Service Mains Deterioration Field Works

Project № PJ1385

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

Service Mains Deterioration Field Works project consists of the required field works for the implementation of automated Neutral Integrity Testing described in the IT Project Justification "PJ12 - Network Analytics".

The system will detect Neutral Integrity issues at all AMI metered service mains (i.e. approximately 650,000) in an automated fashion using data from smart meters to avoid the need for manual Neutral Integrity Testing field visits. The system will identify unsafe situations as they develop, so corrective action can be initiated immediately to remove the hazard before a customer experiences a shock.

This project consists of upgrading the AMI communications network that was initially designed in 2009 to provide sufficient bandwidth to satisfy the mandated AMI requirements. The collection of 5 minute Voltage and Current data, that forms the foundation of realising advanced benefits from smart meters, will increase network traffic by more than 6 times. Currently the AMI network is not able to meet the additional bandwidth requirements that will be imposed. However, the AMI Communications network can be economically modified to meet the mandated smart meter requirements and cater for the additional meter data required.

The aim of the works is to increase the number of AMI network communication devices to support AMI network bandwidth increase.

Project Driver

Neutral Integrity Testing of each customer premises supply service main is a network and public safety ESV mandated regulatory obligation that must be performed at least once every 10 years. Regulation 27(2) of the Electricity Safety (Network Assets) Regulations 1999 provides that "Earthing systems, except common multiple earthed neutral earthing systems, and electrical protection equipment, except fuses, must be inspected and tested at least every 10 years for compliance with regulation 23". Regulation 23 details requirements in relation to earthing and electrical protection.

The cost of performing manual Neutral Integrity Testing is not in our 2014 base year Opex as manual Neutral Integrity Testing for all AMI metered services mains was completed as part of the AMI smart meter commissioning process carried out from 2009 to 2013; to confirm that the sites were safe and free from any Neutral Integrity issues.

In addition the Electricity Safety Act 1988, requires United Energy to "operate" a supply network to minimise as far as practicable:

(a) Risks to the safety of any person; and

(b) Risks of damage to property; and

(c) The bushfire danger.

The Electricity Safety (Management) Regulations 2009, require United Energy to treat/eliminate risk, and where this is not reasonably practicable, reduce the risk to as low as reasonably practicable (ALARP).

Benefits

1. Undertake automated Neutral Integrity Testing to achieve our Neutral Testing obligation at least cost.
    a. Improves Neutral Integrity Testing safety governance by automating and recording Neutral Integrity issues.
2. Safety: ALARP – Improves safety of UE field work force, customers and the public who could be impacted by related Neutral Integrity issues including electric shocks that can result in deaths:
    a. Reduces the risks of shocks by more than 50%, by identifying faults as they occur.
    b. Reduces the consequence of some faults, by identifying them immediately (i.e. candling fuses, and live wire down), this allows a faster response to secure and rectify an unsafe situation.

Options Analysis

- **Reference Case:** The "Reference Case" maintains the status quo, but does not address Neutral Integrity Testing and is therefore an unsuitable option.

- **Option 1:** Perform Manual Neutral Integrity Testing.
- **Option 2:** Perform the "Service Mains Deterioration Field Works" for 5 minute Neutral Integrity Data Reads in line with the Neutral Integrity Testing implementation of other Victorian DNSPs.
- **Option 3:** Perform the "Service Mains Deterioration Field Works" for 1 minute Neutral Integrity Data Reads. Option 3 is not aligned to other Victorian DNSPs Neutral Integrity Testing implementations, but does reduce the safety risk of Neutral integrity issues further, through faster monitoring and alerting.

The overall project cost summary is tabled below:

Table 1: Overall Appraisal Breakdown

Options	Total Cost of Ownership ($'M) 2	Total CAPEX ($'M) 2	Total OPEX ($'M) 2	Present value Cost ($'M)	Overal l Risk Rating	Benefits	Overall Rating (Best Ranking = Lowest value)
Reference Case (Status Quo)	0	0	0	N/A	High	N/A	Unsuitable, does not address our Neutral Integrity Testing safety obligation
Option 1 – Manual Neutral Integrity Testing	17.68 1	0	17.68 1	9.06	High	Performs manual Neutral Integrity Testing every 10 years	3 – Not recommended (High cost)
Option 2 - Service Mains Deterioration Field works for 5 Minute Neutral Integrity Data Reads	4.18	4.18	0	3.61	Low	Perform Neutral Integrity Testing at least cost, Safety (ALARP) – Reduce risk of electric shock by 50%	1 - Recommended
Option 3 – Service Mains Deterioration Field works for 1 Minute Neutral Integrity Data Reads	9.78	9.78	0	8.34	Low	Perform Neutral Integrity Testing lower cost, Safety (ALARP) – Reduce risk of electric shock by more than 50%	2 – Not Recommended (High cost)

The following notes apply to the "Overall Appraisal Breakdown" shown in Table 1 above:

[1] The Reference Case OPEX costs are those incurred in performing the 10 year cyclic Neutral Integrity site visits testing. Options 2 and 3 remove these costs. The cost shown is in fact only one third of the total manual Neutral Integrity Testing cost.

[2] The dollars shown in these columns are without any future value discounting.

Recommendation

3. Option 2 at a capital cost of **$4.177M** is recommended as it allows UE to meet the Neutral Integrity Testing safety obligation at least cost, and
4. In addition, it provides a network safety risk reduction (assessed as ALARP) by:
   a. Reducing the number of electric shocks by more than 50%, by identifying faults as they occur, before a customer experiences a shock.
   b. By facilitating automated detection of other faulty situations like wire down and fuse brown outs, to allow a faster response to make an unsafe situation safe.

2. Objectives / Purpose

The purpose of this project is to enable UE to maintain safety of the supply of standard control services, specifically in relation to providing Neutral Integrity functionality. This operational project is required for the implementation of the Neutral Integrity testing as described in the “IT EDPR Project Justification - Network Analytics”.

The total Neutral Integrity solution provided by this project and the associated IT Network Analytics project allows automated detection and notification when Neutral Integrity faults are detected that endanger customers, the public and UE employees.

3. Strategic Alignment and Benefits

3.1 Asset Management Strategy and Strategic Themes Alignment

This project supports the following key United Energy strategic themes:

1. Ensuring on-going safety, compliance, performance and resilience of the changing more complex distribution network
2. Reduce the risk of injury
3. Improve asset management and field resources effectiveness
4. Meeting customer expectation of a safe electricity supply
5. Maintain systems to industry standard.

The resulting business benefits for Neutral Integrity are:

1. Detect Neutral Integrity Service Mains issues for all smart meter customers
2. Assist the prevention of Pillar Fires
3. Detection of loss of transformer Earth and neutral connections.
4. Detection of high impedance connections anywhere on the LV reticulation network
5. Provide a business Intelligence Dashboard with worst cases in priority sequence
6. Provide visual display of Neutral Integrity issues in GIS.

3.2 National Electricity Rules Expenditure Objectives Alignment

This project addresses the following National Electricity Rule (NER) Expenditure Objectives:

- Maintain the safety of the distribution system through the delivery of standard control services

Performing the “Service Mains Deterioration Field Works” will allow UE to manage an increasing complex distribution network, while continuing to maintain the safety of the supply of standard control services throughout the next regulatory period and beyond.

4. Alternative Options Considered

4.1 Background and Identified Options

Key to managing a distribution network is the ability to sense and predict issues that occur on the network and where possible respond ahead of issues developing in to hazards that can lead to injury and or death.

Neutral Integrity Testing of each customer premise supply service main is a network and public safety ESV mandated regulatory requirement that must be performed at least once every 10 years.

The cost of doing Neutral Integrity Testing is not in our 2014 base year Opex as manual Neutral Integrity Testing for all AMI metered services mains was completed as part of the AMI smart meter commissioning process carried out from 2009 to 2013 to confirm that the sites were safe and free from any Neutral Integrity issues.

Therefore, UE has sought alternatives to meet this obligation, and has submitted the least cost option as part of its revised proposal.

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: Perform Manual Neutral Integrity Testing
- Option 2: Perform the "Service Mains Deterioration Field Works" for 5 Minute Neutral Integrity Data Reads
- Option 3: Perform the "Service Mains Deterioration Field Works" for 1 Minute Neutral Integrity Data Reads.

UE is not aware of any other viable means of addressing the requirements noted above.

The implications of implementing an automated solution results in additional network traffic that will impact meter reads. The automated options 2 and 3 address this additional traffic issue.

4.2 Reference Case - Status Quo

The Reference Case maintains the status quo and is an unsuitable option as it does not address our ongoing 10 year Neutral Integrity Testing safety obligation.

4.3 Option 1 – Perform Manual Neutral Integrity Testing

Neutral Integrity Testing would be performed manually every 10 years with a visit to every site.

The cost of performing manual Neutral Integrity Testing for 650,000 AMI metered services mains, at $40 per test is $26M (i.e. $2.6M per annum).

Option 1 is not the preferred option as it is not the least cost solution, and delivers no additional benefit to reduce the risk of electric shock.

4.4 Option 2 – Perform the Service Mains Deterioration Field Works for 5 Minute Neutral Integrity Data Reads

The initiative outlined in this option performs the required field works for the implementation of Neutral Integrity solution as described in "PJ12 – Network Analytics. This introduces significant extra traffic on the AMI network. This project, "Service Mains Deterioration Field Works" will strategically augment the AMI network with extra relays and access points to keep the AMI network performance relatively constant while addressing the extra bandwidth requirements. Therefore, this solution enables data capture, analysis and notification of Neutral Integrity issues as they arise 24/7 so that issues can be actioned immediately to minimise safety risk.

Analytics requires very granular data in order to calculate network impedance. The longer the sample period, the more noise gets introduces due to customers and neighbours switching on loads, voltage tap changers

tapping up and down, trains going past all impacting the voltage profile, etc. A 10 second sample rate would be ideal but this would saturate the radio mesh network and the associated analytics storage required for the data would be very large. Upgrading the network and IT storage to handle this extra data is too costly. However, 5 minute data has been proven over the last 4 years by other DNSPs to be the sweet point between lost accuracy, but still be able to do reliable neutral integrity calculations and the trade off in analytical power and storage requirements as well as minimising the need to upgrade the communications network for extra bandwidth.

The AMI communications network was initially designed in 2009 to provide sufficient bandwidth to satisfy the mandated AMI requirements with the technology at the time. The collection of 5 minute Voltage and Current data, that forms the foundation of realising additional benefits from Smart Meters, will increase network traffic by more than 6 times. Currently the AMI network is not able to meet this additional bandwidth requirements. All existing endpoints and backbone communications network are Generation 2 and 3 capable of data transfer rates of 100kbs. The latest hardware (Gen 4) is capable of 300kbs and the future gen 5, even higher. This benefit of faster transfer rates can only be utilised on new networks as all the UE meter end points are only capable of 100kbs and cannot take advantage of new technology being introduced in the backbone communications. The AMI Communications network can be economically modified to meet the mandated smart meter requirements and cater for the additional meter data required.

The works will increase the number of Access Points from 314 to 538 and the number of relays from 784 to 905. Th3 small relay increase will be complemented with an additional 2000 cost effective ($170 each) mini pole top mesh strengthening devices.

The additional Access Points and Repeaters enable new meters to communicate at 300Kbps while allowing current meters to continue to communicate at 100Kbps. The equipment to be added as part of this project is listed and costed in Table 2 below.

Table 2: Option 2 - Costs to Procure and Implement Additional Equipment in AUD (excluding labour escalation)

CAPEX in ($ AUD 1)	Additional Access Points	Repeaters (Relays) To be Installed	NMU to install (i.e. wiring / meter mods and special trip)
Number of Units Required	224	121	2,000 2
Equipment Unit Cost	8398	2816	170
Labour	1450	1450	230
Total cost	**$2,205,952**	**$516,186**	**$800,000**
Traffic management		$300,362	
Sub Total Cost	**$3,522,000**		
Total Project Cost (Including overheads) **2016-2020**	$4,148,000 3		
Work to be performed in 2015 pre EDPR period	$533,000		
Overall Total	**4,681,000**		

[1] The conversion rate of 77 cents was used to convert AUD to USD.

[2] 2000 new Pole top Network Mesh Units (NMU) will be installed to strengthen weak mesh areas not capable of returning these larger datasets.

[3] This total cost equates to $4.177M when labour escalation is included.

Implementation of this solution will result in a reduction of electric shocks by more than 50%. This benefit has been delivered by another Victorian DNSP using this approach. The benefit is delivered by identifying Neutral Integrity faults as they occur, before a customer experiences a shock. Importantly we note that our 2011 to 2015 spend on replacing services was $69M, and our 2016 to 2020 spend is proposed to be $34M. So by spending an extra $4.177M for this project we can reduce the network safety risk of shocks by more than 50%, by better targeting our CAPEX spend and applying it before shocks are experienced.

This risk reduction is considered ALARP, as the cost is small in comparison to the replacement CAPEX that addresses this area, whilst the benefit is to reduce the network safety risk of shocks by more than 50%.

The least cost option, Option 2 at a CAPEX cost of **$4.177M,** is recommended as it allows UE to meet the Neutral Integrity Testing safety obligation, while reducing risk of associated Neutral Integrity issues including electric shocks in line with our ALARP safety obligation.

4.5 Option 3 – Perform Service Mains Deterioration Field Works for 1 Minute Neutral Integrity Data Reads

In comparison to reading Neutral Integrity data every 5 minutes as per Option 2, Option 3 reads the Neutral Integrity data every minute. Option 3 reduces the time to pick up Neural Integrity issues and therefore can contribute to maintaining safety by reducing the time that Neutral Integrity issues are active but unknown, and the time to correct the issues.

Option 3 requires a capital investment as per Table 3 below and would include additional access points, repeaters, traffic management and labour. The total CAPEX for Option 3 is estimated at **$9.784M**.

Table 3: Option 3 - Costs to Procure and Implement Additional Equipment in AUD

CAPEX in ($ AUD 1)	Additional Access Points	Repeaters (Relays) To be Installed	NMU to install (i.e. wiring / meter mods and special trip)
Number of Units Required	397	207	2,000 2
Equipment Unit Cost	8398	2816	170
Labour	1450	1450	230
Total cost	**$3,909,656**	**$883,062**	**$800,000**
Traffic management		$370,800	
Additional Head end Hardware, Software and network cost	$3,072,833		
Sub Total Cost	$9,036,351		
Total Project Cost (Including overheads) 2016-2020	$9,784,000		
Work to be performed in 2015 pre EDPR period	$533,000		
Overall Total	**10,317,000**		

The following notes apply to Table 3 above:
[1] The conversion rate of 77 cents was used to convert AUD to USD.
[2] 2000 new Pole top Network Mesh Units will be installed to strengthen weak mesh areas not capable of returning these larger datasets.

Option 3 is not the preferred option as it delivers marginally more benefit than option 1, at considerably more cost.

4.6 Technical Summary

Table 4: Technical Summary

Alternative	Reference Case - Status Quo	Option 1 – Perform Manual Neutral Integrity Testing	Option 2 – Perform the Service Mains Deterioration Field Works for 5 Minute Neutral Integrity Data Reads	Option 3 – Perform the Service Mains Deterioration Field Works for 1 Minute Neutral Integrity Data Reads
Technically Viable	**Yes**	**Yes**	**Yes**	**Yes**
Address Reliability	**No**	**No**	**No**	**No**
Network Flexibility	**No**	**No**	**Yes**	**Yes**
Outcome	Does not meet our ongoing 10 year Neutral Integrity safety obligation, and is therefore an unsuitable option	It meets our obligation to perform Neutral Integrity Testing every 10 years, but is not least cost and does not provide additional safety benefits	Addresses Neutral Integrity safety obligation at least cost, and provides safety risk reduction assessed as ALARP	Provides safety risk reduction assessed as ALARP, but is not the least cost option

5. Economic Evaluation

5.1 Costs and Benefits of Options

The Economic Evaluation table below is the result from the "Business Case Output" from the "Financial Evaluation Spreadsheet Version 1.3". This is UE's Capital Project Evaluation tool. The tool comes with standard parameters and these are protected and cannot be altered. The tool ranks the project based on Least Cost (Net Present Value). The least cost project will have a Project Ranking of 1.

Table 5: Economic Evaluation Financial Summary

	"Status Quo" Reference Case	Option 1: Perform Neutral Integrity Testing	Option 1: Perform the Service Mains Deterioration Field Works for 5 Minute Neutral Integrity Data Reads	Option 2: Perform the Service Mains Deterioration Field Works for 1 Minute Neutral Integrity Data Reads
Net Capex ($)	$0	$0	$3,610,623	$8,343,315
Opex ($) 1	$0	$9,063,621	$0	$0
STPIS ($)	$0	$0	$0	$0
Loss of F Factor Benefit	$0	$0	$0	$0
Risk* ($)**	$0	$0	$0	$0
Least Net Cost ($) (PV)	$0	$9,063,621	$3,610,623	$8,343,315
Project Ranking	Unsuitable	3	1	2

The following note applies to the economic evaluation in Table 5 above:

[1] Option 1 incurs an annual OPEX cost of $884,000 for manual Neutral Integrity Testing. This cost is eliminated in each of the two options (i.e. Option 2 and 3). All OPEX costs are applied in the economic evaluation for the 20 year operational technology lifecycle.

5.2 Evaluation of Options

The options as described in Table 1 and Table 5 clearly shows that Option 2 at a CAPEX cost of **$4.177M (equating to $3.61M in present value terms)** is the preferred least cost option, and allows UE to meet the Neutral Integrity Testing safety obligation. This option also reduces the risk of Neutral Integrity issues including electric shocks in line with our ALARP safety obligation.

5.3 Description of Benefits

The recommended option, Option 2 provides the operational works that allows 24/7 Neutral Integrity Testing and associated reporting to be performed. The benefits delivered are:

1. Undertake Neutral Integrity Testing at least cost.
    a. The automated solution is lower cost than the "10 year" Neutral Integrity manual testing at each customer site.

b. Improves Neutral Integrity Testing safety governance by automating and recording Neutral Integrity issues.

2. Safety: ALARP – Improves safety of UE field work force, customers and the public who could be impacted by related Neutral Integrity issues including electric shocks that can result in deaths:
   a. Reduces the risks of shocks by more than 50%, by identifying faults as they occur
      i. Maintains electrical safety for the end consumer by pro-actively identifying and remediating Neutral Integrity connection issues.
   b. Reduces the consequence of some faults, by identifying them immediately (i.e. candling fuses and live wire down).

   This risk reduction is considered ALARP, as the cost is small in comparison to the replacement CAPEX that addresses this area, whilst the benefit is to reduce the network safety risk of shocks by more than 50%.

5.4 Optimum timing and CAPEX profile

The work will be spread over the EDPR period as follows:

- Implement the solution as per expenditure listed in the “Estimated annual cash flow”
- The work in the recommended Option 2 will be prioritised so that these additional repeaters and access points are implemented where the number of meters per access point is prone to impact current meter traffic SLAs when the additional analytics meter traffic is enabled.

5.5 Estimated Annual Cash Flow

Table 6: Options - Estimated Annual Cash Flow

Forecast ($'000)	2015 Non-EDPR	2016 EDPR	2017 EDPR	2018 EDPR	2019 EDPR	2020 EDPR	EDPR Total	2021 to 2036	Overall Total
Options 1 – OPEX – Perform Manual Neutral Integrity Testing			884	884	884	884	3,536	14,144	17,680
Option 2 – CAPEX - Perform the Service Mains Deterioration Field Works for 5 Minute Neutral Integrity Data Reads	533	1,621.3	950.2	581.3	624.2	399.9	4,177		4,710
Option 3 – CAPEX - Perform the Service Mains Deterioration Field Works for 1 Minute Neutral Integrity Data Reads	533	3,000	2,000	2,000	2,000	784	9,784		10,317

6. PROJECT FINANCIALS

The project financials for internal budgeting purposes are detailed below.

Table 7: Project financials - Preferred Option (Option 1)

PROJECT COST	
Year Budgeted	2016 to 2020
Required Service Date	31 Dec 2020
Budgeted Cost ($A excluding GST)	$3,797,000
Business Case Cost ($A excluding GST)	$3,797,000
Business Case Cost + UE overheads ($A excluding GST)	**$4,176,800**

7. Recommendation

The least cost option, Option 1 at a CAPEX cost of **$4.177M,** is recommended as it allows UE to meet the Neutral Integrity Testing safety obligation, while reducing risk of associated Neutral Integrity issues including electric shocks in line with ALARP safety obligation.

APPENDIX A – HIGH LEVEL SCOPE OF WORK

The scope includes:

- Initiate project, identify and obtain resources
- Purchase equipment as required (i.e. Access Points, Repeaters and meters)
    - Plan equipment rollout
    - Rollout equipment
    - Ensure delivery of business intelligence dashboards
    - Ensure neutral integrity issues are visually displayed in GIS
    - Test equipment functionality with Neutral Integrity functionality and any other functionality deemed necessary.
- Modify processes and complete all documentation
- Closeout project.