Pilot New and Innovative Technologies

Project № PJ1407

Project Justification

This document justifies capital expenditure on the United Energy network.

REPEX Road Map

1. Asset Replacement – Modelled

a. 6 modelled asset categories

2. Asset Replacement – Modelled & Unmodelled

a. Pole top structures + SCADA/protection

3. Other Repex - Unmodelled

a. ZSS Primary Asset Replacement

   (i) CEES - Capacitor Banks + Earth Grid + Neutral Earthing Resistors

   (ii) CEES - Buildings

b. Non VBRC Safety Projects

   (i) Intelligent Secure Substation Asset Management (ISSAM) – UE PL 2401 e.g.CCTV

c. Operational Technology

   (i) OT Safety

   - Service Mains Deterioration Field Works – PJ1385
   - In Meter Capabilities IMC) – PJ1386
   - Light Detection and Ranging (LiDAR) Asset Management – PJ1400
   - OT Security – PJ1500
   - DNSP Intelligent Network Device – PJ5002

   (ii) OT Reliability

   - Distribution Fault Anticipation Data Collection and Analytics (DFADCAA) – PJ1599
   - Fault Location Identification and Application Development – PJ1600

   (iii) OT Other

   - Dynamic Rating Monitoring Control Communication (DRMCC) – PJ1413
   - ~~Test Harness – PJ1398~~
   - Pilot New and Innovative Technologies – PJ1407

d. Network Reliability Assessment UE PL 2304 – Projects

   (i) Automatic Circuit Re-closers (ACRs) and Remote Control Gas Switches (RCGSs)

   (ii) Fuse Savers

   (iii) Rogue Feeders

   (iv) Clashing

   (v) Animal Proofing

   (vi) Communications Upgrade

e. CEES – Environment

f. CEES – Power Quality Maintained

g. Terminal Station Redevelopment HTS and RTS - UE-DOA-S-17-002 & UEDO-14-003

4. VBRC Projects

a. HV Aerial Bundled Cable Strategic Analysis Plan - UE PL 2053

b. DMA and MTN Zone Substation Rapid Earth Fault Current Limiter (REFCL) Installation

c. Other VBRC projects

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1. EXECUTIVE SUMMARY

Project description

The purpose of the "Pilot New and Innovative Technologies" project is to undertake pilot studies for nine technologies that have the potential to deliver significant benefits in relation to asset management efficiency, safety, reliability, power quality, risk mitigation and reduced costs to customers.

Project Driver

The pilot schemes will identify innovative applications of new technology to meet our statutory and regulatory obligations and maximise net benefits to customers in the longer term.

Benefits

UE has an established track record in exploring the potential for new technology to improve the safety, performance and efficiency of the electricity distribution network. The benefits of UE's leadership in new technology are best demonstrated by the Government's current proposal to amend electricity safety regulations to require the installation of REFCLs to minimise bushfire risk in Victoria. UE installed the first Australian REFCL at Frankston South Zone Sub Station (ZSS) in 2010. UE's early adoption of this technology has provided valuable experience and information for the Australian distribution sector. Similarly, UE's investment in new technology has led to its successful deployment of Early Fault Detection devices mounted on lines to detect partial discharge and alert the Network Control Centre before the issue develops in to an outage. This technology can detect damaged hardware like insulators before they completely break down and cause an outage.

The "Pilot New and Innovative Technologies" project continues UE's current approach to developing new technology. The project will provide UE with direct practical experience in the deployment of various new technologies to deliver a wide range of potential benefits. The data and experience gained through the various pilot studies will enable UE to identify those which offer the highest net benefit, and will inform future decisions about the scale and location of the deployment of those technologies across UE's network to maximise the net benefits to customers.

Options analysis

Given the nature of the project, it is not possible to demonstrate unequivocally that its net benefit exceeds the status quo 'reference case'. However, it is possible to form a view as to whether the pilot scheme has reasonable prospects of providing benefits that exceed the project's costs. The table below presents the alternative options.

Table 1: Option Evaluation

Options	PV costs ($M)	PV benefits ($M)	Net Present Value ($M)	PVR (Benefit to Cost Ratio)	Ranking
Reference Case (Status Quo)	0	0	0	0	2
Option 1 - Pilot New and Innovative Technologies	**5.94**	**Pilot studies to determine**	**Pilot studies to determine**	**N/A**	**1** (See Table 2)

As shown in Table 1, the reference case delivers a net benefit of zero. In order for the project to be preferred, the likely benefits would need to exceed the project cost of $5.94 million in present value terms. Table 2 describes the potential benefits, and their magnitude. It is noted that a portfolio of nine pilot studies, each using different, potentially viable technologies is proposed, recognising that some will have a higher probability of success than others. However, at this stage it is not possible to identify the most economic technologies until the proposed pilot studies are completed.

Table 2: Analysis of potential benefits from pilot schemes

Pilot	Potential benefits	Scope / magnitude of potential benefits
Online Dissolved Gas Analysis of Transformer Oil	• Avoidance of costs of transformer failure • Extended transformer life • Lower transformer testing costs	The technology enables remote testing as often as every two hours. This will provide accurate and timely detection of imminent transformer failure, which could otherwise lead to unplanned supply interruptions and unplanned asset replacement costs of many millions of dollars.
24/7 Partial Discharge (PD) / Corona / Infrared (IR) and Ultraviolet (UV) Monitoring	Rapid, low cost identification of insulation deterioration will inform intervention actions that will improve safety, avoid asset damage, reduce electricity losses, reduce noise and radio interference, and reduce costs.	Failure of porcelain insulators due to PD can cause porcelain debris to be projected at high speed, resulting in increased fire risks, damage to neighbouring assets (potentially costing millions of dollars) and a threat to health and safety.
Develop IEC61850 strategy	Adopting the IEC 61850 standard for design of electrical substation automation: • enables a more scalable, replicable substation design; and • improves communication capability with network monitoring devices to substations for onsite troubleshooting.	Potentially significant longer term capital expenditure efficiency benefits through standardisation and enhanced network monitoring capability.
Solid State Circuit Breakers	Enables rapid fault clearance, thus reducing fire risk.	Potentially significant benefits in terms of fire risk reduction.
LV Smart Fuses	This technology automatically restores supply to LV connected customers following a transient fault, thereby reducing the reliability impacts of such faults.	Potentially material contribution to maintaining reliability and customer satisfaction.
Remote Control Pole Capacitor Banks	• Enables power factor to be kept as close to the desired value as possible • Reduces network losses. • Enables correction of over and under voltage situations due to varying loads and distributed generation.	If fully deployed, this technology would make a material contribution to maintaining quality of supply, reducing network losses and potentially deferring capital expenditure.
Static Var Compensators (SVCs)	Increases transfer capability and reduces losses while maintaining a smooth voltage profile under different network conditions. The dynamic stability of the grid can also be improved.	The pilot will identify those parts of the network where use of SCVs will maximise net benefits to customers.
Remote Control LV Voltage Regulators (VR)	Manually operated VRs already installed on UE's network enable management of supply quality issues of flicker and excessive voltage drop. This pilot assesses the benefits of remote control and operation of VRs.	This project will enable UE to maintain quality of supply by implementing remote control and operation of all VRs.

Pilot	Potential benefits	Scope / magnitude of potential benefits
Fuel Cells	Fuel cells provide a very efficient source of distributed generation with low carbon emissions. This study will evaluate the current Fuel Cells available and select an appropriate number for a small customer pilot.	If the pilot is successful the results will lead to more widespread deployment of low carbon, high efficiency fuel cell technology by customers.

Recommendation

It is recommended that the "Pilot New and Innovative Technologies" project should proceed, as it is likely to identify applications of new technology that will provide potentially very significant net benefits. UE's track record in relation to REFCL and fuse saver technology provides tangible evidence that continued investment in new technology is warranted.

2. Objectives / Purpose

The purpose of this project is to undertake pilot studies of new technologies that have the potential to deliver significant benefits in terms of customer service, asset management efficiency, safety, reliability and power quality, and risk mitigation.

The project continues UE's successful record in developing new technology. The project will provide UE with direct practical experience in the deployment of various new technologies to deliver a wide range of potential benefits. The data and experience gained through the various pilot studies will enable UE to identify those which offer the highest net benefit, and will inform future decisions about the scale and location of the deployment of those technologies across UE's network to maximise the net benefits to customers.

3. Strategic Alignment and Benefits

3.1 Asset Management Strategy and Strategic Themes Alignment

This project supports the following key UE strategic themes:

- Ensuring on-going safety, compliance, performance and resilience of the increasingly complex distribution network
- Reducing safety and bushfire risks
- Improving asset management and enable field resources effectiveness
- Meeting customer expectations of a safe and reliable electricity supply
- Maintaining systems to industry standard.

3.2 National Electricity Rules Expenditure Objectives Alignment

This project aims to identify innovative applications of new technology that will enable UE to meet its capex objectives prudently and efficiently, in accordance with the requirements of the National Electricity Rules. It aims to facilitate efficient investment in, and efficient operation of UE's network for the long term interests of electricity consumers, in accordance with the National Electricity Objective.

In relation to safety, a number of pilot schemes are focused on delivering better safety outcomes consistent with our statutory obligation to identify and manage risk to a level that is as low as reasonably practicable (ALARP).

4. Alternative options considered

4.1 Background and Identified Options

The following options have been evaluated in the context of UE's current business and the need to manage an increasingly complex distribution network:

- Reference Case: The "Reference Case" will maintain the status quo
- Option 1: Undertake the proposed New and Innovative Technologies project

The portfolio of nine pilot studies encompasses a wide range and large number of different, potentially viable technologies. In this sense, Option 1 embodies a large number and combination of potential options.

4.2 Reference Case - Status Quo

The Reference Case will maintain current processes and practices, with no additional effort being made to explore the scope for new technology to improve safety, maintain quality and reliability of supply, extend asset life, improve customer service and reduce power losses.

4.3 Option 1 – Pilot New and Innovative Technologies

Option 1 involves UE undertaking nine pilot studies of innovative applications of new technologies, in the following areas:

1. Use of online dissolved gas analysis of transformer oil;
2. 24/7 monitoring of partial discharge, corona discharge, and use of infrared and ultraviolet monitoring;
3. Development of a strategy for the IEC61850 communications standard for zone sub stations;
4. installation of solid state circuit breakers;
5. installation of LV smart fuses;
6. installation of remote control pole capacitor banks;
7. installation of Static Var Compensators;
8. installation of remote control LV voltage regulators;
9. investigation of alternative fuel cell technologies.

The pilot studies will be completed over the five year period from 2016 to 2020.

The results of the pilot studies will inform decisions on the further development or application of new technology across UE's network. Those decisions will be subject to separate formal business case analysis.

Further details of the pilot studies, and the potential benefits of the technologies being examined are set out in Appendix A.

Option 1 has an estimated total capital cost (undiscounted) of $6.98M.

4.4 Technical Summary

Table 3: Technical Summary

Alternative	Reference Case (Status Quo)	Option 1 – Pilot New and Innovative Technologies
Technically Viable	Yes	Yes
Addresses Reliability	No	Yes
Enhances Network Flexibility	No	Yes
Comments	Technically viable but does not investigate the scope for new technology to enhance the long term interest of electricity consumers.	Technically viable. Provides potential for significant net benefits to be achieved in terms of improving safety, maintaining quality and reliability of supply, extending asset life, improving customer service, reducing power losses.

5. Economic Evaluation

5.1 Evaluation of Options

The table below provides a summary of the costs and benefits of Option 1 relative to the Reference Case. However, the purpose of the pilot scheme is to determine the expected benefits from the innovative use of a range of new technologies. For this reason, the benefits of the pilot scheme are shown as “To be determined”.

Table 4: Cost and benefits of Options (in present value terms)

	"Status Quo" Reference Case	Option 1: Pilot New and Innovative Technologies
Costs: **Project Capex ($)**	**$0**	**$5,944,761**
Potential Benefits	$0	To be determined
Net Present Value ($)	**$0**	**To be determined**

As shown in Table 1, the reference case delivers a net benefit of zero. In order for the project to be preferred, the likely benefits would need to exceed the project cost of $5.94 million in present value terms. Table 2 describes the potential benefits, and the magnitude of these. It is noted that a portfolio of nine pilot studies, each using different, potentially viable technologies is proposed, recognising that some will have a higher probability of success than others. However, at this stage it is not possible to identify the most economic technologies until the proposed pilot studies are completed.

Table 5: Analysis of potential benefits from pilot schemes

Pilot	Potential benefits	Scope / magnitude of potential benefits
Online Dissolved Gas Analysis of Transformer Oil	Avoidance of costs of transformer failure Extended transformer life Lower transformer testing costs	The technology enables remote testing as often as every two hours. This will provide accurate and timely detection of imminent transformer failure, which could otherwise lead to unplanned supply interruptions and unplanned asset replacement costs of many millions of dollars.
24/7 Partial Discharge (PD) / Corona / Infrared (IR) and Ultraviolet (UV) Monitoring	Rapid, low cost identification of insulation deterioration will inform intervention actions that will improve safety, avoid asset damage, reduce electricity losses, reduce noise and radio interference, and reduce costs.	Failure of porcelain insulators due to PD can cause porcelain debris to be projected at high speed, resulting in increased fire risks, damage to neighbouring assets (potentially costing millions of dollars) and a threat to health and safety.

Pilot	Potential benefits	Scope / magnitude of potential benefits
Develop IEC61850 strategy	Adopting the IEC 61850 standard for design of electrical substation automation: enables a more scalable, replicable substation design; and improves communication capability with network monitoring devices to substations for onsite troubleshooting.	Potentially significant longer term capital expenditure efficiency benefits through standardisation and enhanced network monitoring capability.
Solid State Circuit Breakers	Enables rapid fault clearance, thus reducing fire risk.	Potentially significant benefits in terms of fire risk reduction.
LV Smart Fuses	This technology automatically restores supply to LV connected customers following a transient fault, thereby reducing the reliability impacts of such faults.	Potentially material contribution to improving supply reliability and customer satisfaction.
Remote Control Pole Capacitor Banks	Enables power factor to be kept as close to the desired value as possible Reduces network losses. Enables correction of over and under voltage situations due to varying loads and distributed generation.	If fully deployed, this technology would make a material contribution to maintaining quality of supply, reducing network losses and potentially deferring capital expenditure.
Static Var Compensators (SVCs)	Increases transfer capability and reduces losses while maintaining a smooth voltage profile under different network conditions. The dynamic stability of the grid can also be improved.	The pilot will identify those parts of the network where use of SCVs will maximise net benefits to customers.
Remote Control LV Voltage Regulators (VR)	Manually operated VRs already installed on UE's network enable management of supply quality issues of flicker and excessive voltage drop. This pilot assesses the benefits of remote control and operation of VRs.	The pilot may enable UE to maintain quality of supply by implementing remote control and operation of all VRs.
Fuel Cells	Fuel cells provide a very efficient source of distributed generation with low carbon emissions. This study will evaluate the current Fuel Cells available and select an appropriate number for a small customer pilot.	If the pilot is successful the results will lead to more widespread deployment of low carbon, high efficiency fuel cell technology by customers.

Option 1 is not the least cost option at a present value cost of $5.94M. However, potentially significant future benefits can be realised by piloting the various technologies under this option. For instance:

- Avoiding one Substation Transformer failure can result in capital savings in the order of $6M. This is the indicative cost of a replacement Substation transformer where associated control and monitoring equipment does not have to be replaced.
- Preventing one bushfire can avoid a multi-million dollar insurance claim cost; avert reputation damage and other associated costs impacting the business.

- Utilising IEC 61850 in the implementation of a new substation can significantly reduce costs. The Life Science Journal 2013, Volume 10(3) reported that for a Substation Automation System on 110 kV Protection and Control Schemes for which the main automation component was IEC61850, 76.7% cost savings were achieved compared to conventional implementations. In UE's case, these savings can easily total several millions of dollars.

In view of these considerations, Option 1 is recommended on the basis that the expected future benefits from the full scale deployment of at least some of the piloted technologies are likely to be realised. A summary of the potential benefits is provided in the next section. Further details of the pilot studies and their potential benefits are provided in Appendix A.

5.2 Summary of benefits

The recommended option, Option 1 has the potential to provide the following key benefits.

Table 6: Option 1 Benefits Summary

Benefits -> Initiatives ↓	Maintain Network Quality of Supply, Security, Reliability	Lower asset costs, and or extend asset life	Improved customer service / increased customer information and or notification	Reduce risk including risk of fire	Reduce Power Losses	Improved asset information history	Improved network and or labour effectiveness	Automation	Lower unplanned outages. Constrain over target Outages	Utilise low emissions energy to contribute to a low carbon economy	Reduced asset down time
Online Dissolved Gas Analysis of Transformer Oil (ODGAoTO)	✓	✓		✓		✓	Possible	✓	Possible		✓
24/7 Partial Discharge (PD) / Corona / Infrared (IR) and Ultraviolet (UV) Monitoring	✓	✓		✓	✓	✓	Possible		Possible		✓
Develop IEC61850 strategy and pilot	✓	✓				✓	Possible	✓			
Solid State Circuit Breakers	✓	✓	✓	✓		✓		✓			
Smart Fuses	✓	✓	✓	✓		✓		✓	Possible		✓
Remote Control Pole Capacitor Banks	✓	✓	✓	✓	✓	✓	Possible	✓			
Static Var Compensators	✓	✓	✓	✓	✓	✓	Possible	✓			
Remote Control and Monitoring of HV / LV Voltage Regulators	✓	✓	✓	✓	✓	✓	Possible	✓			
Fuel Cells	✓	✓	✓			✓	Possible			✓	

Appendix A provides further details of the potential benefits of the various technologies being examined in the pilot studies.

5.3 Optimum timing and capex profile

The work will be spread over the five year period from 2016-2020, resulting in the forecast capital expenditure profile shown in the table below.

Table 7: Option 1 Estimated Annual Cash Flow

CAPEX Forecast in ($'000) CAPEX Type: Augmentation	2016	2017	2018	2019	2020	2016 -20 forecast total
Option 1 - Pilot New and Innovative Technologies	2,070.9	1,506.6	1,294.8	1,514.2	598.8	**6,985.3**

Note: The capex amounts shown in the table above are undiscounted, and are consistent with the present value costs shown for Option 1 in Table 4.

6. Project Financials

The project financials for internal budgeting purposes are detailed below.

Table 8: Project financials - Preferred Option (Option 1)

PROJECT COST	
AMP Approved Project?	Yes
Year Budgeted	2016 to 2020
Required Project Completion Date	31 Dec 2020
Budgeted Cost ($A excluding GST)	$6,350,000
Business Case Cost ($A excluding GST)	$6,350,000
Business Case Cost + UE overheads ($A excluding GST)	**$6,985,300**

Note: The capex amounts shown in the table above are undiscounted, and are consistent with the present value costs shown for Option 1 in Table 4.

7. Recommendation

It is recommended that Option 1 (the "Pilot New and Innovative Technologies" project) should proceed, as it is likely to identify applications of new technology that will potentially provide very significant net benefits. UE's track record in relation to REFCL and fuse saver technology provides tangible evidence that continued investment in new technology is warranted.

APPENDIX A – Description of Proposed Pilot Studies

A1 Online Dissolved Gas Analysis of Transformer Oil (ODGAoTO)

ODGAoTA is a comprehensive tool for assessing transformer condition in situ.

The current environment of higher loading on aging transformers, deferred capital expenditure and increased service reliability requirements have driven the industry to investigate the use of innovative transformer condition assessment and management tools. As transformers age, they endure various stresses that can contribute to a variety of failure mechanisms. Appropriate online ODGAoTO monitoring and diagnostic tools help avoid unplanned failures, leading to lower costs and extended transformer life.

Gas chromatography (GC) has long been the accepted standard for the measurement of dissolved gas levels in transformer oil. The sensor used in ODGAoTO provides accurate and repeatable measurement of the eight critical fault gases as well as other significant parameters. The sensor is mounted on or near the subject transformer, and so it brings the ODGAoTO laboratory to the transformer.

Through chromatography, the sensor generates individual measurements of eight critical fault gases found in transformer oil. Accuracy is commensurate with traditional lab results. The sensor continually collects oil samples as often as every two hours. The sensor can also measure moisture in the oil, oil temperature and ambient temperature. ODGAoTO results and other measurement data are date/time stamped and can thus be correlated to transformer load.

The software package included with the sensor allows the user to graphically display continuous gas evolution for each of the eight critical fault gases as well as moisture, load and ambient temperature. It also allows the user to trace changes in fault severity over time through dynamic plots created using the Duval Triangle and Rogers Ratios analysis tools.

Remote IP communications monitoring is implemented either through a cellular modem or fibre Ethernet.

UE will perform a pilot to determine whether this technology is effective and suitable for wide deployment across the UE network. The pilot will determine how the data will be collected and if the data collected will be initially fed in to UE's Analytics systems. A cloud solution is preferred with the vendor handling communication from the ODGAoTOs to their cloud. If the pilot is successful UE will then source the data in the cloud and perform any additional analytics.

Benefits include:

- Remote monitoring of transformers is provided, with up to 2 hourly data sampling.
- Reduces CAPEX and OPEX through reduced manual transformer oil testing, with the aim of reducing multi-million-dollar Transformer failures.

A2 24/7 Partial Discharge (PD) / Corona / Infrared (IR) and Ultraviolet (UV) Monitoring

This pilot study investigates PD, Corona, IR and UV monitoring in order to inform intervention actions that will avoid asset damage, reduce electricity losses and reduce costs. Monitoring should preferably be automated with data automatically analysed and reported so that issues can be targeted and rectified.

In cases where PD and or Corona can be minimised or associated monitoring shows evidence of decaying assets about to fail, significant OPEX and CAPEX can be saved. For example, failure of porcelain insulators due to PD can cause porcelain debris to be projected at high speed, causing increased fire risks, damage to neighbouring assets (potentially costing millions of dollars) and a threat to health and safety.

Partial Discharge (PD)

A PD is a localized dielectric medium breakdown. The PD occurs across a portion of the insulation between two conducting electrodes, without completely bridging the gap between them. It is a sure sign of electrical insulation deterioration. The key to on-line, diagnostic partial discharge testing is to be able to differentiate between the dangerous and the benign.

The aim of this pilot study is to detect and quantify the problem in a short time and at a lower cost. Partial discharge testing methods fall into one of four categories: electrical, chemical, acoustical and optical. No technology can single-handedly detect every type of problem. By employing a variety of technologies as part of a predictive maintenance program, many problems will be detected and many failures will be prevented.

Traditionally, partial discharge tests have been performed on a periodic basis, approximately every 6 to 12 months. However, most standards relating to the online assessment of insulation systems recommend trending of data in order to provide the best assessment. Setting alarms or basing judgments on partial discharge pulse magnitudes alone are not sufficient.

Trending is the key factor in determining the condition of an insulation system. A low level of partial discharge increasing quickly will signify a major defect, while a high level of partial discharge that is stable indicates there is a major defect, but it is not getting worse.

There are several factors that may significantly affect partial discharge. The most important are electrical field, temperature, humidity or absolute moisture in the air, insulating fluid, load current and hydrogen pressure. Neglecting these factors may produce incorrect diagnostic conclusions resulting in missing a problem or producing a false alarm. In addition, correlating partial discharge characteristics to these factors frequently provides valuable information that allows one to further discriminate the type of partial discharge failure mechanism and to plan a more appropriate corrective action.

Corona

The localized electric field near a conductor can be sufficiently concentrated to ionize air close to the conductors. This can result in a partial discharge of electrical energy called a corona discharge, or corona. Corona occurs by stress of the electric field and is not current dependent. Therefore it can be revealed by UV inspection but not by thermographic equipment as the infrared (IR) technology does not locate corona.

Corona produced on a transmission line can be reduced by the design of the transmission line and the selection of hardware and conductors used in the construction of the line. For instance the use of conductor hangers that have rounded rather than sharp edges and no protruding bolts with sharp edges will reduce corona. The conductors themselves can be made with larger diameters and handled so that they have smooth surfaces without nicks or burrs or scrapes in the conductor strands.

The aim of this pilot study is to trial transmission line designs that are intended to reduce corona generation. The study will focus on network components where corona is significant enough to warrant addressing the issue.

The main reasons why corona needs to be addressed are detailed below:

- Corona from conductors and hardware may cause audible noise and radio noise
- Corona loss may be significant when compared with resistive loss of conductors
- Corona can cause damage to and failure of polymeric insulators.

Infrared (IR) and Ultraviolet (UV) Monitoring

Infrared (IR) and ultraviolet (UV) spectral ranges are deployed by different inspection technologies to detect different types of failures. While IR cameras, also known as thermal cameras, detect hot spots generated by current, UV cameras, also known as corona cameras, detect faults related to voltage which are invisible to IR cameras. Associated predictive maintenance includes alerts of potential damages and faults, and therefore deployments of IR and UV technologies in tandem. Thus, UV and IR are considered as complementary inspection technologies.

A3 Develop IEC 61850 strategy and pilot for the design of susbstation automation

This initiative has two components:

- Develop UE's IEC 61850 strategy for the Substation environment and associated IEC 61850 communications between Substations and SCADA data centres
- Build a Substation pilot to develop the IEC 61850 implementation template for future deployment.

Benefits of IEC61850 Communication Standard in Substations

Substation automation is one of the first steps utilities are taking to maintain grid reliability, enhance security, and reduce costs of managing the grid. Adopting industry standards such as IEC 61850 can help drive down OPEX by converging on a common communications protocol. The degree of adoption of IEC 61850 standards can vary. Therefore, it is important that a strategy be formulated to define the high level objectives, requirements, solutions and roadmap to enable the migration path from conventional SCADA and hardwired protection systems to IEC 61850 to maximize the useful life of existing assets.

Adopting a communications standard such as IEC 61850 provides several benefits:

- First, it allows communications interoperability among devices, and no longer locks a utility into a particular vendor's solution.
- Second, a standards based network enables a more scalable, replicable substation design which can streamline the test, setup, and reconfiguration of substation networks.
- A third benefit is that with devices now addressable on an IP network, grid operations improve their visibility and remote engineering access to the network. This reduces time travelling to substations for onsite troubleshooting.
- And finally, as Distributed Energy Resources continue to scale up, substation automation provides valuable instrumentation to manage and control variable energy supplies.

In summary, automating substations with networking devices such as routers and switches enables utilities to manage, control, and automate remote grid assets more efficiently, thereby converging network functions and streamlining grid operations.

IEC61850 also standardises and reduces cabling in the Substation with most protection, control and monitoring devices having only two IP cables for X and Y connections to the local Substation X and Y switches. The wiring simplification provides agility and reduces time to deploy Control, Protection and Monitoring Substation solutions.; This removes the need for using large numbers of copper wires, thus providing considerable cost reductions.

A4 Solid State Circuit Breakers

This study assesses the effectiveness of Solid State Circuit Breakers (SSCBs) installed in the transformer Neutral earth Resistance (NER) circuit to fast open the Transformer Neutral to Earth path and then trip the associated Transformer LV Circuit Breaker upstream from the fault. The benefit of SSCBs is to enable rapid fault clearance, thus reducing fire risk.

A conventional HV circuit breaker can take up to 60 seconds to open. In a fault where one of the phases is on the ground, 60 seconds is more than enough time to start a ground fire. By utilising a SSCB in the Transformer Neutral Earth Resistance (NER) path the fault current can be interrupted in less than 1ms which is insufficient time to start a fire. The SSCB will then send a trip signal to also open the transformer fault side circuit breaker.

There is no doubt that a successful SSCB pilot and future deployment of this technology has the potential to reduce fires, including bushfires, which can result in damage to public property and UE assets as well loss of human, livestock and other animal life. The resultant improvements in reliability will also provide a significant benefit to customers.

A5 LV Smart Fuses

The primary aim of this initiative is to test the feasibility of installing Smart Fuses to reduce the impact of transient faults on the network. If the Smart Fuses prove to be a reliable solution the project will provide enough data to develop a business case for the installation of a substantial number of units. The Smart Fuse debate on smart grids has developed significantly with the recognition that the Low Voltage Network will become ever more important as domestic scale renewable energy generation is expected to play an ever greater part in the transition to a low carbon economy.

The Smart Fuse has been designed to provide a high specification voltage and load profiling platform with full communications capability and a range of fault analysis applications under development. This initiative will provide the data needed to develop the network load modelling and profiling algorithms to support the optimisation of the low voltage network.

The scope of the project is to install up to 30 Smart Fuse units and Gateways in identified LV circuits. The Smart Fuse units are retrofitted to the LV Fuse position in the LV Fuse pillar with 3 Smart Fuse units installed per feeder (one on each phase). 30 units will provide coverage for 10 feeders and one gateway is needed in each substation where Smart Fuses are installed.

The objective is to demonstrate the advantages of being able to automatically restore supplies to LV connected customers and to gather data about the performance such a device delivers to the network. It is envisaged that other smart grid opportunities will arise once data has been gathered.

A6 Remote Control Pole Capacitor Banks

United Energy’s Pole Capacitor Banks (PCBs) are not currently remote controlled. The PCBs are controlled by local pre-set timers or local voltage control limits. The process of modifying the pre-set PCB switching parameters requires a predominantly manual process including a site visit.

These manual processes were sufficient in the past when the load profile had less variance and was more predictable. With the addition of distributed generation it is now important to be able to remotely control the PCBs so that power factor can be kept as close to the desired value as possible and reduce losses. This will also have the benefit of correcting over and under voltage situations due to varying loads and distributed generation.

The associated Remote Control PCB pilot will determine if the remote controls to the PCBs are required in a remote manual or automated fashion or a combination of both.

The above initiative when fully deployed will help maintain quality of supply, reduce network losses and potentially defer CAPEX.

A7 Static Var Compensators (SVC)

The SVC is a solid-state reactive shunt power compensation device based on high power thyristor technology. The main function of an SVC is to keep the network voltage constant at a set reference value.

An SVC can improve power system distribution performance in a number of ways. Installing an SVC at one or more suitable points in the network can increase transfer capability and reduce losses while maintaining a smooth voltage profile under different network conditions. The dynamic stability of the grid can also be improved, and active power oscillations mitigated. Portable SVCs are now available so that units can be relocated and installed in different locations within two weeks.

There are three main types of SVCs:

- Thyristor controlled reactor and fixed capacitor, TCR/FC
- Thyristor switched capacitor, TSC
- Thyristor controlled reactor / Thyristor switched capacitor, TCR / TSC

The combined TCR and TSC is the optimum solution. With a TCR / TSC compensator, continuously variable reactive power is obtained across the entire control range plus full control of both the inductive and the capacitive parts of the compensator.

The principal benefit is optimum performance during major disturbances in the power system, such as line faults and load rejections. TCR / TSC combinations are characterized by

- Continuous control
- No transients
- Elimination of harmonics via filters or TSR (thyristor switched reactor) control
- Low losses
- Redundancy
- Flexible control and operation

The aim of this pilot is to install an SVC at a preselected substation to measure the following benefits:

- Stabilize voltage at the receiving end of long lines
- Increase productivity as stabilized voltage means better utilized capacity
- Reduced reactive power consumption, which gives lower losses and improved tariffs
- Balance asymmetrical loads thus reducing system losses and enable lower stresses in rotating machinery
- Enable better use / utilisation of equipment (particularly transformers and cables)
- Reduced voltage fluctuations and light flicker
- Decreased harmonic distortion

The aim is to use the knowledge from this pilot to refine future SVC deployments in a systematic manner in areas of the network where SVCs are most needed.

A8 Remote Control and Monitoring of LV Voltage Regulators

UE currently has five (5) voltage regulators (VRs) in the network. The self-automated VR units solve the common utility problems of flicker and excessive voltage drop.

The power electronics contained in the VR dynamically regulate voltage flow up or down to within 1 per cent of a programmable set point, stabilising the voltage to its nominal set point voltage. This precise regulation of voltage ensures grid stability and compliance with appropriate service standards. The installation of the units on the pole currently involves the placement of three units on a pole, one for each of the three phase wires.

VRs have been implemented as decentralised assets without any form of centralised control. Although VRs can be manually operated they present significant challenges when there is a requirement to perform a quick reset. VRs that malfunction can produce high voltages that can cause damage to customer equipment; they can sometimes go in to a lockout condition where the unit can only resume normal operation after a being reset manually. Efficiencies and sustained quality of supply can be achieved by implementing VR remote control and monitoring of all VRs in the network.

A9 Fuel Cells

This initiative will perform analysis of the current Fuel Cells available and select an appropriate number for a small customer pilot. Assuming the pilot is successful the results will lead to future larger scale deployment for customers that want take up the option of Fuel Cell electricity generation.

Emitting 60 per cent less carbon dioxide than traditional combustion generators, and able to be used in a wide range of applications, fuel cells offer an alternative and cleaner solution to energy generation.

Fuel cells convert natural gas and renewable fuels like hydrogen into heat and power, and are particularly promising as a clean energy source because they increasingly address the need for higher efficiency energy production with relatively low greenhouse gas emissions.

While batteries store a limited amount of electrical energy, fuel cells instead consume fuel and are able to operate virtually continuously as long as the necessary flows of fuel and air are maintained.

Solid Oxide Fuel Cell (SOFC) technology is a prime example of a fuel cell that has electrical efficiency ranging up to 70 per cent. They mostly use hydrocarbon-based fuels and can be used for all types of stationary power and heat energy generation, from below 1 kilowatt to many megawatts.

Since the production of electricity is a direct process, SOFCs do not produce large quantities of greenhouse gases, nitrous oxides or sulphur oxides and only emit steam and possibly low levels of carbon dioxide (except where the fuel cell uses pure hydrogen). The production of heat makes SOFCs ideal for domestic combined heat and power applications, which not only produce heat for space heating and hot water, but also electricity which can be used around the house or fed back into the electricity grid. This process is considered to be more efficient than separate production of heat energy and electricity, with wastage through the generation, transmission and distribution process.

APPENDIX B - High Level Scope of Work

The scope includes:

- After business case approval, initiate project, identify and obtain resources
- Perform the following for each pilot study:
  - Plan equipment rollout and software changes
  - Purchase equipment and any software required
  - Rollout equipment and implement software changes
  - Test equipment and software functionality
  - Commission in to service
  - Modify processes and complete all documentation
- Closeout project