

# NEED/OPPORTUNITY STATEMENT (NOS)



Broken Hill Substation Renewal

NOS- 000000001193 revision 3.0

**Ellipse project no.:** P0005256

**TRIM file:** [TRIM No]

**Project reason:** Capability - Asset Replacement for end of life condition

**Project category:** Prescribed - Replacement

## Approvals

|                                    |                  |  |
|------------------------------------|------------------|--|
| <b>Author</b>                      | Adam Hoare       | Secondary Systems Senior Analyst                   |
|                                    | Alistair Cameron | Substation Asset Support Officer                   |
| <b>Endorsed</b>                    | Mark Jones       | Secondary Systems and Communications Asset Manager |
|                                    | Robert Li        | Substations Asset Strategist                       |
| <b>Approved</b>                    | Lance Wee        | M/Asset Strategy                                   |
| <b>Date submitted for approval</b> | 9 November 2016  |  |

## Change history

| Revision | Date            | Amendment                 |
|----------|-----------------|---------------------------|
| 0        | 28 April 2016   | Initial issue             |
| 1        | 30 August 2016  | Update to 2016/17 dollars |
| 2        | 13 October 2016 | Minor amendments          |
| 2        | 9 November 2016 | Update to format          |

## 1. Background

Broken Hill 220/22kV Substation comprises 2x 220kV feeders, 2x 220kV reactors, 2x 220/22 transformers, 8x 22kV feeders, 4x 22kV capacitor banks and 2x 22kV SVCs. The site was established in 1979, and the secondary systems assets have install dates between 1979 and 2015.

Broken Hill Substation is a customer connection point supplying the Essential Energy 220kV and 22kV networks in the area inclusive of Broken Hill Mines and Cockburn. Broken Hill Substation is also a customer connection point for the AGL Solar Farms in the area. The site will remain a connection point to Essential Energy and AGL into the foreseeable future as outlined in the load forecasts of the 2015 Transmission Annual Planning Report.

## 2. Need/opportunity

There is a need to address the risk associated with the widespread aging of the primary and secondary systems asset at Broken Hill. Furthermore, there is significant advantage in addressing them in a combined and uniform approach.

### 2.1 Secondary systems

In accordance with TransGrid's Renewal and Maintenance Strategies for Automation<sup>1</sup> and Metering Systems<sup>2</sup>, Table 1 shows the assets at Broken Hill Substation that have been identified for replacement by 2023.

**Table 1 – Identified asset replacements at Broken Hill Substation from 2014-2023**

| Need Description   | Quantity of Assets to be addressed | % of services at Site                            | Need Driver   |
|--|------------------------------------|--|---|
| Need ID 605 – Replacement of Quadramho Protection Relays | 1                                  | 5% of all line/feeder protection relays on site  | <ul style="list-style-type: none"> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> <li>&gt; Relays known to become trapped in a logic loop, rendering the relay non-auto and initiating the "Relay Inoperative Alarm"</li> </ul> |
| Need ID 606 – Replacement of THR Protection Relays       | 2                                  | 10% of all line/feeder protection relays on site | <ul style="list-style-type: none"> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> <li>&gt; Inaccurate measurement of fault angles due to deteriorated internal components</li> </ul>  |
| Need ID 610 – Replacement of EDMI MKIII Energy Meters    | 15                                 | 79% of all market meters on site                 | <ul style="list-style-type: none"> <li>&gt; Microprocessor Energy Meters failing as they approach 15 years of life</li> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> </ul>  |

<sup>1</sup> Refer SSA Strategy - Renewal and Maintenance - Automation Systems

<sup>2</sup> Refer SSA Strategy - Renewal and Maintenance - Metering Systems

| Need Description  | Quantity of Assets to be addressed | % of services at Site                             | Need Driver   |
|---|------------------------------------|---|---|
| Need ID 621 – Replacement of DB Series Protection Relays  | 4                                  | 100% of all transformer protection relays on site | <ul style="list-style-type: none"> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> <li>&gt; Faulty harmonic bias circuitry due to component failure</li> <li>&gt; Internal wiring connection problems</li> </ul> |
| Need ID 1368 – Replacement of Feeder OC Protection Relays | 12                                 | 60% of all line/feeder protection relays on site  | <ul style="list-style-type: none"> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> <li>&gt; Inaccurate measurement of fault angles due to deteriorated internal components</li> </ul>                            |
| Need ID 1387 – Replacement of Capacitor Protection Relays | 8                                  | 100% of all Capacitor protection relays on site   | <ul style="list-style-type: none"> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> <li>&gt; Inaccurate measurement of fault angles due to deteriorated internal components</li> </ul>                            |
| Need ID 1388 – Replacement of SVC Protection Relays       | 4                                  | 100% of all SVC protection relays on site         | <ul style="list-style-type: none"> <li>&gt; Component obsolescence resulting in a lack of spares and no manufacturer support</li> <li>&gt; Inaccurate measurement of fault angles due to deteriorated internal components</li> </ul>                            |

Additionally, condition assessments for all these individual asset types have been completed<sup>3</sup>.

The risk cost associated with all secondary systems at Broken Hill is \$4.42m per annum. The most significant element of concern is the reliability consequence associated with an unplanned outage due to inadvertent operation of the protection relays identified for replacement above. There is a mixed customer load at the site with a forecast 35MW as the average of the summer and winter loads in the Transmission Annual Planning Report and an estimated 16 hours to recover the site and load after a hazardous event. Broken Hill Substation forms part of the 220kV which runs below TransGrid's N-1 planning criteria. Therefore failure of any component on this system has an increased likelihood of a hazardous consequence occurring. The risk costs are based on 2015/16 probabilities of failure taken as a trend of existing defect rates of applicable asset types derived from the condition assessments. These probabilities are forecast to continue increasing over the coming years, with the consequence of failure also likely to escalate due to TransGrid's means of mitigating and repairing these failures being almost exhausted.

There is additional risk identified from market meters (which considers repair and potential litigation costs).

In accordance with TransGrid's Renewal and Maintenance Strategy for Secondary Systems Site Installations<sup>4</sup>, an opportunity exists to address these risks by performing a full secondary system replacement at Broken Hill (as

<sup>3</sup> Refer NACA-SSAP - Protection, NACA-SSAC – Control, NACA-SSAM - Metering

<sup>4</sup> Refer SSA Strategy - Renewal and Maintenance -Secondary Systems Site Installations

listed in the risk summary in Attachment 1). This opportunity is expected to provide additional benefits for the organisation including:

- > Moving from a centralised Alarm and Control platform to a distributed control architecture that improves operational control and reliability while reducing the consequence of equipment failure
- > Upgrading Auto Reclose facilities to allow better control, indication and fault analysis than what is currently available at the site
- > Upgrading Transformer Control facilities to allow better control, indication and fault analysis than what is currently available at the site
- > Optimising the current investment in TransGrid's High Capacity Telecommunications to the site by upgrading all ancillary systems to TransGrid's latest design standard which provides the greatest amount of real time operational and condition data to better support the planning, operation and maintenance of the Network

## 2.2 Primary systems

The 22kV primary system assets at Broken Hill Substation identified for replacement by 2023 are listed in Table 2.

**Table 2 – Identified 22kV primary system asset replacements at Broken Hill Substation from 2014-2023**

| Need Description  | Quantity of Assets to be addressed | % of services at Site   | Need Driver   |
|---|------------------------------------|---|---|
| Need ID 1338 – Various Locations CT Renewal Program     | 12                                 | 75% of all 22kV CTs (excluding CTs installed in the SVC bays) | <ul style="list-style-type: none"> <li>&gt; Deterioration indicating assets nearing the end of their useful life</li> <li>&gt; Significant risks associated with asset failure</li> </ul>   |
| Need ID 1442 – Various Locations VT Renewal Program     | 10                                 | 100% of all 22kV VTs  | <ul style="list-style-type: none"> <li>&gt; Deterioration indicating assets nearing the end of their useful life</li> <li>&gt; Significant risks associated with asset failure</li> </ul>   |
| Need ID 541 – Magrini Galileo MGE 33kV Circuit Breakers | 2                                  | 12.5% of all 22kV CBRs  | <ul style="list-style-type: none"> <li>&gt; Wear of mechanism components, leading to unreliable operation</li> <li>&gt; Low insulation resistance of the high voltage components</li> <li>&gt; Poor spare parts availability</li> </ul> |

In addition to the above asset replacements, there are further issues with some of the 22kV plant at Broken Hill Substation:

- > There are ongoing problems with the reliability of the 22kV circuit breakers, and replacement of these units would improve the operation of the site.
- > The short length of insulators combined with the high level of vermin activity has made the 22kV busbar susceptible to trips caused by vermin strike. There has been extensive bird proofing installed however this has not eliminated the risk.
- > Due to the remoteness of the site, maintenance and renewal works are costly and inefficient.

There are no significant issues with the 22kV capacitor banks and SVCs and so these assets are excluded from consideration of replacement.

The total risk cost associated with the 22kV primary plant is \$1.34m per annum. The most significant portion of the risk cost is the reliability impact from the failure of switchgear, which would result in large loss of load for an extended period and is more likely given the advanced age of the assets.

Given the large proportion of assets scheduled for replacement in the next regulatory period, and the existing issues with the 22kV plant, there exists an opportunity to combine these replacements with the secondary systems replacement and replace all of the 22kV primary systems at once. Addressing the 22kV assets requiring replacement by replacing them together with the remaining portion of the assets onsite in a single program is expected to provide the following benefits:

- > Consistency in installed equipment allowing for reduced maintenance of new assets. This benefit will help mitigate the inefficiency in maintenance caused by the remote nature of the site.
- > Increased efficiency in future asset replacements due to uniform age and models of new assets.
- > Improvement of reliability through reducing the incident of tripping due to vermin strikes through redesign of the 22kV busbar

### 3. Related Needs/opportunities

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The following related Needs contain works for Broken Hill that could be fulfilled by completing a Primary & Secondary Systems Replacement:

- > Need ID 605 – Replacement of Quadramho Protection Relays
- > Need ID 606 – Replacement of THR Protection Relays
- > Need ID 610 – Replacement of EDMI MKIII Energy Meters
- > Need ID 621 – Replacement of DB Series Protection Relays
- > Need ID 1368 – Replacement of Feeder OC Protection Relays
- > Need ID 1387 – Replacement of Capacitor Protection Relays
- > Need ID 1388 – Replacement of SVC Protection Relays
- > Need ID 1338 – Various Locations CT Renewal Program
- > Need ID 1442 – Various Locations VT Renewal Program
- > Need ID 541 – Magrini Galileo MGE 33kV Circuit Breakers

### 4. Recommendation

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It is recommended that options be considered to address the identified Need.

# Attachment 1 – Risk costs summary

Summary of results is attached below. Refer to supporting document in PDGS for full risk assessment.



## Current Option Assessment - Risk Summary

Project Name: Broken Hill Secondary Systems Renewal

Option Name: 1193 - Base Case

Option Assessment Name: 1193 - Base Case - Assessment 1

Rev Reset Period: Next (2018-23)

| Major Component            | No. | Minor Component                | Sel. Hazardous Event   | LoC x CoF (\$M) | Failure Mechanism | NoxLoC xCoF (\$M) | PoF (Yr 1) | Total Risk (\$M) | Risk (\$M) (Rel) | Risk (\$M) (Op) | Risk (\$M) (Fin) | Risk (\$M) (Peo) | Risk (\$M) (Env) | Risk (\$M) (Rep) |
|----------------------------|-----|--------------------------------|--|-----------------|-------------------|-------------------|------------|------------------|------------------|-----------------|------------------|------------------|------------------|------------------|
| 22kV Circuit Breakers      | 1   | Electrical                     | Explosive Failure of Asset (22kV Circuit Breakers)                       | \$59.59         | Failure           | \$59.59           | 0.54%      | \$0.32           | \$0.30           | \$0.01          | \$0.01           | \$0.01           | \$0.00           | \$0.00           |
| 22kV CTs (excluding SVCs)  | 1   | Electrical                     | Explosive Failure of Asset (22kV CTs (excluding SVCs))                   | \$37.17         | Failure           | \$37.17           | 1.24%      | \$0.46           | \$0.42           | \$0.02          | \$0.02           | \$0.02           | \$0.00           | \$0.00           |
| 22kV MVTs                  | 1   | Electrical                     | Explosive Failure of Asset (22kV MVTs)                                   | \$21.67         | Failure           | \$21.67           | 2.51%      | \$0.54           | \$0.47           | \$0.02          | \$0.02           | \$0.05           | \$0.00           | \$0.00           |
| Battery and Charger System | 2   | Battery                        | Uncontrolled Electrical Contact / Discharge (Battery and Charger System) | \$0.15          | Failure           | \$0.29            | 9.20%      | \$0.03           | \$0.02           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Battery and Charger System | 2   | Battery                        | Unplanned Outage - HV (Battery and Charger System)                       | \$0.14          | Failure           | \$0.29            | 9.20%      | \$0.03           | \$0.02           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Battery and Charger System | 2   | Charger                        | Uncontrolled Electrical Contact / Discharge (Battery and Charger System) | \$0.15          | Failure           | \$0.29            | 9.20%      | \$0.03           | \$0.02           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Battery and Charger System | 2   | Charger                        | Unplanned Outage - HV (Battery and Charger System)                       | \$0.14          | Failure           | \$0.29            | 9.20%      | \$0.03           | \$0.02           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Controls                   | 8   | Bay Controller                 | Unplanned Outage - HV (Controls)   | \$0.20          | Failure           | \$1.57            | 4.80%      | \$0.08           | \$0.05           | \$0.02          | \$0.02           | \$0.00           | \$0.00           | \$0.00           |
| Controls                   | 8   | Control Cabling                | Unplanned Outage - HV (Controls)   | \$0.20          | Failure           | \$1.57            | 4.80%      | \$0.08           | \$0.05           | \$0.02          | \$0.02           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage AC Supply      | 2   | AC Low Voltage Board/Panel/Box | Uncontrolled Electrical Contact / Discharge (Low Voltage AC Supply)      | \$0.48          | Failure           | \$0.97            | 31.00%     | \$0.30           | \$0.08           | \$0.21          | \$0.21           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage AC Supply      | 2   | AC Low Voltage Board/Panel/Box | Unplanned Outage - HV (Low Voltage AC Supply)                            | \$0.69          | Failure           | \$1.38            | 31.00%     | \$0.43           | \$0.21           | \$0.21          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage AC Supply      | 2   | AC Low Voltage Cable           | Uncontrolled Electrical Contact / Discharge (Low Voltage AC Supply)      | \$0.48          | Failure           | \$0.97            | 3.20%      | \$0.03           | \$0.01           | \$0.02          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage AC Supply      | 2   | AC Low Voltage Cable           | Unplanned Outage - HV (Low Voltage AC Supply)                            | \$0.69          | Failure           | \$1.38            | 3.20%      | \$0.04           | \$0.02           | \$0.02          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |

| Major Component       | No. | Minor Component                | Sel. Hazardous Event  | LoC x CoF (\$M) | Failure Mechanism | NoxLoC xCoF (\$M) | PoF (Yr 1) | Total Risk (\$M) | Risk (\$M) (Rel) | Risk (\$M) (Op) | Risk (\$M) (Fin) | Risk (\$M) (Peo) | Risk (\$M) (Env) | Risk (\$M) (Rep) |
|-----------------------|-----|--------------------------------|---|-----------------|-------------------|-------------------|------------|------------------|------------------|-----------------|------------------|------------------|------------------|------------------|
| Low Voltage DC Supply | 2   | DC Low Voltage Board/Panel/Box | Uncontrolled Electrical Contact / Discharge (Low Voltage DC Supply) | \$0.15          | Failure           | \$0.29            | 2.00%      | \$0.01           | \$0.01           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage DC Supply | 2   | DC Low Voltage Board/Panel/Box | Unplanned Outage - HV (Low Voltage DC Supply)                       | \$0.14          | Failure           | \$0.29            | 2.00%      | \$0.01           | \$0.01           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage DC Supply | 2   | DC Low Voltage Cable           | Uncontrolled Electrical Contact / Discharge (Low Voltage DC Supply) | \$0.15          | Failure           | \$0.29            | 2.00%      | \$0.01           | \$0.01           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| Low Voltage DC Supply | 2   | DC Low Voltage Cable           | Unplanned Outage - HV (Low Voltage DC Supply)                       | \$0.14          | Failure           | \$0.29            | 2.00%      | \$0.01           | \$0.01           | \$0.00          | \$0.00           | \$0.00           | \$0.00           | \$0.00           |
| LV AC Cable Safety    | 1   | AC Low Voltage Cable           | Uncontrolled Electrical Contact / Discharge (LV AC Cable Safety)    | \$1.50          | Failure           | \$1.50            | 15.00%     | \$0.23           | \$0.23           | \$0.00          | \$0.00           | \$0.23           | \$0.00           | \$0.00           |
| LV DC Cable Safety    | 1   | DC Low Voltage Cable           | Uncontrolled Electrical Contact / Discharge (LV DC Cable Safety)    | \$0.09          | Failure           | \$0.09            | 15.00%     | \$0.01           | \$0.01           | \$0.00          | \$0.00           | \$0.01           | \$0.00           | \$0.00           |
| Metering              | 19  | Meter                          | Failed Compliance Obligations (Metering)                            | \$0.11          | Failure           | \$2.12            | 4.23%      | \$0.09           | \$0.09           | \$0.00          | \$0.00           | \$0.09           | \$0.00           | \$0.00           |
| Protection - 220kV    | 8   | Protection                     | Unplanned Outage - HV (Protection - 220kV)                          | \$11.77         | Failure           | \$94.16           | 2.89%      | \$2.72           | \$2.67           | \$0.02          | \$0.02           | \$0.02           | \$0.02           | \$0.02           |
| Protection - 220kV    | 8   | Protection Relay               | Explosive Failure of Asset (Protection - 220kV)                     | \$0.60          | Failure           | \$4.80            | 2.89%      | \$0.14           | \$0.06           | \$0.01          | \$0.01           | \$0.00           | \$0.02           | \$0.05           |
| Protection - 22kV     | 15  | Protection                     | Unplanned Outage - HV (Protection - 22kV)                           | \$0.24          | Failure           | \$3.55            | 1.27%      | \$0.05           | \$0.02           | \$0.02          | \$0.02           | \$0.02           | \$0.02           | \$0.00           |
| Protection - 22kV     | 15  | Protection Relay               | Explosive Failure of Asset (Protection - 22kV)                      | \$0.53          | Failure           | \$7.98            | 1.27%      | \$0.10           | \$0.03           | \$0.01          | \$0.01           | \$0.00           | \$0.01           | \$0.04           |
|                       |     |                                |   | \$137.17        |                   | \$242.78          |            | \$5.75           | \$4.52           | \$0.74          | \$0.34           | \$0.03           | \$0.12           | \$0.12           |

Total VCR Risk: \$4.24      Total ENS Risk: \$0.22