

Scope

Investigate potential cost effective and/or low energy last mile communication networks.

6.1.5.2 Wireless Enabled Streetlight

Introduction

Endeavour Energy maintains a large distribution network for the purpose of electrical distribution. This network is also currently used to provide public street lighting. The distribution network may be further utilised to provide additional services through Endeavour Energy streetlight assets to deliver Wireless (Wi-Fi) Enabled poles/lights as an additional last mile communications network option. By leveraging Endeavour Energy’s communications network, strategic distribution of Wi-Fi enabled poles/lights can provide a number of improved network operating efficiencies by providing high speed internet access for Endeavour Energy staff and contractors as well as providing an additional communications channel for distributed monitoring of assets..

Scope

The Wi-Fi street lighting trial requirements:

- Restricted to an area with Endeavour Energy communications infrastructure e.g. Fibre MPSL backhaul
- Medium to high density CBD or commercial district.
- Utilise existing distribution infrastructure
- Monitoring services e.g. Weather
- Remote control of street lights

Wi-Fi Enabled Street Lighting Potential Benefits

- Energy efficient LED street lights reduce power usage and maintenance costs
- Remote control of street lights and schedules
- Realtime monitoring of street light failure, removing the need to be notified by the public regarding failures.
- High speed internet access for Endeavour Energy staff reduces mobile broadband usage, access to corporate services could be provided e.g VPN.
- Smart Sensing applications such as weather monitoring, air pollution, noise detection, movement detection

6.1.5.3 Fast Secure Core Network

Introduction

A fast and secure core communications network primary purpose is to support the protection systems used to protect the energy transmission and distribution assets and operate within statutory and regulatory limits.

Services may include the following typical offerings: -

- Dark fibre;
- Fibre swap;
- Shared DWDM circuits; or
- Fully managed IP services.

The primary purpose of the communication infrastructure is to protect the energy transmission and distribution assets and operate within statutory and regulatory limits, the ability to leverage communications assets to deliver a return to shareholders, better utilisation of the existing skilled workforce and specialised test and diagnostic tools.

Endeavour Energy currently utilises (Synchronous Digital Hierarchy) SDH and (Plesiochronous Digital Hierarchy) PDH over fibre optic. SDH is a very secure and reliable real time digital multiplex technology. The standard long range STM16 optical interface can reliably transmit over fibre optic cables up to 80km long.

To operate up to 120km a single wave of Dense Wave Division Multiplex (DWDM) equipment is required. To extend the range to 250km amplifiers are also required.

There are current and proven technologies which increase data throughput optic fibre cables by Wave Division Multiplexing(WDM) methods.

WDM is a frequency division multiplex technology that splits a laser beam into separate frequencies or wave lengths (colours) and each wave length is then connected to separate digital multiplex equipment.

Coarse Wave Division Multiplexing (CWDM) splits the beam into up to 8 wave lengths and Dense Wave Division Multiplexing (DWDM) splits the beam into up to 100 wave lengths. At present 32 wave length DWDM is available from several manufacturers.

The greater the number of wave lengths the greater the likelihood of one interfering with another. Also, the higher the power of the laser there is greater the likelihood of one interfering with another.

The dark fibre offering represents a low risk, low customer contact service but may absorb much of the value from the underutilised communication network. By rolling out a range of DWDM units it is possible to break out further marketable services and gain improved utilisation of the available spare dark fibre capacity.

The service will generally rely on: -

- Bespoke design;
- Configuration, monitoring, maintenance and support for MDWM equipment at terminal stations;
- Point to point links provided to support a dedicated fibre link between points A and B;
- This may require links and bridging across multiple routes;
- Limited capability to house customer equipment in communications rooms;
- Typical demarcation point is in a pit outside the boundary of a substation;
- Last mile connections between the customer premises and Endeavour Energy must be provisioned.

Scope

Investigate potential applications for cost effective distribution of high speed secure networking solutions including DWDM.

6.1.5.4 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
CC007 UHF bases	870k	696k	696k	696k	696k
Microwave refurbishment and extension	550k	450k	450k	450k	450k
Cost Effective Last Mile Communications	750k	500k	500k	500k	500k
Wireless Streetlight Hubs	0	100k	200k	100k	110k
Fast Secure Core Network	200k	250k	180k	150k	20k

6.1.6 Substation Automation Systems (SAS)

6.1.6.1 Introduction

Endeavour Energy has invested a significant effort in developing automation in substations over a thirty year period. The industry has moved away from copper serial communications towards high-speed channels including Ethernet and more recently, towards fibre. Development within this space has also required a review of the cyber security philosophy with the wider adoption of IP connected SCADA equipment.

6.1.6.2 Scope

Development of standards and technology within the industry in recent history has focused on improved data latency, additional reporting functionality and interoperability.

To ensure Endeavour Energy remains aligned with the industry, the following will require ongoing review and development:

- System architecture and redundancy;
- Cyber security;
- Substation LAN communications and protocols;
- Substation WAN communications;
- Fault information retrieval;
- IEC61850 practices; an d
- Automation routine schemes.

The continuing development of the SAS ensures that Endeavour Energy maintains technical currency within all SAS related technologies and remains abreast of industry practices. These projects will ultimately result in reduced delivery cost and timeline of new SAS systems through standardisation, reduced outage durations due to faster automation operation and increased cyber security of the SAS, providing assurance of system security.

A large subset of existing SCADA/SAS equipment is either approaching or are past, the designated end of life. Both the installation of new greenfield sites and renewal projects for the replacement of aging or unsupported equipment provide an opportunity to develop an improved SAS to provide the following benefits:

- Improved cyber security
  - Separation of substation LAN and SCADA WAN
  - Intrusion protection
  - Malicious behaviour alarming
- Improved SAS availability
  - Redundancy
- Improved system reliability
  - Reduced data latency
  - Faster SAS automation timing
- Improved troubleshooting
  - Fault record retrieval
  - Additional logging functionality
- Standardisation
  - IEC61850 and DNP 3.0 over Ethernet
  - Ethernet/Fibre
  - Interoperability
  - Removal of proprietary protocols

Future installations of SAS include:

Greenfield substations – Endeavour Energy services the high growth regions of NSW, with the population of Greater Western Sydney forecast to grow approximately 46% by 2031. Endeavour Energy's franchise area includes the North West and South West priority growth areas of Sydney, with the population of Western Sydney expected to increase by 900,000 over the next 20 years. These areas are predominantly where new substations will be required.

Brownfield substations – Endeavour Energy still has 137 substations with Logica MD1000 RTUs, which were designed in the earlier 1990s. Due to the quantities involved, significant investment in asset renewal is required to maintain network performance and safety as these assets reach their end of life. To avoid unacceptable levels of failure and emergency investment, renewal programs will recognise the need to replace some assets before their end of life to maintain manageable levels of investment.

6.1.6.1 Budget and Timeline

Project delivery costs for RTU replacements (AU004) covered under Capital programs.

Project ($)	19/20	20/21	21/22	22/23	23/24
Substation Automation Systems	1044k	1840k	1840k	1840k	1840k

6.1.7 Supporting Infrastructure

Endeavour Energy maintains OT supporting infrastructure in the form of a high availability (HA) datacentre (hosted in the Huntingwood and Springhill Office) and medium scale Desktop Computing Platform.

6.1.7.1 Operational Technology (OT) Data Centre

6.1.8.1.1 Introduction

The OT data centre is primarily used for the operation of Endeavour Energy's mission critical operational systems including the MOSAIC SCADA system and supporting smart grid applications such as the Distribution Feeder Automation (DFA), Data Historian and others. The OT data centre will also host the future Advanced Distribution Management System (ADMS).

The OT data centre comprises of blade servers in a blade centre housing, fibre channel communications, N5K and N3K Cisco switches, high capacity SAN and NAS storage devices, disaster recovery and back systems, and others.

6.1.8.1.2 Scope

The five year program of work for the OT data centre focuses primarily on upgrading and/or replacing aging assets, operating systems and supporting firmware and software:

- Review and develop new data centre architecture to avail of new technology including high-availability architecture, cloud technology and commodity hardware;
- Replace aging blade server technology with new technology to maintain technical currency, reduce operating failure due to the age of the current assets and increase operational capacity to meet the increasing demand of the business;
- Replace and update aging data storage facility to accommodate the increased amount of data and processing required by the distribution network;
- Update virtualisation architecture and improve virtualised environments;
- Improve capabilities on cyber security including updating systems on intrusion detection, traffic monitoring, encryption and others; and
- Improve connectivity between data centres (Huntingwood and Springhill) through improved communications hardware, redundant systems and cross data centre backups.

By maintaining technical currency and taking advantage of new technology, the following benefits are expected:

- Reduce failure points and reduce the risk of operating systems failure, which may lead to the failure of systems controlling the distribution network;
- Phase out and replace end of support assets and ensure technical currency;
- Improve data storage capability to meet the increased network operational control and data demands of the network;
- Improve data centre communications to improve data management and processing needed to meet the increased demand of the network;
- Utilise commodity based hardware appliance to reduce cost in maintenance and support;
- Utilise virtualisation across the data centre to improve management, performance, flexibility and scalability;
- Improve disaster mitigation and recovery;
- Improve the high availability capabilities and system performance;
- Improve cyber security capabilities; and
- Provide increased capacity, performance, scalability and management to support future ADMS.

6.1.7.2 OT Desktop Platform

6.1.8.2.1 Introduction

OT desktop computing platform is primarily to support SCADA development and SCADA operations in the control room.

Endeavour Energy's current Windows 7 desktop platform was introduced in 2012 in order to reduce the operational risk of Microsoft no longer supporting Windows XP and the lack of support for applications based on the XP operating system. A similar situation is now at hand, as Microsoft phases out Windows 7 support in favour of Windows 10 and future desktop operating systems.

6.8.2.1.2 Scope

This program of work will ensure the technical currency of Endeavour Energy's desktop operating systems, as well as interoperability between Endeavour Energy's desktop platform and its core infrastructure and application architectures. The scope of works is as follows:

- Purchase of upgraded software licenses;
- Configuration of new operating environment and rollout; and
- Support and maintenance upgrade on the operating environment.

The expected benefits of this program are as follows:

- Reduction of failure points by maintaining technical currency of the operating system; and
- Reduction of annual support and maintenance costs by maintaining the technical currency of the operating system.

6.1.7.3 SCADA Sofware Development

6.1.8.2.1 Introduction

The SCADA system is the primary tool for the monitoring and control of transmission substations, zone substations and field assets such as reclosers and load break switches through the Endeavour's Electricity Network.

6.8.2.1.2 Scope

This program focuses on the continued development of the SCADA software and supporting systems to meet BAU requirements as well as the need for increased demand for data and functionality required by the needs of the business. The scope of works is as follows:

- Maintain technical currency and license requirements of the SCADA system;
- Configuration and support of operating systems and environments;
- Development of additional software functionality to meet the needs of the business;
- Development and configuration of the SCADA system to meet increased data requirements;
- Configuration and support of communication protocols such as DNP3 and ICCP;
- Improve the usability of the SCADA system for system control;
- Improve network efficiency through the development of automated control routines;
- Improve the efficiency in the design and documentation of SCADA databases;

The expected benefits of this program are as follows:

- Meet Business As Usual (BAU) operating requirements of the business;
- Maintain technical currency of the SCADA system
- Meet operational support and maintenance requirements of the SCADA system

- Meet reliability requirements of the SCADA system
- Meet demand for data and additional functionality needs of the business
- Meet DNSP license requirements

6.1.8.2.3 Budget and Timeline

The five year program of work focuses primarily on maintaining technical currency by upgrading or replacing aging assets and supporting software. By taking advantage of new technology we can reduce cost, improve efficiency, increase flexibility and maintain reliability.

Project ($)	19/20	20/21	21/22	22/23	23/24
Data Centre / Infrastructure*	300k	1000k	1000k	300k	300k
Desktop Platform**	150k	400k	400k	150k	500k
SCADA and OT Software Development and Support***	550k	600k	600k	550k	550k
Total	**1000k**	**2000k**	**2000k**	**1000k**	**1000k**

*OT data centre will have reached end of life in 2019/20 and will be upgraded and replaced in a two-stage process to minimise risk and disruption to control room operation. The upgrade and replacement will consider increased performance and capacity to support the future ADMS.

**OT desktop platform will be upgraded and replaced in 2019/20 to upgrade and replace end of life assets and maintain technical currency.

***Development and support of SCADA and OT systems as required by System Control, Protection, Communications and Programs/Projects

6.2 Optimisation of existing capabilities and systems

6.2.1 Field Force Automation and Scheduling

Endeavour Energy has a suite of asset management systems that are fit for purpose, highly integrated and suitable for recording and accessing the information required for efficient and effective asset management. There is, however, an opportunity for

improvement in the data quality contained in these systems through robust input validation at the point of entry to ensure accuracy and completeness. This will further enhance the current investment decision-making process for asset maintenance and renewal.

To facilitate this, information technologies that allow for the provision and collection of asset information data by field staff, are being progressively deployed. This will facilitate field staff being able to receive work requests in the field, and the recording of asset information at the time the work is performed.

To date, Endeavour Energy has implemented field force data systems in business areas with high data volumes and where a positive business case could be made. This includes activities such as overhead and ground line inspections of transmission and distribution lines, service mains renewal scoping assessments, emergency service dispatch, street light replacement, and column and pillar inspections.

With the ongoing reductions in technology deployment costs, there is increasing business justification to broaden the deployment of field-force mobility solutions to dispatch to other field-based asset maintenance and inspection processes. Smart tablets including iPad's are currently being deployed. The mobility roll-out is expected to provide benefits in asset management through improved data collection (such as better RCM and FMECA analysis) as well as improved efficiency in the field processes themselves, particularly when combined with improved work scheduling required as part of the Network Services Strategy.

The iPad deployment program in 2016 has initially covered timesheets, leave applications, worksite hazard and risk assessments, safety documentation, network loading history access, and heavy vehicle documentation. Further applications to be progressively deployed include maintenance activity recording systems for different asset classes.

Schedulers and Ops Managers use spread sheets and other manual processes with assistance from Google Earth tools. Resources are typically under-utilised because the technology enabling improved productivity is not available. This means:

- Difficulties in bundling jobs in the same outage or within a geographic area.
- Difficulties in taking account travelling time when scheduling jobs.
- Difficulties in being responsive to changes in the schedule on the day.
- Difficulties in packaging jobs into work packets to fill up as much as the working day as possible.
- Difficulties in coordinating the utilisation of plants across depots.
- Difficulties in real time reporting.

6.2.1.1 Justification

- Allow improved resource planning to a planning horizon (3 months min) in real time reporting.
- Allow improved resource planning to a planning horizon (3 months min)
- Provide visibility of all Field force work and Field force resource constraints.
- Provide visibility of task inter-dependencies.
- Provide for dynamic scheduling and re-scheduling of crews resulting in more responsive crews.
- Provide mobile crew despatch and real-time job completion data.
- Provide management reporting to facilitate process improvement.

6.2.1.1 Budget and Timeline

Project delivery in November 2017. Project is being delivered by the Operational Performance branch.

6.2.2 Distribution Management System (DMS)

Endeavour Energy's Outage Management System (OMS) is the main system by which customer outages are monitored, reported and managed on a real time basis. The system is critical to the operation of the business, especially during times of large scale incidents such as storms.

Automated systems such as OMS are the only way that large scale incidents can be efficiently managed to minimise customer impacts and maintain visibility of the status of the network in real time. The current OMS was installed in 2007 to assist Endeavour Energy to efficiently manage the planned and unplanned network outage process; the system provides efficiency benefits through automation of previously manual processes, the scalability of the system and the effective provision of information to the business and customers.

The existing OMS system is comprised of a bespoke system of software interfaces and systems. The majority of these systems are now at end of life from both a platform and software perspective, and have experienced declining levels of stability during 2016.

The implementation of an integrated DMS system is expected to provide the greatest benefits to Endeavour Energy through the significant risk management, safety, efficiency and reliability benefits. The option will allow ongoing accurate real time monitoring and control of customer outages. It will also facilitate the ongoing critical operation of the business, especially during times of large scale incidents such as storms. The use of a DMS automated system is the only way that large scale incidents can be efficiently managed to minimise customer impacts and maintain visibility and control of the status of the network in real time.

The successful completion of this project allows the business to realise the benefits identified including but not limited to:

- Replace the out of support OMS with a best-of-breed OMS product;
- Full screen-based geo-schematic, geographic, schematic network views to fully replace pin-board paper based drawings for real time system status representation;
- Multiple points of control with full control room functionality;
- Collection of distribution network snapshots;
- Advanced network applications including load flow, state estimation, Short circuit analysis etc.;
- Switch Planning with selectable optimisation;
- Mobile Switching as part of a suite of field force mobility tools and services; and
- Advanced network applications including load flow, state estimation, short circuit analysis etc.

Project ($)	19/20	20/21	21/22	22/23	23/24
Distribution Management System	12000k	8585k	3616k	92k	0

6.2.3 Efficient Distributed Database to determine local network conditions

6.2.3.1 Introduction

Setting up peer-to-peer energy markets using microgrids will enable neighbours to buy and sell energy within their community. Microgrids are possible using technologies such as batteries (for storage) and solar panels (for electricity generation). At times of peak demand, Endeavour Energy can call upon these peer-to-peer energy markets for peak lopping.

These options enable a consumer to either sell their produced energy to their peers in the microgrid, store the energy in a battery located on their site/their peer's site or continue to use the produced energy to offset their consumption.

The buying, selling and distribution of electricity among peers within these microgrids requires local collection, analysis and computation of data. This is where distributed database systems will be utilised.

Distributed database systems utilise local CPU and storage resources at the consumer site to analyse and store local energy production and consumption data.

These type of microgrid setups not only provide opportunities for Endeavour Energy to reduce peak demand but also provides cost savings to consumers by relying more on their local peer-to-peer markets for energy.

6.2.3.2 Scope

If peer-to-peer trading platforms are available on the market, Endeavour Energy will attempt to harness these for demand management purposes.

6.2.3.3 Budget and Timeline

If appropriate technology is available, it will be trialled under the expanded SolarSaver program refer to 6.3.2.

6.2.4 Analytics and Distribution State Estimation

6.2.4.1 Introduction

Endeavour energy maintains a large distribution network for the purpose of electrical distribution. The Endeavour network at times is required to be reconfigured / switched in order to maintain or restore supply during maintenance or equipment failure scenarios. Due to the complexity of the network, it is not always known what the effects of various switching configurations could have on the network in regards to power load flows, load estimations during high network demand, network and feeder losses etc.

6.2.4.2 Scope

The scope of this project is to develop advanced analytics and state estimation utilising all monitor data from distributed monitoring technologies, SCADA and network data from retailer installed smart metering.

The potential benefits of implanting an analytics and distribution state estimation system are as follows:

- Simulate and estimate network switching constraints in real-time for System Operators
- Improve asset management, network planning, float voltage settings, distributed generation assessments
- Defer network investment
- Determine power quality issues
- Simulate impact of future customer loads and behaviours e.g. PV, EV Vehicles, air conditioning, grid batteries

The project will involve investigating various platforms for implementing analytics and distribution state estimation system. Endeavour Energy currently has a load flow simulation package “Power Factory” which has SCADA integration capabilities. Endeavour Energy’s future DMS system may also be capable in providing the required functionality.

6.2.4.1 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Analytics and Distribution State Estimation	0	20k	80k	80k	90k

6.2.5 Drone Line Inspections

Flying a drone commercially Beyond Visual Line of Sight (BVLOS) requires Flight authorisation, and approvals can take in excess of 7 - 28 days to complete. As such, current regulation does not allow for autonomous flight on a predetermined path.

Manually piloted drones for close inspection of conductors and conductor hardware is already common practice, however the use is typically reserved non-distribution voltages (33kV to 132kV). Endeavour Energy already utilises drones for this purpose. There are also external companies that offer this service.

6.2.5.1 Scope

The scope of this project will include, but is not limited to:

- Determine viability of introducing drone technology into Endeavour Energy business as usual practices through a feasibility study
- Develop detailed use cases for drone technology
- Development of Endeavour Energy drone specifications
- Development of standard practices for use of drone technology
- Procurement and trial of drone technology

Automated drones could provide the following benefits:

- Automatic line inspection following a network fault. Drones could be automatically deployed from substations to determine the exact fault location and the extent of the damage.
- Cost efficient and more frequent routine visual inspection of overhead lines. This would avoid the need for helicopter patrols, for example, the yearly pre-summer bushfire inspections.

Manually piloted drones could provide the following benefits:

- Reduced inspection times.
- Cost effectiveness.
- Provides a more detailed inspection, which could assist in identifying failures such as insulators cracks, conductor damage and cross arm deterioration.
- Avoid the need to traverse difficult terrain.

6.2.5.2 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Drone Line Inspection	0	50k	360k	100k	0

Endeavour Energy

6.2.6 IPAD Forms Rollout

6.2.6.1 Scope

The scope of the project will include, but is not limited to:

- Developing maintenance forms and ensuring accurate collection of asset information and failure data.
- Liaising with the appropriate staff to ensure terminology and formatting are aligned with the current operating practices of the organisation;
- Facilitating the appropriate level of change management to ensure Field Staff understand their responsibilities and benefits of the new maintenance forms.

6.2.6.2 Scope

Current data capture methodology does not allow the asset data to be analysed efficiently and effectively. Some of the deficiencies include:

- Manufacturer and models are often incorrectly or inconsistently recorded
- Corrective tasks carried out during planned maintenance activities are generally not captured, as current data capture methodology is too onerous; and,
- Defects data recording largely relies on free text comments, which leads to inconsistent or incomplete records.

Endeavour Energy's 2016/17 priority is to "Manage assets commercially" as follows:
"Optimise assets through decisions supported by timely and accurate data and benchmarking efficiency"

6.2.6.1 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
IPAD Forms Rollout	0	0	75k	75k	50k

Endeavour Energy

6.2.7 Non-destructive Pole Inspection

Endeavour Energy currently perform destructive inspections techniques on timber poles, which involves drilling holes in the pole below ground line. This practice accelerates fungal decay and reduces the functional service life of the asset.

Endeavour Energy plan to investigate non-destruction internal inspection techniques for timber poles improving asset functional service life reliability, deferring pole replacement requirements and reducing the risk of functional failures which can have high consequences, including public safety and bushfire ignition.

6.2.7.1 Scope

Investigate non-destruction internal inspection techniques for timber poles.

Current internal inspections of timber poles are considered destructive, and the inspection involves drilling holes in the pole below ground line. This practice accelerates fungal decay and reduces the functional life of the pole.

Endeavour Energy currently has around 300,000 timber poles. Replacement of a timber pole, including labour, is around $8,000 per pole. Non-destructive techniques could provide the following benefits:

- Avoid premature pole replacement, thus extending the useful life of timber poles.
- Avoid accelerating fungal decay introduced by the current destructive techniques.
- Non-destructive techniques may increase the effectiveness of the internal inspection, thus reducing the number of functional failures. Functional pole failures can have high consequences, including public safety and bushfire ignition.

Endeavour investigated non-destructive technique approximately 10-15 years ago. The conclusion of this study was that the current drilling method was the most effective method. Recent technological advancements may provide new opportunities with and more core effective techniques.

6.2.7.1 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Non-destructive Pole Inspection	0	0	200k	280k	0

6.3 Initiatives to Facilitate Customer Opportunities

6.3.1 Demand Response (AS4755) Trial

6.3.1.1 Introduction

Australian Standard AS/NZS 4755 defines the framework for demand response capabilities and supporting technologies for electrical products. This standard creates a framework that will allow off-the-shelf equipment, communication technologies and electrical products to be integrated and adapted so that demand management solutions may be developed and deployed in a timely and economical fashion.

The availability of electrical products that are AS4755 compliant provides an opportunity for Endeavour Energy to reduce peak demand. During critical peak demand days, a demand response signal is sent to a Demand Response Enabling Device (DRED) to limit the amount of power that a DRED-enabled electrical product such as air conditioners, swimming pool pumps, electric storage water heaters, electric vehicle chargers and electrical energy storage systems, can consume in comparison to its nominal full load power consumption. The aim is to reduce overall demand to the supply network at times of critical peak load.

Home automation technology will also be integrated into the system in order to connect to smart appliances like thermostats for heating and cooling, fridges, washing machines, and other appliances. These smart appliances are able to communicate using the home WiFi which makes it capable of being remotely controlled and monitored.

In this scenario, Endeavour Energy will send a demand response signal to the customer at times of critical peak demand. When the customer agrees to participate in the demand response event, Endeavour Energy will send a signal to the connected appliances in order to limit the demand from the premises for that period. Customers will be incentivised for participating in the event.

6.3.1.2 Scope

This initiative will mainly be structured as a demand management trial which involves the following:

- Identifying a constraint in the network as a target area
- Recruiting customers to participate in the program
- Supply and installation of DREDs to AS4755 compliant electrical products which includes:
    - Air conditioners
    - Swimming pool pumps
    - Electric storage hot water systems
    - Electric vehicle chargers (proposed)
    - Battery energy storage system
- Supply and installation of smart thermostats and the application to remotely control its operation
- Incentivising the customer in return of demand reduction

6.3.1.1 Budget and Timeline

At the moment, most air conditioner manufacturers offer the AS4755 functionality in their products. The availability of AS4755 compliant electric hot water systems, swimming pool pumps and electric vehicle chargers are yet to be seen.

The estimated budget is around $500,000 for 3 years from FY2019/20 up to FFY2021/22.

6.3.2 Residential Battery System

6.3.2.1 Introduction

The customer battery system is proposed for the North West sector of Sydney where significant load growth associated with the North West Rail Link is forecast. This pilot is to determine what incentives and control issues are associated with batteries installed within customer's residential dwellings. If successful this pilot will form part of Endeavour Energy's suite of demand management solutions which include air-conditioning and pool pump control.

Customers with existing PV and battery system can sign up for a program and Endeavour Energy will offer financial incentive for allowing Endeavour to control their battery system for demand management purposes.

6.3.2.2 Scope

The scope of this project will include, but is not limited to:

- Demand Management trial to determine the following:
    - Determine customer acceptance over external control of their system
    - Test the performance of controlling the inverter remotely (DRM modes)
    - Quantify the potential network demand reduction
- Potential deployment in locations with particularly poor PQ

6.3.2.1 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Residential Battery System	50k	50k	200k	200k	70k

6.3.3 Smart Inverter Integration

6.3.3.1 Introduction

Strategic integration with new inverters offering remote generation management capabilities such as the SunSpec protocol or AS4777.2:2015 compliant equipment with AS4755 capabilities could be enabled by advanced analytics for the efficient operation of the electricity network to support localised system stability, increased hosting capacity and assist in spot price stability. Improved market spot and dispatch price stability will provide financial benefits to all participants in the Electricity Market, including customer consumers and prosumers.

SunSpec is an open standard protocol facilitating the interoperability of distributed energy resources. The inclusion of Section 6 – "Operational Modes and Multiple Mode Inverters" within AS4777.2:2015 provides Endeavour Energy with an opportunity to strategically utilise:

- DRM modes on AS4755.3 compliant inverters to improve local network utilisation
- Improved PQ responses

6.3.3.2 Scope

The scope of this project will include, but is not limited to:

- Targeted Demand Management programs;
- Potential deployment in locations with particularly poor PQ;
- Distributed Inverter operation to assist in AEMO's management of network stability, and
- Improve LV load stability to reduce number of Zone Substation tap change and cap bank operations
  - Develop a virtual STATCOM as a proof of concept alternative to zone substation capacitor banks or distribution line voltage regulators

Qualitative financial benefits can be derived from:

- Non-network solution for Demand Management projects;
- Ensuring compliance to expected inclusion of Voltage management within STIPS scheme;
- Improve Power Quality for customers in locations with poor PQ, and
- Improved asset operations – reduced maintenance requirements.

6.3.3.3 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Smart Inverter Integration	54k	19k	46k	140k	0

6.3.4 Demand Response Management System (DRMS) Enhancements

6.3.4.1 Introduction

The Demand Response Management System (DRMS) was developed and deployed as part of the Smart Grid initiative for trialling various demand response initiatives. To date, it has been employed for the PeakSaver, CoolSaver and Endeavour Energy SolarSaver demand response programs.

The DRMS has the following capabilities:

- Creation and management of demand response programs;
- Enrolment and management of customers who are participating in programs;
- Scheduling and initiating ad hoc demand response events;
- Provision of notifications and feedback to enrolled customers about the demand response event;
- Forecasting customers' demand (when there is a planned demand response event) and then afterwards calculating whether they are entitled to an incentive payment for reducing their energy usage; and
- Interfacing with the metering database to validate customer data and usage.

To support future trials and programs, enhancements would need to be made to the DRMS.

6.3.4.2 Scope

The scope of this project will include, but is not limited to:

- Updating the DRMS and fixing any known bugs to enable functionality initially programmed to be operational;
- DRMS enhancements including:
  - Integration with online program registrations forms to manage customer enrolments;
  - Integration with Endeavour Energy systems and databases to verify and validate customer data during enrolment in programs;
  - Mechanism to send a demand response event notification to SCADA or another system for both scheduled or ad hoc demand response events to initiate events and send customer notifications;
  - Updating the user interface to initiate event commands to have direct load control of enabled devices such as air conditioners, swimming pool pumps, electric storage water heaters, energy storage batteries and electric vehicle chargers;
  - Direct interaction with customers' appliances such as fridges, dishwashers, washing machines and dryers; and limiting their power consumption during a peak period; and
  - Forecasting the effect of creating a demand response event.

6.3.4.3 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
Demand Response Trial	100k	100k	100k	100k	100k

6.3.5 LV Statcoms

6.3.5.1 Introduction

A Static Synchronous Compensation (STATCOM) is a voltage regulating device based on a power electronics voltage-source converter. It can act as either a source or sink of reactive AC power allowing management of voltage fluctuations or flicker, and control over power factor. When installed on the LV network STATCOMs are an effective tool to manage power quality issues such as voltage outside of limits, excessive voltage unbalance and flicker introduced by PV, load imbalance or potentially in future EV charging.

Endeavour Energy will investigate the efficacy of LV STATCOMs to address PQ issues on the network as an alternate approach to costly network augmentation. As LV STATCOMs can control voltage rises they have potential to enable more customers to utilise the grid for distributed generation export. These devices also support conservation voltage reduction, by flattening the LV voltage drop profile and allowing the average voltage for many customers to be reduced. It is envisaged the LV STATCOMs will be pole mounted units capable of correcting PQ issues on medium to heavily loaded LV feeders or supporting the broader HV feeder voltage when operating in aggregate.

6.3.5.2 Scope

To investigate use of LV STATCOMs for application within Endeavour Energy's LV network. The pilot will involve installing four pole mounted LV STATCOMs on heavily loaded feeders with PV generation.

As LV STATCOMs can control voltage rises they have potential to enable more customers to utilise the grid for distributed generation export. It is envisaged the LV STATCOMs will be capable of correcting PQ issues on medium to heavily loaded LV feeders.

6.3.5.1 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
LV Statcom	80k	100k	160k	120k	120k

6.3.6 Electric Vehicle V2G, Charging infrastructure and transport electrification

6.3.6.1 Introduction

With Electric Vehicles (EV) become increasingly affordable the uptake rate is projected to increase. Numerous independent studies have indicated varying uptake rates for EV's; but have also indicated that if EV charging remains unmanaged that once the penetration of EV passes certain volumes, it could lead to significant Power Quality issues to the electricity grid, impacting on Endeavour Energy's customer's electricity supply. It therefore remains in the best interest of both Endeavour Energy and the customers for the business to stay abreast of the technology, and contribute to the development of future standards and installation practices.

Customers may also wish to leverage the storage within the EV battery to trade on the electricity whole market. Trialling Vehicle to Grid (V2G) technology will provide Endeavour Energy with insight into the potential impacts of this technology on the Network and AEMO market prices, and develop strategies to integrate it with other initiatives to improve network operation (i.e. Smart Inverter Integration).

6.3.6.2 Scope

The scope of this project will include, but is not limited to:

- Electric Vehicle(s) included to Endeavour Energy Fleet
- Pilot different charging technologies at Endeavour Energy sites:
    - Gain practical experience with the different standard Connections
    - Type 2 - 3 phase connector (VDE-AR-E 2623-2-2/Mennekes)
    - IEC62196-1, AS IEC62196.2
- Performance/Impact assessment on different charging technologies:
    - Mode 3 charging (IEC61851-1)
    - DC Fast Charging
- Test Vehicle 2 Grid technology for potential future DM applications
    - The Esprit Curtailment Technology was used for load shifting in the UK
- Potential Trial for strategic deployment of Public charging stations
- Engage in commercial agreements with Councils to deploy potentially controllable EV changing
- Potentially Investigate public charging payment systems/models:
    - Direct payment
    - Network Fees
    - Third Party systems etc.
- Finalise Charging Infrastructure deployment strategy
- Define demand management strategy for Public Vs Private Charging
- Network utilisation

6.3.6.3 Budget and Timeline

Project ($)	19/20	20/21	21/22	22/23	23/24
V2G	0	50k	90k	50k	0