Program of Works

2017 – 2022

Secondary Systems

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1 Summary

PROGRAM	Secondary Systems Replacement
SERVICE DATE	On-going throughout period 2017 – 2022
LOCATION	Terminal Stations across Victorian Electricity Transmission Network
VALUE	$82.9M for the period 2017/18 to 2021/22

Table 1 – Program overview

This works program document should be read in conjunction with AMS 10-68 Secondary Systems and AMS 10-52 DC Power Supplies. These AMS documents detail the background and describe the condition assessment approach, risks and performance of secondary systems and DC power supplies.

1.1 Program scope

This program involves replacement of secondary (protection, control, monitoring and metering) systems and associated DC power supplies across the Victorian Transmission Network. Equipment to be replaced is primarily located at Terminal Station however some items, such as weather monitoring stations can be located on towers.

The approach to replacement of 'end-of-life' secondary systems is to target specific stations where the systems have deteriorated rather than target specific classes of assets. This approach reduces the overall cost of asset replacement as significant synergies can be obtained by replacing multiple assets at one location and the program can be more easily delivered as fewer outages are required.

Assets to be replaced are:

1. Protection and Network Asset – Reactive Plant:
    - SVC Protection at KGTS;
    - SVC controls and protection at HOTS;
    - SVC 2 controls and SVC 1 and 2 Protection at ROTS.

2. Protection Assets – Critical relays at various sites:
    - Line protection;
    - Bus protection;
    - High impedance transformer protection;
    - High impedance reactor protection;
    - Transformer protection;
    - Capacitor bank protection.

3. Protection and station control – Protection relays and CB Management relays:
    - Protection and CB management at KTS;
    - Protection, CB management and PLCs at HOTS and MLTS.

4. Protection, Secondary Infrastructure and Station Controls:
    - Protection and RTUs at YPS;
    - Protection, PLCs and RTUs at ROTS;
    - Protection, CB management, PLCs and RTUs at RCTS, DDTS, BETS, BATS and SHTS.

5. Secondary Infrastructure and Station Controls:
    - CB management at ROTS;
    - DC inter-tripping and RTUs at HWPS;
    - CB management, PLCs and RTUs at TTS, SMTS, BLTS, KGTS and TSTS.

6. Network Control Assets:
    - Load shedding at 24 sites;
    - DBUSS, VFRB and BARBS schemes.

7. Metering and Monitoring:
    - 600 Energy meters;
    - Weather stations at 22 sites.

8. DC supplies:
    - Battery, chargers and DC isolation and distribution panels at various sites.

1.2 Program expenditure forecast

2017/18 ($k)	2018/19 ($k)	2019/20 ($k)	2020/21 ($k)	2021/22 ($k)	Total ($k)
20,805	17,688	15,005	14,280	15,117	82,895

Table 2 – Program timing and forecast expenditure

Forecast costs shown in Table 2 are $2014/15 P50 direct costs. These costs exclude overheads, finance charges and cost escalation. Unit costs are described in Appendix 4D: Unit Rates.

2 Program Drivers

Unlike primary plants (transformers, transmission lines and circuit breakers), the replacement drivers for the secondary assets are not necessarily asset condition. The ability of a Secondary System to deliver its expected function is paramount to the safety of the general public and workers), safety of equipment and to maintain power system reliability.

Secondary Equipment replacements have three key drivers:

1. **MODERNISATION** – Replacement of relays as a progression to a modern standardised design for station equipment using integrated functions in an intelligent device and serial communication.
2. **COMPLIANCE** with National Electricity Rules (NER) and AEMO Protection & Control Requirements (PCRs).
3. **OBSOLESCENCE** – Replacement of relays that are inadequate, obsolete, failing, aged and unsupported. Ultimately, relay populations need to be replaced because they can no longer be supported (eg parts and technical skills are no longer available or modern PCs and SCADA cannot communicate with them), rather than actual or predicted failures.

In addition, some replacement is driven by customer requirements and, where these requirements extend beyond the level of prescribed transmission services, they are funded by the customer.

3 Obligations

The National Electricity Rules (clauses 6A.6.6 and 6A.6.7) require AusNet Services to forecast operating and capital expenditures to, amongst other objectives, *comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services;*

The Electricity Safety Act (clause 98) requires a major electricity company, such as AusNet Services to design, construct, operate, maintain and decommission its supply network to minimise as far as practicable:

a) the hazards and risks to the safety of any person arising from the supply network; and

b) the hazards and risks of damage to the property of any person arising from the supply network; and

c) the bushfire danger arising from the supply network.

In the definitions of this Act, the term 'practicable', means having regard to:

a) the severity of the hazard or risk in question; and
b) the state of knowledge about the hazard or risk and any ways of removing or mitigating the hazard or risk; and
c) the availability and suitability of ways to remove or mitigate the hazard or risk; and
d) the cost of removing or mitigating the hazard or risk;

This means "as low as reasonably practicable" which has been interpreted as until the safety related costs are (grossly) disproportionate to the safety related benefit.

The *Occupational Health and Safety Act 2004* (Vic) (**OHSA**) requires AusNet Services to:

> *as far as is reasonably practicable, provide and maintain for employees of the employer a working environment that is safe and without risks to health.*[1]

When determining what is (or what was, at a particular time), reasonably practicable in ensuring health and safety, the OHSA requires that regard be had to the following matters:

a) the likelihood of the hazard or risk concerned eventuating;
b) the degree of harm that would result if the hazard or risk eventuated;
c) what the person concerned knows, or ought reasonably to know, about the hazard or risk and any ways of eliminating or reducing the hazard or risk;
d) the availability and suitability of ways to eliminate or reduce the hazard or risk.[2]

1 Section 21(1).

2 Occupational Health and Safety Act 2010, section 20(2).

4 Overview

Secondary systems can be broadly categorised into four main categories:

1 **Protection Systems** – Protection systems play a vital role in identifying and isolating the faulty sections of the network to maintain the supply reliability. Components include transformer protection, bus protection, line & feeder protection and SVC protection at various voltage levels.

2 **Control Systems** – These systems include circuit breaker management replays, SVC controls, control schemes such as capacitor bank and reactor AVC controls, PLC controls, etc.

3 **Monitoring and Metering** – The SCADA system gathers remote station data such as instrumentation (volts, amps, frequency, watts, VARs, transformer temperature, conductor strain, environmental monitoring, etc.) circuit breaker (CB) and plant status, station alarms, etc., interprets it and displays it to operations personnel to take appropriate action to control the network. The revenue meters monitor wholesale energy flows, calculate losses and facilitate invoicing amongst National Electricity Market (NEM) participants.

4 **DC Supply** – DC supply systems provide energy for SCADA, instrumentations, communications equipment, alarm systems, CB controls and auxiliary power and emergency lighting.

5 Risks

Protection systems are essential parts that protect the network from damage in the event of a component failure or external influence which affects the safe and reliable operation of the network. While many systems are duplicated, failure of a system to operate as designed can lead to extreme adverse consequences such as live conductors on the ground or terminal station fires.

Monitoring and metering provide information for safe and efficient operation of the network and electricity market. Risks associated with failure of monitoring and metering include incorrect measurements affecting electricity market financial transactions and loss of 'visibility' of assets which results in conservative operation of the network as true operating conditions are unknown.

Control systems failure can result in damage to equipment and incorrect network operation which affects market operations and can result network efficiency.

DC supplies are essential for protection and control systems to provide the required capability in the event of a 'system black'. The consequences of a total failure of DC supplies to perform when they are needed are the same as failure of the protection and control systems which could lead to a "station black".

In the event of "station black" all associated remote ends with connections to the terminal station concerned would be disrupted and required to be switched off to minimise further damage to plant in case of external faults.

In summary, the risks associated with the failure of secondary systems are considerable and include safety, major equipment damage, and efficient operation of the electricity network and market.

6 Options

This section details the asset management options investigated for each secondary sub category.

6.1 Protection systems options

6.1.1 Option 1 – Do Nothing

The Do Nothing option involves:

- Continuing inspection and maintenance activities of secondary system;
- Progressive failure of protection relays and systems;
- Damage to unprotected assets in circuits within the electricity transmission network;
- Progressive loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs for protection assets.

6.1.2 Option 2 – Replace on failure

The Replace on Failure option involves:

- Continuing inspection and maintenance activities;
- Multiple failures of protection relays and systems;
- Multiple unplanned replacements of secondary systems following functional failures;
- High risk of damage to unprotected assets in the electricity transmission network;
- High risk of loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs for protection assets.

6.1.3 Option 3 – Planned replacement based on risk

Implementing an optimised replacement program involves:

- Continuing inspection and maintenance activities;
- Planned replacement of high risk assets when the associated risk cost exceeds the cost of funding a planned replacement;
- Low risk of protection systems failures;
- Low risk of damage to other assets in the electricity transmission network;
- Low risk of loss of service from the electricity transmission network
- Compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Economic life cycle costs for protection assets;
- Proactively replacing secondary assets in the most suitable time interval.

6.2 Control systems options

6.2.1 Option 1 – Do Nothing

The Do Nothing option involves:

- Continuing inspection and maintenance activities of secondary system;
- Progressive failure of control systems;
- Progressive malfunctioning of primary assets within the electricity transmission network;
- Progressive loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs for control system assets.

6.2.2 Option 2 – Replace on failure

The Replace on Failure option involves:

- Continuing inspection and maintenance activities;
- Multiple failures of control systems;
- Multiple unplanned replacements of secondary systems following functional failures;
- High risk of damage to uncontrolled assets in the electricity transmission network;
- High risk of loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs for control system assets.

6.2.3 Option 3 – Planned replacement based on risk

Implementing an optimised replacement program involves:

- Continuing inspection and maintenance activities;
- Planned replacement of high risk assets when the associated risk cost exceeds the cost of funding a planned replacement;
- Low risk of control system failures;
- Low risk of damage to other assets in the electricity transmission network;
- Low risk of loss of service from the electricity transmission network;
- Compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Economic life cycle costs for control system assets;
- Proactively replacing secondary assets in the most suitable time interval.

6.3 DC supply options

6.3.1 Option 1 – Do Nothing

The Do Nothing option involves:

- Continuing inspection and maintenance activities of secondary system;
- Progressive failure of DC supplies;
- Unplanned supply disruptions to protection systems, control systems, instrumentations, communications equipment, alarm systems, etc;
- Damage to primary assets within the electricity transmission network;
- Progressive loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs of DC supply systems.

6.3.2 Option 2 – Replace on failure

The Replace on Failure option involves:

- Continuing inspection and maintenance activities;
- Multiple DC supply failures;
- Multiple unplanned replacements of DC supply systems following functional failures;
- High risk of damage to primary assets in the electricity transmission network;
- High risk of loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs of DC supply systems.

6.3.3 Option 3 – Planned replacement based on risk

Implementing an optimised replacement program involves:

- Continuing inspection and maintenance activities;
- Planned replacement of high risk assets when the associated risk cost exceeds the cost of funding a planned replacement;
- Low risk of DC supply failures;
- Low risk of damage to other assets in the electricity transmission network;
- Low risk of loss of service from the electricity transmission network
- Compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Economic life cycle costs of DC supply systems;
- Proactively replacing secondary assets in the most suitable time interval.

6.4 Monitoring and metering options

6.4.1 Option 1 – Do Nothing

The Do Nothing option involves:

- Continuing inspection and maintenance activities of secondary system;
- Progressive failure of monitoring and metering equipment;
- Unplanned disruptions to monitoring and metering functions;
- Progressive loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs of monitoring and metering systems.

6.4.2 Option 2 – Replace on failure

The Replace on Failure option involves:

- Continuing inspection and maintenance activities;
- Multiple monitoring and metering system failures;
- Multiple unplanned replacements of monitoring and metering system following functional failures;
- High risk of loss of service from the electricity transmission network;
- Non-compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Uneconomic life cycle costs of monitoring and metering systems.

6.4.3 Option 3 – Planned replacement based on risk

Implementing an optimised replacement program involves:

- Continuing inspection and maintenance activities;
- Planned replacement of high risk assets when the associated risk cost exceeds the cost of funding a planned replacement;
- Low risk of monitoring and metering system failures;
- Low risk of loss of service from the electricity transmission network;
- Compliance with the National Electricity Rules, Electricity Safety Act and Occupational Health and Safety Act;
- Economic life cycle costs of monitoring and metering systems;
- Proactively replacing secondary assets in the most suitable time interval.

7 Options Analysis

This section outlines the advantages and disadvantages of each options analysed against each secondary sub category.

7.1 Protection systems options analysis

7.1.1 Option 1 – Do Nothing

This option will lead to the existing protection systems going out of date and inoperative gradually. The protection systems will no longer be able to isolate the faulty network components within the expected time. This will lead to various safety, regulatory, financial and corporate risks.

7.1.2 Option 2 – Replace on Failure

Similar to the "Do Nothing" option, this option will lead to the existing protection systems going out of date and inoperative gradually. The protection systems will no longer be able to isolate the faulty network components within the expected time. Unplanned replacements of secondary systems following functional failures effect service disruptions. This will lead to various safety, regulatory, financial and corporate risks.

7.1.3 Option 3 – Planned replacement based on risk

These risks could be minimised through a targeted protection system replacement program. Planned protection system replacement program would ensure;

- Safety of employees, contractors and the general public:
  - Minimise OH&S risk to employees and contractors (safe workplace / environment);
  - Minimise risk to public due to asset failure.
- Financial risk reduction:
  - Increased operating costs through asset failures;
  - Rebate penalties associated with asset availability.
- Regulatory Compliance:
  - Compliance with Electricity Safety (Management) Regulations;
  - Compliance with preventative maintenance requirements;
  - Occupational Health & Safety Act (Provide Safe Work Environment).
- Maintenance of Best practise:
  - Ensure Best practise is maintained for all secondary procedures.
- Corporate image maintained as prudent asset managers:
  - Manage risk as low as practicable.

7.2 Control systems options analysis

7.2.1 Option 1 – Do Nothing

A "Do Nothing" option would cause malfunctioning of existing control systems gradually. They will not be able to perform the functions expected from them. They will no longer be compatible with modern primary equipment hence of no use. Failure of control systems could render primary equipment inoperative and the consequence of no actions by primary plant under critical events will lead to various safety, regulatory, financial and corporate risks.

7.2.2 Option 2 – Replace on failure

This option would cause gradual malfunctioning of existing control systems, similar to "Do Nothing" option. They will not be able to perform the functions expected from them. Unplanned replacements of secondary systems following functional failures cause service disruptions resulting various safety, regulatory, financial and corporate issues.

7.2.3 Option 3 – Planned replacement based on risk

These issues could be minimised through a targeted control system replacement program. Planned control system replacement program would ensure;

- Safety of employees, contractors and the general public:
  - Minimise OH&S risk to employees and contractors (safe workplace / environment);
  - Minimise risk to public due to asset failure.
- Financial risk reduction:
  - Increased operating costs through asset failures;
  - Rebate penalties associated with asset availability.
- Regulatory Compliance:
  - Compliance with Electricity Safety (Network Assets) Regulations;
  - Compliance with preventative maintenance requirements;
  - Occupational Health & Safety Act (Provide Safe Work Environment).
- Maintenance of Best practise:
  - Ensure Best practise is maintained for all secondary procedures.
- Corporate image maintained as prudent asset managers:
  - Manage risk as low as practicable.

7.3 DC Supply options analysis

7.3.1 Option 1 – Do Nothing

Not upgrading and replacing the DC supplies would cause unplanned supply disruptions to protection systems, control systems, instrumentations, communications equipment, alarm systems, etc. Failure of DC supplies will lead to various safety, regulatory, financial and corporate issues.

7.3.2 Option 2 – Replace on failure

Not upgrading and replacing the DC supplies at the proper time interval would cause unplanned supply disruptions to protection systems, control systems, instrumentations, communications equipment, alarm systems, etc. This will lead to various safety, regulatory, financial and corporate issues.

7.3.3 Option 3 – Planned replacement based on risk

The advantages of planned DC supply systems capital work program is similar to that of protection systems and control systems as mentioned above as DC systems provide auxiliary supply for those systems to operate as expected.

7.4 Monitoring and metering systems options analysis

7.4.1 Option 1 – Do Nothing

A “Do Nothing” option would cause malfunctioning of existing monitoring and metering systems gradually. They will not be able to perform the functions expected from them. They will no longer be compatible with modern primary equipment hence of no use. This will result in various safety, regulatory, financial and corporate issues.

7.4.2 Option 2 – Replace on failure

This option would cause gradual malfunctioning of existing monitoring and metering systems, similar to “Do Nothing” option. They will not be able to perform the functions expected from them. Unplanned replacements of secondary systems following functional failures cause service disruptions resulting various safety, regulatory, financial and corporate issues.

7.4.3 Option 3 – Planned replacement based on risk

The issues associated with failure of monitoring and metering assets can be minimised through a planned, targeted monitoring and metering system replacement program. Planned monitoring and metering system replacement program would ensure;

- Safety of employees, contractors and the general public:
  - Minimise OH&S risk to employees and contractors (safe workplace / environment);
  - Minimise risk to public due to asset failure.

- Financial risk reduction:
  - Increased operating costs through asset failures;
  - Rebate penalties associated with asset availability.
- Regulatory Compliance:
  - Compliance with Electricity Safety (Network Assets) Regulations;
  - Compliance with preventative maintenance requirements;
  - Occupational Health & Safety Act (Provide Safe Work Environment).
- Maintenance of Best practise:
  - Ensure Best practise is maintained for all secondary procedures;
- Corporate image maintained as prudent asset managers:
  - Manage risk as low as practicable.

8 Recommended Actions

This section outlines the recommended asset management action identified following the completion of options analyses.

8.1 Protection Systems

As described in the Section 7.1, a targeted asset replacement of protection systems demonstrates prudent secondary asset management. Further this aligns with the AusNet Services secondary asset management strategy. Therefore it is recommended to implement a secondary asset replacement program.

8.2 Control Systems

As described in the Section 7.2, a targeted asset replacement of control systems demonstrates prudent secondary asset management. Further this aligns with the AusNet Services secondary asset management strategy. Therefore it is recommended to implement a secondary asset replacement program.

8.3 DC Supply

As described in the Section 7.3, a targeted replacement of DC supplies demonstrates prudent secondary asset management. Further this aligns with the AusNet Services secondary asset management strategy. Therefore it is recommended to implement a secondary asset replacement program.

8.4 Monitoring and metering systems

As described in the Section 7.4, a targeted replacement of monitoring and metring systems demonstrates prudent secondary asset management. Further this aligns with the AusNet Services secondary asset management strategy. Therefore it is recommended to implement a secondary asset replacement program.

8.5 Program components

Table 3 shows the planned expenditure profile for components of the secondary system replacement program in $000s.

PROGRAM COMPONENTS	2017/18	2018/19	2019/20	2020/21	2021/22
Protection and Network Control Asset Reactive Plant at KGTS, HOTS and ROTS	8,785	2,500	2,500	1,500	1,750
Protection Asset Critical relays at various sites	2,607	2,575	600	1,095	551
Protection and Station Controls Relays and PLCs at KTS, HOTS and MLTS	50	340	1,835	1,705	3,216
Protection, Secondary Infrastructure and Station Controls RTUs, Relays and PLCs at ROTS, YPS, RCTS, DDTS, BETS, BATS and SHTS	1,410	4,333	2,235	2,980	2,350
Secondary Infrastructure and Station Control Assets SCIMS, PLCs, AVC, CBM at SYTS, TSTS, TTS,ROTS, ERTS, HWPS, BLTS and KGTS	6,203	3,635	1,890	1,290	250
Network Control Assets Load shed at 24 sites and DBUSS,VFRB and BARBS schemes	500	2,205	2,195	1,510	1,000
Metering and Monitoring Assets 600 Energy Meters and 22 weather stations			400	1,200	2,200
DC supplies at various sites	1,250	2,100	3,350	3,000	3,800
Total	**$20,805**	**$17,688**	**$15,005**	**$14,280**	**$15,117**

Table 3 – Program components

9 Reference Documents

- National Electricity Rules.
- Electricity Safety Act.
- Electricity Safety (Management) Regulations.
- AMS 10-68 Secondary Systems.