Fault Location Identification and Application Development

Project № PJ1600

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

This project is called ‘Fault Location Identification and Application Development’. It involves the installation of 1500 Power Line Monitoring devices with associated analytics to enable UE to identify and locate faults more quickly and precisely.

Project Driver

This project contributes to achieving the STPIS target. It is therefore consistent with our regulatory obligation to maintain reliability.

Benefits

The rapid and accurate detection and location of faults enables fault crews to be despatched directly to the fault location. This will shorten the supply restoration time following a fault, leading to an estimated SAIDI benefit of 1.5 minutes, which is a material contribution to achieving the STPIS target. It should be emphasised that this project is not self-financing, as its objective is to achieve (rather than exceed) the STPIS target.

Network investment efficiencies will also be achieved through improved asset management decisions. In particular, the monitoring devices will enable UE to replace some assets prior to failure, which is lower cost and also minimises the risk of damage to other assets.

Options analysis

Table 1: Overall Appraisal

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 – Installation of Power Line Monitors	2.34	4.57	2.23	1.96	1 Recommended
Option 2 – Installation of Power Line Monitors with enhanced tolerances	6.19	4.57	-1.62	0.74	3
Option 3	This option recognises that alternative capex and opex projects may deliver the same reliability benefits as Option 1, but at a lower present value cost. Chapter 7 of UE’s Network Reliability Assessment document ranks alternative reliability projects to identify the portfolio of projects that maximises net benefits.				

Notes:

Net Present Value = present value of benefits minus present value of costs

PVR (Present Value Ratio) = present value of benefits divided by present value of costs. The PVR measures capital efficiency. If the PVR > 1 then the project / option has a net present value (relative to the reference case) greater than zero, and is therefore economic. The greater this ratio the more efficient the capital.

Recommendation

It is recommended that Option 1 (Installation of Power Line Monitors) should proceed. The project employs new operational technology to quickly and accurately identify the location of network faults, enabling earlier restoration of supply to deliver an estimated SAIDI benefit of 1.5 minutes and improved capex efficiency.

Option 1 is the preferred option. It maximises net benefits, with a Net Present Value of $2.23 million. Option 1 also has the highest PVR, at 1.96.

It must be emphasised that this project is not self-financing. It is part of a portfolio of asset replacement plans and reliability programs, which together are forecast to achieve the STPIS target at minimum efficient cost. This project has been selected as it is ranked ahead of other reliability projects, as detailed in Chapter 7 of UE's Network Reliability Assessment.

2. Objectives / Purpose

The purpose of this project is to enable UE to maintain the quality, reliability and security of the supply of standard control services at minimum efficient cost. The project options being considered in this document will contribute to the achievement of this objective by improving UE's capability in identifying and locating faults.

3. Strategic Alignment and Benefits

3.1 Asset Management Strategy and Strategic Themes Alignment

This project supports the following strategic themes:

Ensure ongoing safety, performance, resilience and risk mitigation

Facilitate effective asset management

Maintain systems in accordance with industry standards

Prudent and efficient network investment.

3.2 National Electricity Rules Expenditure Objectives Alignment

This project is aligned to the regulatory objective of maintaining the quality, reliability and security of the supply of standard control services.

To ensure that we achieve this objective, all reliability projects have been ranked to identify the portfolio of projects that meets the STPIS targets at the minimum efficient cost. This ranking process is explained in Chapter 7 of UE's Network Reliability Assessment (document No. UE PL 2304).

4. Alternative Options Considered

4.1 Background and Identified Options

The installation of Power Line Monitors provides an enhanced level of monitoring on the 66kV, 22kV and 11 kV networks. Power Line Monitors are able to collect and process locally captured data at many points along the network, and communicate specific alerts and analysis to SCADA and associated master analytics systems for feeder and system wide studies.

Each Power Line Monitor communicates via new Master Power Line Bridges, installed at each Zone Substation. If a Master Power Line Bridge fails the redundancy is provided by another Master Power Line Bridge in the next closest Zone Substation. The SCADA systems will communicate to the Master Power Line Bridges and then on to the Power Line Monitors utilising the Internet Protocol (IP). Much like modern smart phones, Power Line Monitors can accept new applications downloaded over-the-air and configured to meet UE's evolving needs.

The primary driver for the project is reliability improvement. It must be emphasised that 'reliability improvement' recognises that this project is capable of making a positive contribution to achieving the STPIS target, noting that current performance is well below target. Whether this project should proceed depends on its ranking compared to other feasible reliability projects. This question is addressed in Option 3 below.

The following options have been evaluated:

Reference Case:	Under the "Reference Case", the status quo is maintained
Option 1:	Installation of Power Line Monitors
Option 2:	Installation of Power Line Monitors with enhanced tolerances
Option 3	Implement an alternative project to deliver the target reliability outcome

4.2 Reference Case - Status Quo

Under the Reference Case the current processes would remain unchanged. Under these processes, the precise location of a fault is often not able to be determined until a fault crew has been dispatched, and the crew has completed a patrol which often involves unnecessary drive / walk throughs of un-faulted areas.

4.3 Option 1 – Installation of Power Line Monitors

Option 1 will implement 1500 Power Line Monitors that will allow 500 three phase line points fault location indications and monitoring that include ambient temperature, current, voltages, limits and analytics to identify current and possible future faults. It also analyses previous faults to improve future fault detection capability.

The ruggedized Power Line Monitors can be clamped on live lines. They detect faults in 4 milliseconds and measure volts, current and ambient temperature at a 7.8 KHz sampling rate. This fast sampling provides data at 156 samples per cycle including 1st to 9th harmonics. Power Line Monitor features include:

- Faulted Circuit Indication;
- Detailed load monitor;
- High-resolution waveform capture;
- Line induction power and approximately 18 minutes back up power;
- Events and data sampling time stamped to the local GPS synchronised clock;
- Ability to define multiple upper / lower levels limits for current, temperature and ampacity; and
- Inter-operability with AMI network communication devices.

The Advanced Monitoring Platform provides ample analytics, field monitoring devices and distributed applications to deliver high-performance, distributed Intelligent Electronic Devices (IEDs) featuring substation-class measurement, and computing and processing capabilities.

The decentralized analytics under this approach maximizes the amount of information gathered in the field while optimizing the amount of communication bandwidth consumed, whereas the associated centralised data collection assists in the derivation of a more granular enterprise view. The overall head-end analytics functionality will identify network issues and alarm faults. The alarms will be fed to DMS for the Network Control Centre (NCC) and / or engineering personnel to action.

Option 1 delivers a SAIDI benefit of 1.5 minutes, which is a material contribution to the STPIS target.

The total capital cost of Option 1 is $2.830M. The total undiscounted cost of the option (including $81k of opex for software licences) is $2.911M.

4.4 Option 2 – Installation of Power Line Monitors with enhanced tolerances

Option 2 utilises an alternative Power Line Monitoring device to that described in Option 1. The device provides higher measured value tolerances including a wider temperature operating range.

The total capital cost of Option 2 is $7.622M. The total cost of the option (including $81k of opex for software licences) is $7.703M.

4.5 Option 3 – Implement an alternative reliability project

In relation to Option 3, chapter 7 of UE's Network Reliability Assessment (document No. UE PL 2304) ranks alternative reliability projects. Therefore, the preferred Power Line Monitoring solution will be compared against all other feasible options to ensure that the STPIS targets are met at minimum efficient cost.

Option 3 is addressed in chapter 7 of UE's Network Reliability Assessment (document No. UE PL 2304), and is not considered further in this project justification document.

4.6 Technical Summary

Table 2: Technical Summary

Alternative	Reference Case (Status Quo)	Option 1 – Installation of Power Line Monitors	Option 2 – Installation of Power Line Monitors with enhanced tolerances
Technically Viable	Yes	Yes	Yes
Addresses Reliability	No	Yes	Yes
Enhances Network Flexibility	No	Yes	Yes
Comments	Technically acceptable, but does not enable rapid and accurate detection and location of faults.	Technically acceptable. Enables rapid and accurate detection and location of faults.	Technically acceptable. As per Option 1, with the benefit of monitors with enhanced tolerances.

5. Economic Evaluation

5.1 Costs and benefits of Options

The table below provides a summary of the cost and benefits of Options 1 and 2 relative to the Reference Case. The table shows that although Option 2 involves the installation of Power Line Monitors with enhanced tolerances, it is not expected that these monitors will provide any additional benefits compared to Option 1.

Table 3: Cost and benefits of Options (in present value terms)

	"Status Quo" Reference Case	Option 1: Installation of Power Line Monitors	Option 2: Installation of Power Line Monitors with enhanced tolerances
Costs: **Project Capex ($)**	**0**	2,273,858	6,125,836
Project Opex ($)	**0**	62,808	62,808
Total Costs ($)	**0**	**2,336,666**	**6,188,644**
Benefits: **Reduced capex ($)** [1]	0	961,799	961,799
Improved reliability ($)	0	3,608,173	3,608,173
Total Benefits ($)	**0**	**4,569,972**	**4,569,972**
Net Present Value [3] **($)**	**0**	**2,233,305**	**-1,618,672**

The notes below apply to Table 3 above:

1. Options 1 and 2 deliver a capital expenditure efficiency of $100,000 per annum. These savings are achieved through the detection of imminent faults, enabling asset replacement to be undertaken on a planned rather than unplanned basis.
2. Similarly, Options 1 and 2 are expected to deliver a SAIDI benefit of 1.5 minutes by anticipating faults and reducing outages.
3. Net Present Value = present value of benefits minus present value of costs.

5.2 Evaluation of Options

Table 4 below shows that Option 1 is the preferred option because:

- it maximises net benefits at $2.23 million; and
- it has the highest PVR, at 1.96.

It must be emphasised that this project is not self-financing. It is part of a portfolio of asset replacement plans and reliability programs, which together are forecast to achieve the STPIS target at minimum efficient cost. Option 1 has been selected as it is ranked ahead of other reliability projects, as detailed in Chapter 7 of UE's Network Reliability Assessment (document No. UE PL 2304).

Table 4: Economic evaluation of options

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 - Installation of Power Line Monitors	**2.34**	**4.57**	**2.23**	**1.96**	**1 Recommended**
Option 2 - Installation of Power Line Monitors with enhanced tolerances	6.19	4.57	-1.62	0.74	3
Option 3	This option recognises that alternative capex and opex projects may deliver the same reliability benefits as Option 1, but at a lower present value cost. Chapter 7 of UE's Network Reliability Assessment document ranks alternative reliability projects to identify the portfolio of projects that maximises net benefits.				

Note: PVR (Present Value Ratio) equals present value of benefits divided by present value of costs. PVR measures capital efficiency:

- If the PVR > 1 then the project / option has a net present value (relative to the reference case) greater than zero, and is therefore economic. The greater this ratio the more efficient the capital expenditure.
- If the PVR = 1 then the project / option has a net present value of zero relative to the reference case. There is no net benefit and no net cost (relative to the reference case) of an option that has a PVR of 1.
- If the PVR < 1 then the project / option is not economic, because it has a negative net present value compared to the reference case.

5.3 Benefits Summary

The recommended option, Option 1 will provide the following benefits:

Table 5: Option 1 Benefits

Option 1 Benefits -> Initiatives ↓	Maintain Quality of Supply	Maintain Network supply Resilience / Compliance / security / Reliability	Extend asset life	Meeting Customer expectation of a safe and secure electricity supply	Mitigate Risk	Improved asset information history and or incident tracking	Enabler for network and or labour effectiveness	Realizing True Capacity by reducing supply peaks	Lower number of impacted customers for fault related unplanned outages	Enabler to reduce asset down time	Automate and implement self-healing / Reduce rushed operational Human decisions
Fault Location Identification and Application Development	✓	✓	Possible	✓	✓	✓	✓	Possible	✓	✓	Possible

Option 1 (Installation of Power Line Monitors) is expected to provide the following benefits:

- Assist in maintaining system reliability by delivering a SAIDI benefit of 1.5 minutes. It should be emphasised that this project is not self-financing, as its objective is to achieve (rather than exceed) the STPIS target.
- Estimated capital expenditure efficiencies equivalent to $100 k per annum due to improved asset management decisions.
- Helps manage energy flow, helps predict asset failures and therefore can assist in protecting against and reduce asset failure.
- Helps monitor and control power quality and maintain system reliability.

Table 5 shows that the proposed project will also deliver a number of ‘possible’ benefits, which are incidental or secondary to the primary benefits noted above. These possible benefits are not the key drivers for the project, but provide further reasons to proceed with the preferred option.

5.4 Optimum timing and expenditure profile

The work associated with Option 1 will be spread over the four year period commencing in 2017. The work will be prioritised by rating the benefits for each line / feeder, and installation of Power Line Monitors will be progressed in order of the highest benefit first.

Table 6 provides a summary of the capital and operating costs and timing for Option 1.

Table 6: Option 1 Costs and Timing ($M)

Expenditure ($000) CAPEX Type: AUGEX	2016	2017	2018	2019	2020	Total
Option 1 - Augmentation CAPEX	0	760.3	651.9	761.2	656.9	2830.4
Option 1 - Software licences OPEX	0	0.0	27.0	27.0	27.0	81.0
Option 1 - Total Expenditure	0	760.3	678.9	788.2	683.9	2911.4

Note: The expenditure amounts shown in the table above are undiscounted, and are consistent with the present value costs shown for Option 1 in Tables 1, 3 and 4.

6. Project Financials

The project financials for internal budgeting purposes are detailed below.

Table 7: Project financials - Preferred Option (i.e. Option 1)

PROJECT CAPITAL COST	
Year Budgeted	2017 to 2020
Required Service Date	31 Dec 2020
Budgeted Capital Cost ($A excluding GST)	$2,573,000
Business Case Capital Cost ($A excluding GST)	$2,573,000
Business Case Capital Cost + UE overheads ($A excluding GST)	**$2,830,400**

Note: The capital expenditure amounts shown in the table above are undiscounted, and are consistent with the present value costs shown for Option 1 in Tables 1, 3 and 4.

7. Recommendation

Option 1 will provide the benefits described in sections 4.1 and 4.3, and it is the most economic option because:

- it has the highest net present value of all the options, at $2.23 million; and
- it has the highest PVR of 1.96.

It is therefore recommended that Option 1 (Installation of Power Line Monitors with enhanced tolerances) proceed, subject to the results of the ranking of all alternative reliability projects.

APPENDIX A – HIGH LEVEL SCOPE OF WORK

The scope includes:

- After business case approval, initiate project, identify and obtain resources
- Perform the following:
  - Plan software and hardware changes
  - Rollout Power Line Monitors equipment in order of priority,
  - Develop applications, make hardware and configuration changes, and then suitably test
  - Initiate any customer programs that will improve and / or impact customer supply
  - Rollout new applications, commission in to service and validate functionality effectiveness
  - Modify processes and complete all documentation
- Closeout project