



Ensuring Reliable Supply for Adelaide's Eastern Suburbs

Options Screening Notice

7 October 2022

SA Power Networks

www.sapowernetworks.com.au

Disclaimer

This Options Screening Notice has been prepared in accordance with clause 5.17.4(d) of the National Electricity Rules (NER) for the purpose of demonstrating why SA Power Networks believes there are no credible non-network options or standalone power systems (SAPS) available nor such options which form a significant part of a potential credible option to address the identified need.

This notice makes use of historic non-network option costs and contains assumptions regarding, amongst other things, economic growth and load forecasts which by their nature, may or may not eventuate. SA Power Networks advises that anyone proposing to use this information should verify its reliability, accuracy and completeness before committing to any course of action.

Whilst care has been taken in the preparation of the information contained in this notice, it is provided in good faith. SA Power Networks makes no warranties or representations as to its reliability, accuracy or completeness and accepts no responsibility or liability for any loss or damage that may be incurred by any person acting in reliance on this information or assumptions drawn from it.

This document is not intended to be used for other purposes, such as making decisions to invest in generation, transmission or distribution capacity.

Copyright

Copyright in the material contained within this document is owned by or licensed to SA Power Networks. Permission to publish, modify, commercialise or alter this material must first be obtained from SA Power Networks.

Contents

Disclaimer	2
Copyright	2
Contents.....	3
Figures	4
1 Introduction.....	5
2 Description of the identified need.....	6
2.1 Relevant area of the SA Power Networks distribution network.....	6
2.2 Design of the Northfield GIS.....	6
2.2.1 Condition of the aging O-ring seals is leading to risk of gas leakages	8
2.2.2 Attempts at refurbishing/repairing the seals have been unsuccessful	8
2.3 Expected unserved energy if action is not taken.....	9
2.3.1 Scenario 1 – single Northfield 66kV bus section failure	9
2.3.2 Scenario 2 – two Northfield 66kV GIS bus section failures.....	9
2.3.3 Scenario 3 – total loss of Northfield 66kV GIS	11
2.4 Environmental Impact.....	13
3 Proposed network options to meet the identified need	13
3.1 Option 1 – Construct a new Northfield 66kV AIS.....	13
3.2 Option 2 – Construct a new indoor Northfield GIS.....	14
3.3 Options considered but not proposed to be progressed in the DPAR.....	15
4 Assessment of non-network solutions and SAPS	15
4.1 Requirements that a non-network option or SAPS would need to satisfy.....	16
4.1.1 Requirements to address complete loss of the Northfield GIS.....	16
4.1.2 Consideration of SAPS options.....	16
5 Conclusion.....	17

Figures

Figure 2.1: Northfield GIS location within Greater Adelaide Metropolitan.....	6
Figure 2.2: Simplified line diagram of the Northfield GIS configuration	7
Figure 2.3: Condition of O-rings in the Northfield GIS.....	8
Figure 2.4: Load duration curve under Scenario 2	10
Figure 2.5: Daily peak loads from 2018/19.....	10
Figure 2.6: Load duration curve under scenario three.....	11
Figure 2.7: Daily peak loads from 2018/19.....	12
Figure 2.8: Peak summer day profile for Northfield substation	12
Figure 2.9: Layout of Northfield AIS under Option 1.....	14
Figure 2.10: Layout of Northfield indoor GIS under Option 2	15

1 Introduction

The Northfield 66 kilovolt (kV) substation is a key link in the 66kV interconnected network that supplies approximately 115,000 customers in Adelaide's eastern suburbs. It was installed in the late 1980s and components of its infrastructure are now reaching the end of their service lives and are in poor condition. In particular, the gas insulated switchgear (GIS) that forms part of the substation is in poor mechanical condition and subject to accelerated ageing. These condition issues are principally a result of significant external corrosion – specifically on the flanges and O-rings in the GIS – caused by 35 years of continuous service in an outdoor environment.

Reflecting its age, the condition of the Northfield GIS has deteriorated to the extent that there is a material risk of asset failure. Failure of the GIS installation has the potential to lead to significant levels of unserved energy to customers in Adelaide's eastern suburbs. SA Power Networks has therefore commenced this Regulatory Investment Test for Distribution (RIT-D) to determine the most efficient means of ensuring reliable supply for Adelaide's eastern suburbs. Further, SA Power Networks expects there to be significant market benefits associated with ensuring reliable supply for Adelaide's eastern suburbs – principally in the form of avoided involuntary load shedding – and considers the identified need for this RIT-D to be delivering market benefits. In addition to market benefits, SA Power Networks expects there will be significant environmental benefits from avoided leakages of the gas used to insulate Northfield.

The purpose of this options screening notice is to inform all Registered Participants, the Australian Energy Market Operator (AEMO), Interested Parties, non-network service providers and parties on our industry engagement register that SA Power Networks has determined that there are no credible non-network options or stand-alone power systems (SAPS) options that are able to address in full, or as part of a potential credible option, the identified need for this RIT-D. This notice has been developed in accordance with clause 5.17(c) of the National Electricity Rules (NER) and represents the first formal stage of the RIT-D assessing how to most efficiently ensure reliable supply for Adelaide's eastern suburbs.

The second formal stage of this RIT-D is a Draft Project Assessment Report (DPAR), which includes a full net present value (NPV) options assessment.

If you have any comments or enquiries regarding this notice, please send to the following email: requestforproposals@sapowernetworks.com.au.

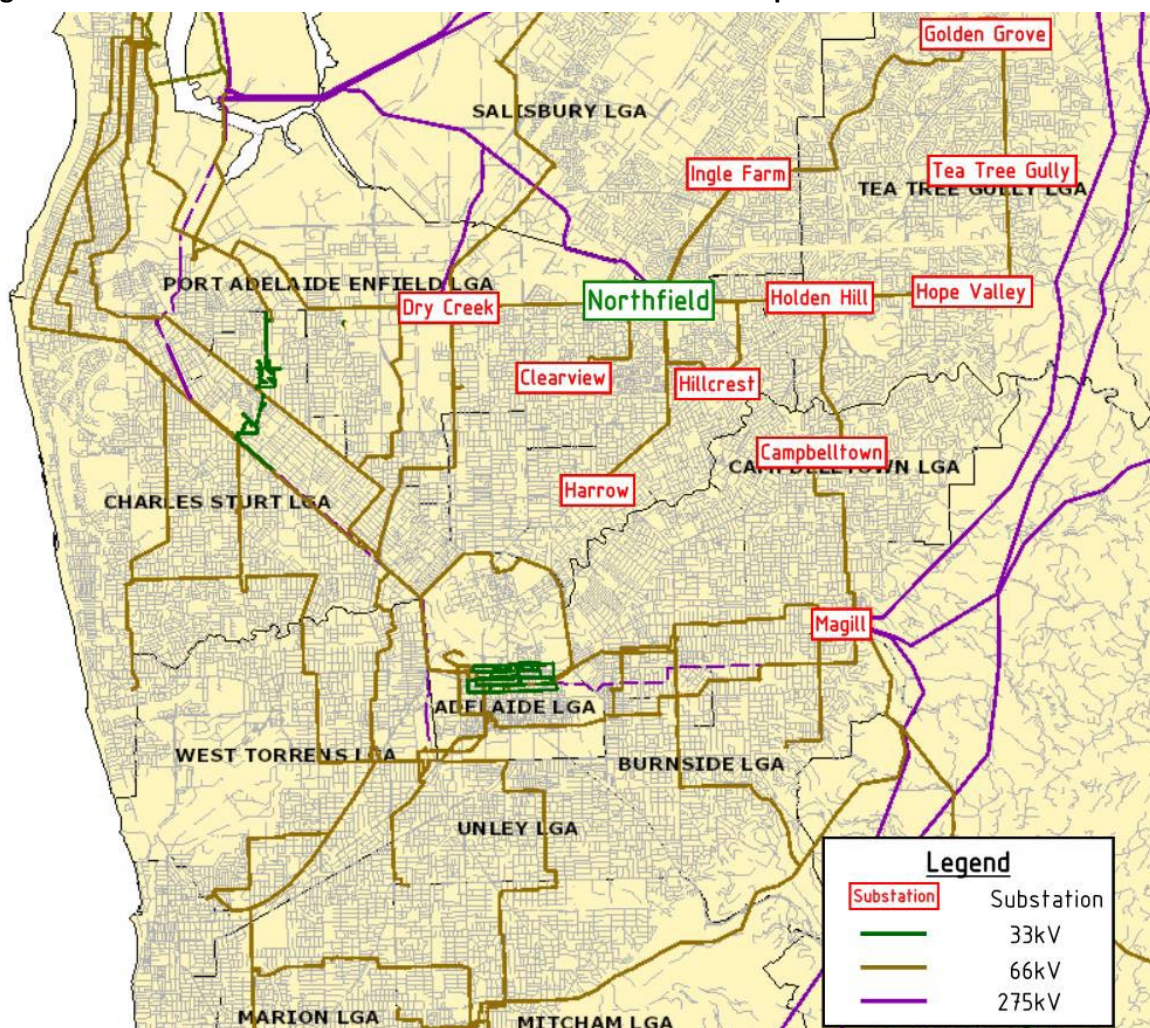
2 Description of the identified need

This section describes the identified need for this RIT-D and sets out the key assumptions and methodologies that underpin this need. SA Power Networks has used these assumptions in making the determination that there will not be a potential credible non-network option or SAPS option on a standalone basis, or that forms a significant part of a potential credible option, capable of meeting this need, in accordance with clause 5.17.4(c) of the NER.

2.1 Relevant area of the SA Power Networks distribution network

The Northfield substation is a key link in the 66kV interconnected network that supplies approximately 115,000 customers in Adelaide's eastern suburbs. Figure 2.1 provides an overview of where the Northfield substation is located within the SA Power Networks distribution network and the surrounding network infrastructure.

Figure 2.1: Northfield GIS location within Greater Adelaide Metropolitan



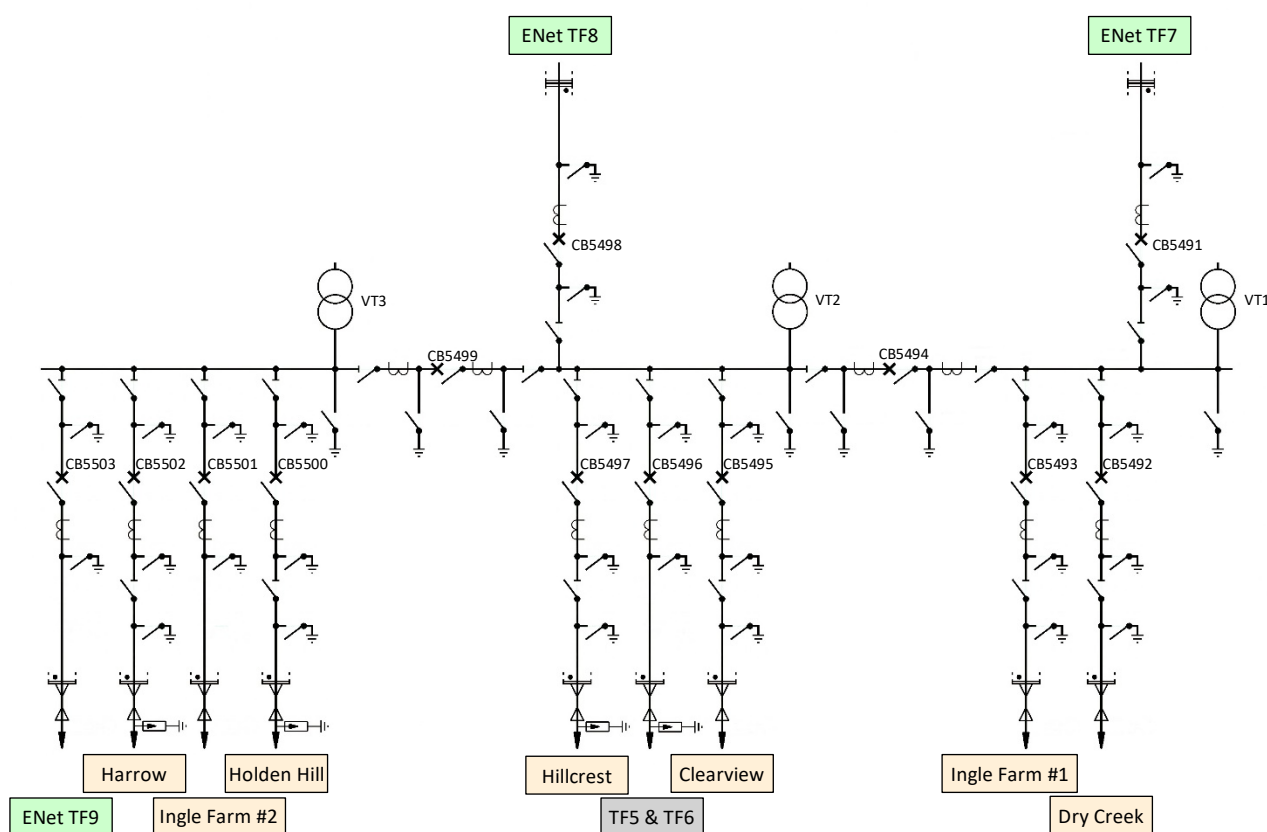
2.2 Design of the Northfield GIS

The Northfield substation is classified as a connection point substation because it is a physical link between South Australia's transmission and distribution networks. It contains an outdoor air-insulated switchgear (AIS) installation operating at 275kV owned by ElectraNet and an outdoor GIS installation operating at 66kV majority owned by SA Power Networks. These installations consist of

three 275/66kV transformers supplying seven 66kV sub-transmission lines to Adelaide’s eastern suburbs and the surrounding Northfield and Northgate areas via two 66/11kV transformers.

The present 66kV GIS installation at Northfield is configured into three basic bus sections, with the bus sections linked together through a circuit breaker and associated disconnect switches. Each bus section has the provision to connect a maximum of four external sources (one incomer and up to three outgoing connections), with each connection achieved through a circuit breaker and associated disconnect switches. Figure 2.2 provides an overview of the existing configuration of the Northfield GIS.

Figure 2.2: Simplified line diagram of the Northfield GIS configuration



Functionally, the Northfield GIS is used primarily to inject power into SA Power Networks’ eastern suburbs 66kV network. To do this, it takes power from the three 275/66kV ElectraNet transformers on site and directs it into the 66kV network via seven sub-transmission lines also located in the substation. The output of these transformers is fed into the 11kV feeder network surrounding the substation via SAPN’s two 66/11kV transformers 5 and 6.

The switchboard high voltages are insulated using gas (specifically SF₆), which is used extensively in the industry as an insulator and an arc interruption medium in gas insulated switchboards, cubicles, circuit breakers and other switchgear components. Within the switchboard, flanges are used to connect separate sections of switchgear with O-ring seals to contain the gas in separate chambers. The separate chambers have gas injection ports to enable the chambers to be filled with gas or for topping up should gas leaks occur. The gas is critical for the functioning of the electricity equipment and if low pressure occurs SCADA alarms are raised. If a sudden loss of gas was to occur the circuit breakers would attempt to isolate the faulted section. If any of the circuit breakers failed, supply to all 115,000 customers could be lost and the GIS could be damaged beyond repair.

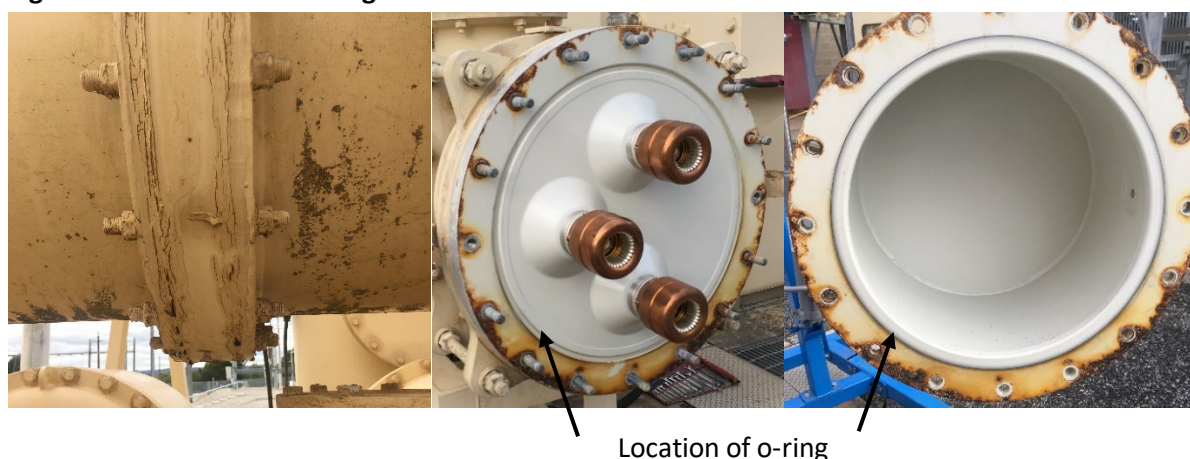
A critical element of the design is the rubber gas seal that holds the gas within the chambers. The equipment at Northfield GIS was designed with one sealing O-ring between the flanges instead of two sealing O-rings that other manufacturers adopted at the time, and which is currently design practice for GIS. The double seal is superior to a single seal for two key reasons:

- it provides higher protection against leaks; and
- if leaks do occur, the repairs are more likely to be successful.

2.2.1 Condition of the aging O-ring seals is leading to risk of gas leakages

O-ring seals age over time and become brittle, with the rate of ageing increasing with higher operating temperatures. The outdoor installation of the switchboards at Northfield GIS has meant that, after 35 years of continuous operation, the O-ring seals and flanges are in poor condition and a material risk of failure. In particular, the flanges are severely corroded – figure 2.3.

Figure 2.3: Condition of O-rings in the Northfield GIS



The condition of the O-rings are such that SA Power Networks is already experiencing seal failures. In April 2017, there were seal failures at two flanges that resulted in uncontrolled atmospheric gas leaks. In September 2019, seal failure occurred on a third flange. The leaks were caused by increasing corrosion on the flange surface and further leaks are expected which will compromise the integrity of the switchgear.

2.2.2 Attempts at refurbishing/repairing the seals have been unsuccessful

SA Power Networks has attempted to address the gas leaks and moisture ingress resulting from the severe external corrosion of the O-rings by refurbishing/repairing the seals. The attempts to provide sealing to stop the leaks was carried out by the manufacturer (Hitachi) in October 2018, which aimed to prolong the asset's useful life.

The repair works for one of the leaks at one of the metal-to-metal flanges was successful. The repair works for the second gas leak at a metal-to-board-to-metal flange took two attempts to seal the leak. However, in January 2019, a gas leak appeared at the same joint. The metal-to-board-to-metal flange repair has been unsuccessful since and more severe leakage of gas has occurred compared to the original gas leak. An additional gas leak at a third flange was identified in September 2019.

In July 2019, Hitachi advised that it is unable to provide the same repair solution to address the more recent leaks because it was no longer viable. SA Power Networks subsequently engaged BLJ In-Situ Solutions to attempt further repair works on the leaks (three attempts, the last in May 2022), all of

which have been unsuccessful. Today the flange continues to leak SF₆, requiring the constant addition of gas to maintain pressure and keep the GIS in service.

2.3 Expected unserved energy if action is not taken

If investment is not undertaken, there will be significant unserved energy (USE) in SA Power Networks' distribution network because the asset condition will continue to deteriorate increasing the prospect of GIS failure. However, the extent of load at risk depends on the nature of the failure. SA Power Network has therefore considered three significant failure scenarios:

- Scenario 1: an event where a single GIS bus section fails;
- Scenario 2: an event where a failure causes two GIS bus sections to be inoperable, such as the failure of the circuit breaker connecting two adjacent bus sections; and
- Scenario 3: an event where failure results in total loss of Northfield GIS.

In developing each of these scenarios, SA Power Networks has assumed that the failed GIS is non-repairable and cannot be returned to service – triggering replacement that takes at least two years, which results in on-going load at risk during this replacement period, as well as the immediate load-shedding during the failure event. SA Power Networks' experience has been that even slow leaks cannot be repaired in some cases.

In estimating the load at risk, SA Power Networks has used the average load from 2018/19 of 89.15 megawatts (MW), because more recent data does not accurately represent future loads due to the effects of COVID-19 and mild summers. 10 per cent probability of exceedance (POE) forecast values were also used with a total peak load of 357MW. It was also assumed there is a total of 113,666 customers resulting in 318.4 customers per MW.

2.3.1 Scenario 1 – single Northfield 66kV bus section failure

Scenario one considers an event where a single GIS bus section fails, such as the loss of the centre bus section (identified as TF8 in figure 2.2 above). Under this scenario, SA Power Networks has contingency response plans in place to re-establish supply from the substation within a 24-hour period. Northfield and Clearview substations are restored via bypasses and offloads. 24 hours after the initial event, there is no on-going load at risk, however, there is a significant N-1 risk because of the single GIS bus section failure.

2.3.2 Scenario 2 – two Northfield 66kV GIS bus section failures

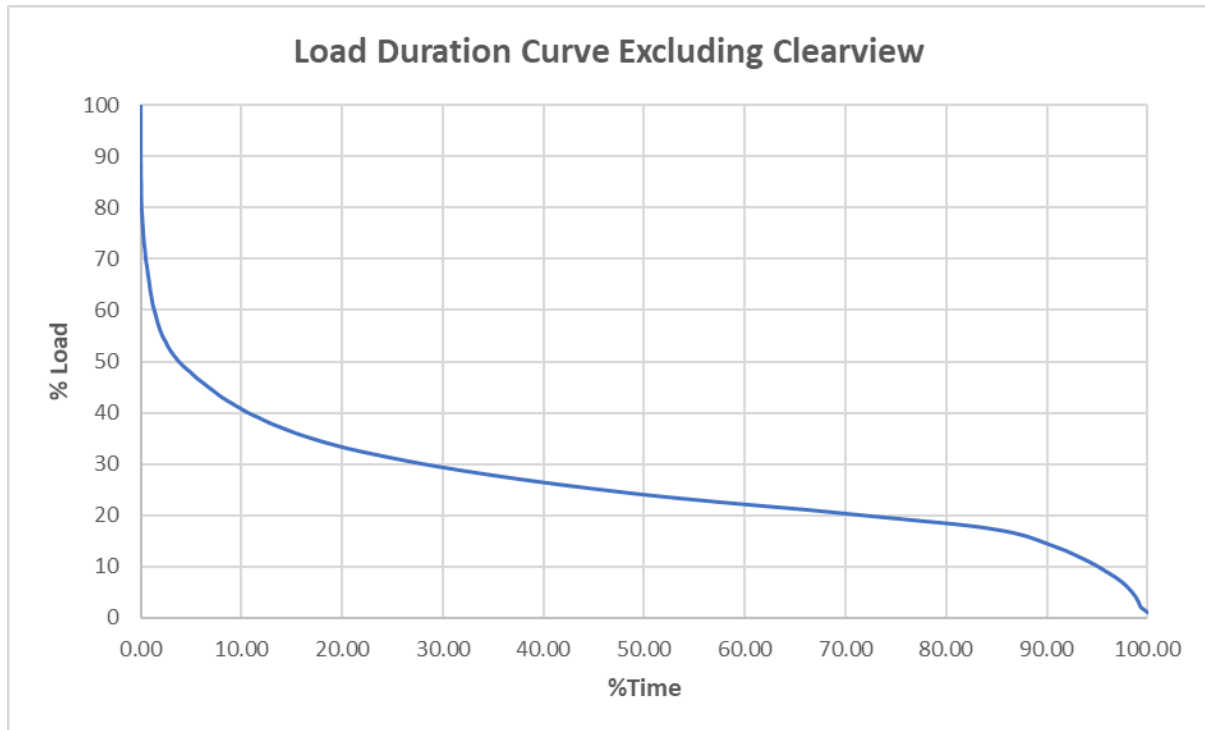
Scenario two considers an event where there are two GIS bus section failures, such as a leak on a section circuit breaker chamber or the centre section as well as a subsequent leak on the TF9 section (see figure 2.2).

Following such a fault the Clearview, Northfield 11kV and Harrow substations would experience an outage, resulting in the Magill to Campbelltown and Northfield to Ingle Farm 1 lines supplying the entire load in the area. These lines would be supplying the entire load in the north-east and have a total emergency rating of 281MW, meaning they can support all load initially before the restoration of the affected substations.

After 24 hours the Clearview, Northfield 11kV and Harrow substations would be restored via bypasses or 11kV load transfers. However, there would be an ongoing risk of unserved energy during the two-year replacement period because the nature of the supply restoration is such that network would not be able to meet peak demand in the area. SA Power Networks notes that Clearview would be restored via the Dry Creek 66kV line which would then result in it being supplied outside of the

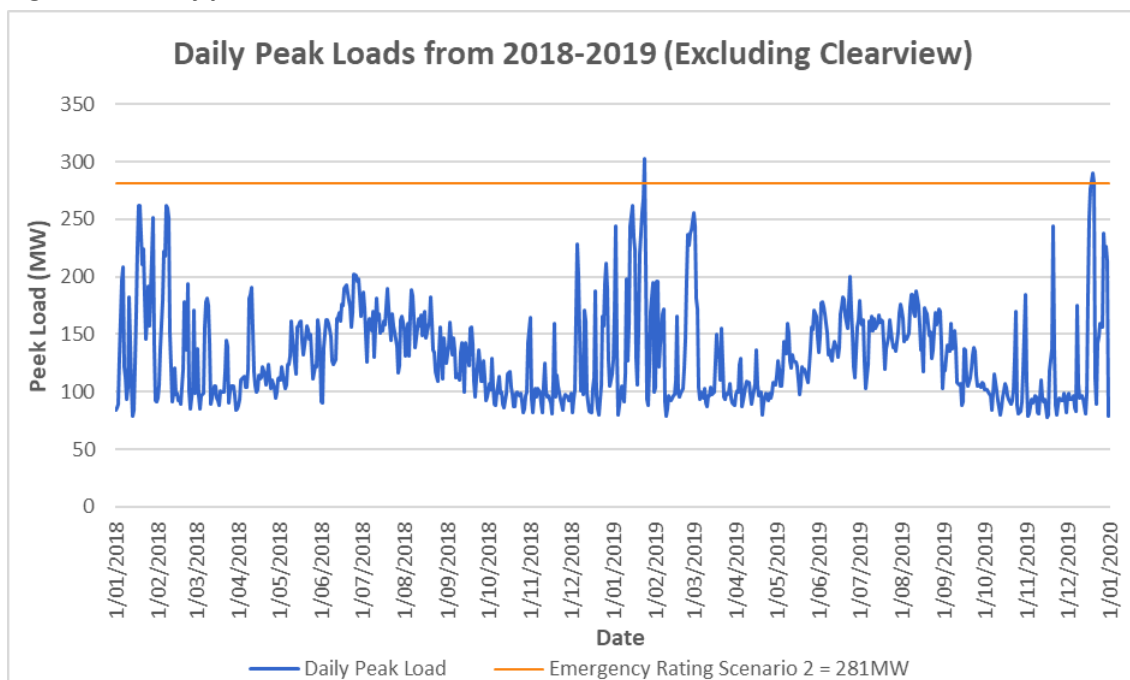
constrained eastern suburbs network. It has therefore been excluded from the load duration curve underpinning the assessment of load at risk during the replacement period under this scenario – figure 2.4.

Figure 2.4: Load duration curve under Scenario 2



Based on the load duration curve in figure 2.4, the amount of time the Magill to Campbelltown and/or Northfield to Ingle Farm # 1 lines would be overloaded prior to the replacement of the failed bus sections is 0.08 per cent – or eight hours at risk per 10 per cent POE year, implying that load shedding would be required for three days – figure 2.5.

Figure 2.5: Daily peak loads from 2018/19

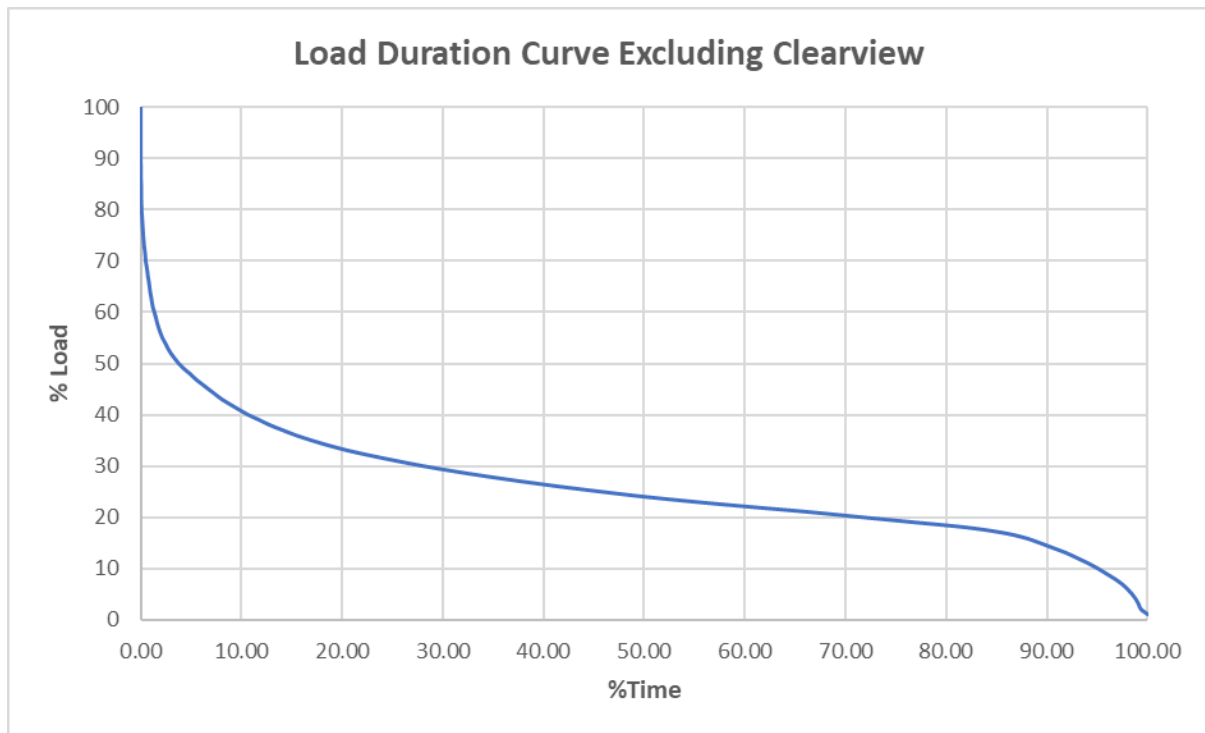


2.3.3 Scenario 3 – total loss of Northfield 66kV GIS

Scenario 3 considers the total loss of the Northfield GIS. SA Power Networks considers this is a credible risk due to the poor condition of the asset and large number of joints with the potential to leak on the GIS. In particular, two or more significant leaks on different bus sections could cause this scenario, leading to complete failure of the asset.

Depending on the particular nature of the failure, any radial load lost would be restored within 24 hours of the initial fault. Specifically, Clearview, the Northfield 11kV and Harrow substations would be restored via bypasses or 11kV transfers. However, similar to Scenario 2, there would be an ongoing risk of unserved energy during the two-year replacement period because the nature of the supply restoration is such that network would not be able to meet peak demand in the area. Clearview would again be restored via the Dry Creek 66kV line and therefore supplied outside of the eastern suburbs 66kV interconnected network and it has therefore been excluded from the load duration curve underpinning the assessment of load at risk under this scenario – figure 2.6.

Figure 2.6: Load duration curve under scenario three



Under this scenario the only supply into the eastern suburbs 66kV interconnected network is the Magill to Campbelltown 66kV line (Northfield to Ingle Farm # 1 is no longer available due to the complete loss of the GIS). Drawing on the load duration curve presented in figure 2.6, this line would be overloaded 8.1 per cent or 707 hours per POE10 year. In particular, during peak load periods there would be 332MW of demand compared to the 142MW emergency rating of the line – implying an overload of 134 per cent which translates to a 190MW supply shortfall. Further, peak load at Northfield substation would likely exceed the emergency rating of the line on 140 days – figure 2.7.

Figure 2.7: Daily peak loads from 2018/19

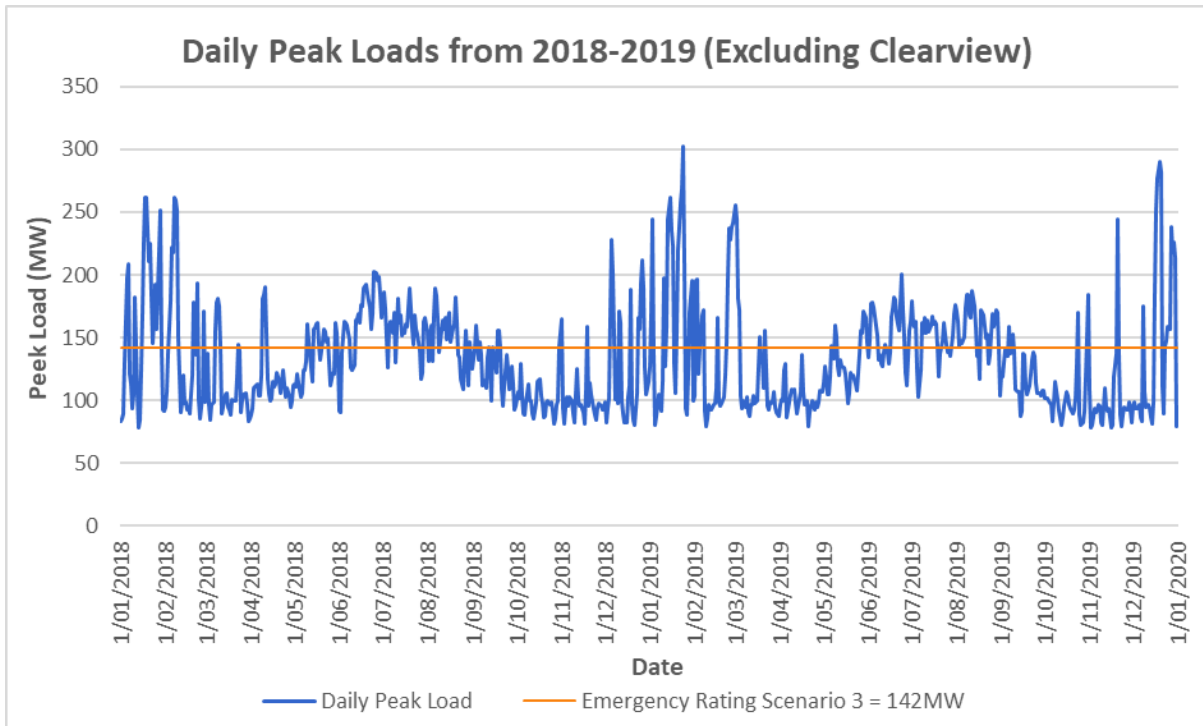
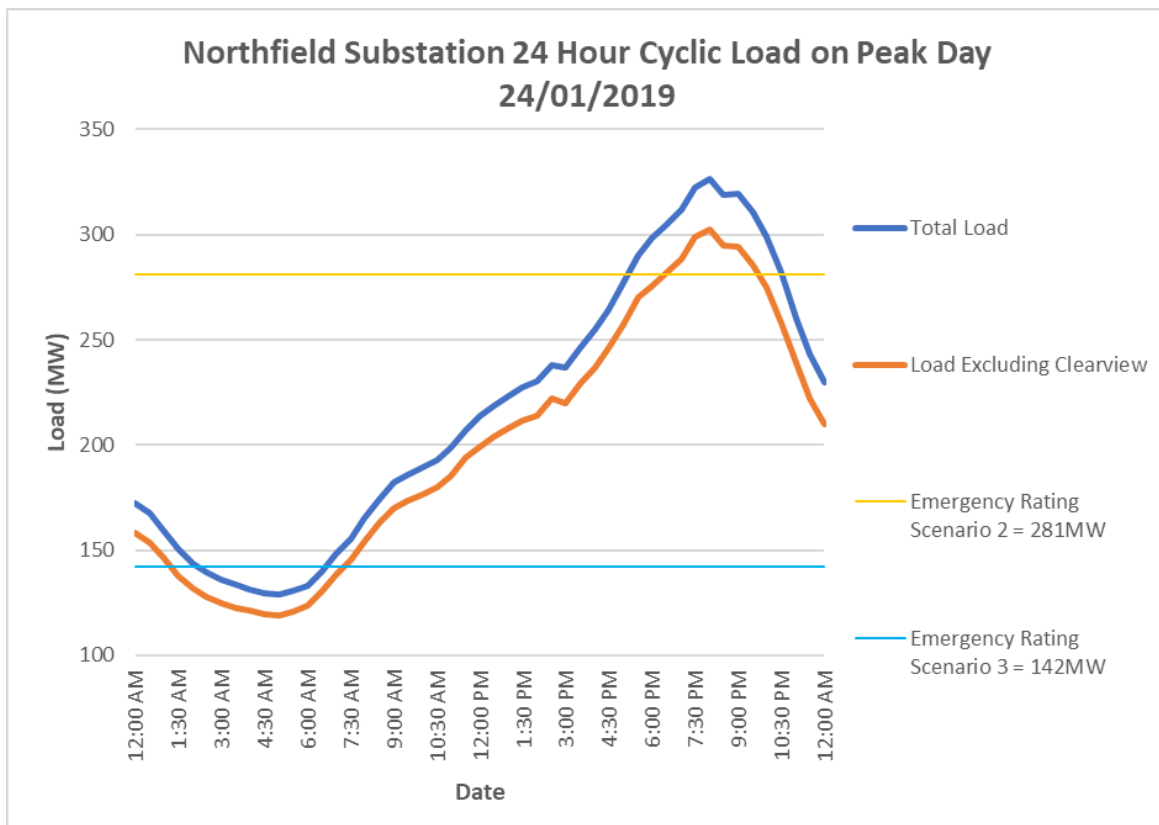


Figure 2.8 presents the peak load profile for a summer day at Northfield substation and compares this profile to the emergency rating of the available lines under Scenarios 2 and 3, illustrating that network support would be required for the majority of the day during the summer period irrespective of the failure scenario (with the exception of Scenario 1).

Figure 2.8: Peak summer day profile for Northfield substation



2.4 Environmental Impact

The Northfield 66kV GIS is currently leaking significant volumes of SF₆ gas into the atmosphere from known leak points. The leak rate is highly likely to increase as more leaks develop and the existing unreparable leaks deteriorate further. SF₆ gas is the most potent greenhouse gas known, approximately 23,000 times worse than CO₂.

In the financial year 2020-2021, the annual emission of SF₆ amounted to approximately 76kg from Northfield Substation alone, adversely contributing to climate change. It is likely the condition of the GIS will continue to deteriorate, increasing the rate of uncontrolled SF₆ release into the atmosphere.

SA Power Networks acknowledges that environmental impacts are not an assessment factor in the RIT-D process, but the company environmental policy recognises that SF₆ losses should be minimised and its use discontinued owing to the significant negative environmental impact. There are also reputation risks faced by SA Power Networks (and potentially the broader electricity sector) because of releasing SF₆, and there is growing pressure internationally to ban the use of this gas.

3 Proposed network options to meet the identified need

SA Power networks has identified two credible network options to address the identified need. This section provides more information on the scope and cost of these options. It also outlines options considered but that SA Power Networks does not propose to progress further.

3.1 Option 1 – Construct a new Northfield 66kV AIS

Option 1 involves constructing a new 66kV outdoor AIS immediately south of the existing Northfield substation with three 66kV bus sections supplying all existing seven 66kV lines as well as supplying the two 66/11kV transformers at the existing Northfield substation. In particular, the outdoor AIS would comprise:

- three 275/66kV transformer connections;
- three 66kV bus sections with ring bus cable tie;
- seven 66kV line exits, with provision for nine exits in total;
- connection to the existing 66/11kV transformers at Northfield substation, with provision for three additional transformers; and
- building characteristics that are capable of accommodating future 11kV upgrades to meet capacity constraints (forecast to be required by 2030).

Figure 2.9 provides an overview of the layout of Northfield substation under this option.

Figure 2.9: Layout of Northfield AIS under Option 1



The total cost of this option is expected to be \$35.5 million, including approximately \$5M in transmission (ElectraNet) capex. Construction of the new AIS would commence in 2023 with commissioning of the asset completed by H1 2025.

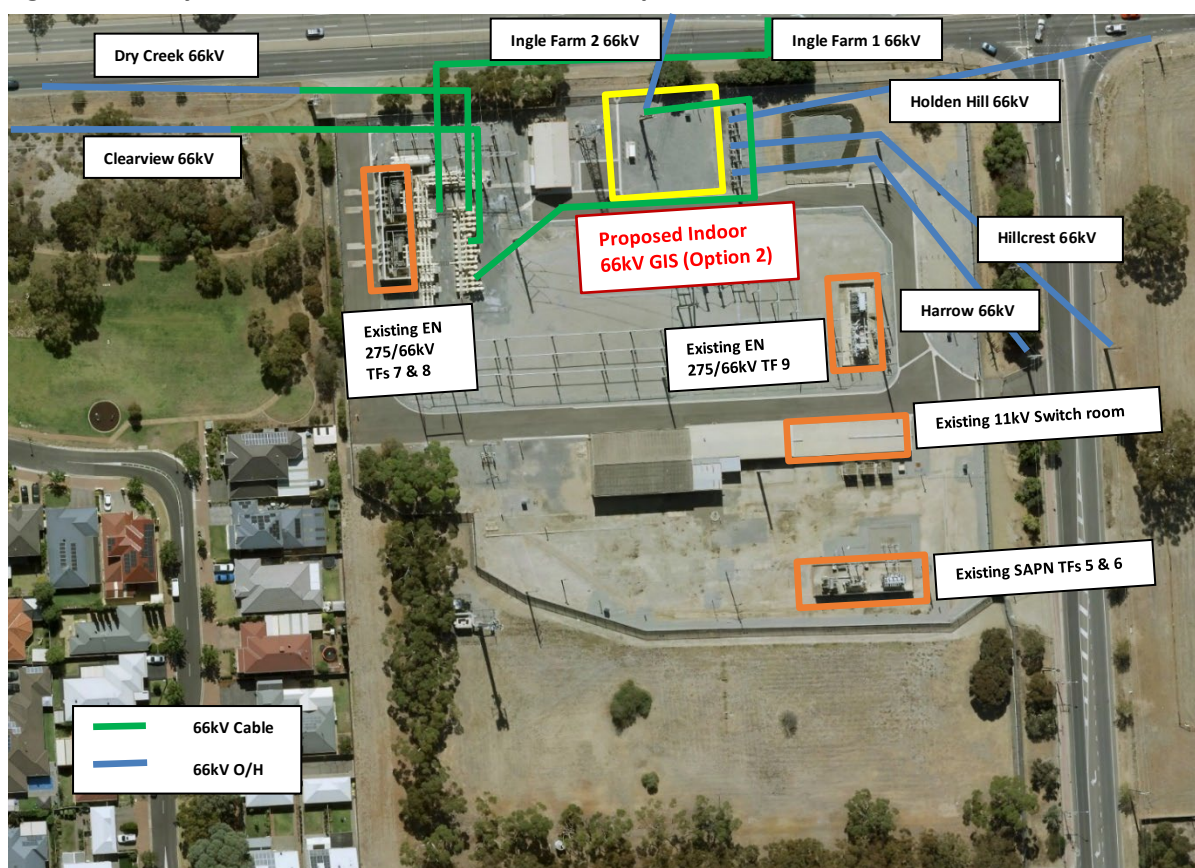
3.2 Option 2 – Construct a new indoor Northfield GIS

Option 2 involves constructing a new three section 66kV GIS in a climate-controlled building in the northeast corner of the Northfield substation. The new GIS would be housed indoors so as to minimize the potential for corrosion and thereby avoid the present asset condition issues. Within the climate-controlled building the GIS would comprise:

- three 275/66kV transformer connections;
- three 66kV bus sections with ring bus cable tie;
- seven 66kV line exits, with provision for nine in total; and
- connection to the existing 66/11kV transformers at the Northfield substation, with provision for three additional transformers.

In contrast to Option 1, the building characteristics would not be capable of accommodating future 11kV upgrades to meet network constraints forecast to arise by 2030. Figure 2.10 provides an overview of the layout of Northfield substation under this option.

Figure 2.10: Layout of Northfield indoor GIS under Option 2



The total cost of this option is expected to be \$37.0 million, including approximately \$1M in transmission (ElectraNet) capex. Construction of the new indoor GIS would commence in 2023 with commissioning of the asset completed by H1 2025.

3.3 Options considered but not proposed to be progressed in the DPAR

Section 2.2.2 describes the various approaches SA Power Networks has adopted to address the asset condition issues of the existing Northfield GIS, none of which have proven to be successful over an extended period.

SA Power Networks engaged EA Technology, a British engineering firm with significant experience in GIS management, to complete an engineering assessment of the management of the existing Northfield GIS including its condition, previous repair attempts and future options to be explored.

EA Technology’s assessment recommended that the least intrusive solution to customer supply, lowest risk for supply interruptions and best solution for environment protection is replacement of the existing GIS switchboard. SA Power Networks has therefore not considered alternative approaches that do not involve replacement of the switchboard. Rather, the focus of the RIT-D assessment is on the most efficient technical means of replacing the switchboard.

4 Assessment of non-network solutions and SAPS

SA Power Networks has determined that there is unlikely to be a non-network option or SAPS option that could form a potential credible option on a standalone basis, or that could form a significant part of a potential credible option for this RIT-D.

This section sets out the assessment behind this determination, which draws on the assumptions outlined in the sections above, and considers the required technical characteristics that a non-network option or SAPS option would need in order to meet the identified need.

4.1 Requirements that a non-network option or SAPS would need to satisfy

A viable non-network option or SAPS that maintains supply to all customers in the eastern suburbs must be capable of reducing the estimated shortfall in the supply capability of the network in the event of a failure of the Northfield GIS. It should also be capable of providing the entire peak demand of the area to provide security of supply to the network as it operates in contingent conditions.

As discussed in section 2.3, there are number of failure scenarios that will affect the size of load reduction or additional supply required from a non-network option or SAPS option. SA Power Networks considers that any non-network option or SAPS option must be capable of alleviating the shortfall in supply in the worst-case scenario, i.e., total loss of the Northfield GIS (Scenario 3). Non-network options or SAPS options must therefore be able to address this failure scenario to be able to address the identified need. Being able to address the complete loss of the Northfield GIS would also ensure that any non-network or SAPS option could manage the other failure scenarios.

This section therefore focuses on the requirements that a non-network option or SAPS would need to satisfy in the event of a complete loss of the Northfield GIS.

4.1.1 Requirements to address complete loss of the Northfield GIS

Under Scenario 3 the only supply into the eastern suburbs 66kV interconnected network is the Magill to Campbelltown 66kV line. Drawing on the load duration curve presented in figure 2.6, this line would be overloaded 8.1 per cent or 707 hours per POE10 year. In particular, during peak load periods there would be 332MW of demand compared to the 142MVA emergency rating of the line – implying an overload of 134 per cent which translates to a 190MW supply shortfall.

Figure 2.8 in section 2.3.3 also demonstrates that on a peak summer day demand at the Northfield substation would exceed the emergency rating of the line for the majority of the day.

The analysis above illustrates that the requirement for support from non-network options and SAPS is substantive in both the numbers of days expected to be required and the magnitude of the support needed. In particular, it demonstrates that the required characteristics of a non-network or SAPS option to represent a credible option for this RIT-D is an order of magnitude that does not appear realistic (given the scale of assistance needed).

4.1.2 Consideration of SAPS options

Recent changes to the NER, RIT-D and RIT-D application guidelines require SA Power Networks to consider whether a SAPS option can fully or partly address an identified need. In practice, this relates to consideration of whether an identified need could be fully or partly addressed by converting part of SA Power Networks' distribution network forming part of the interconnected national electricity system to a regulated SAPS.¹ Regulated SAPS are set out in section 6B of the National Electricity Law (NEL), which defines a SAPS as a system that:²

- generates and distributes electricity; and
- does not form part of the interconnected national electricity system.

¹ See definition of 'SAPS option' in the NER.

² Section 6B(6) of the NEL.

SA Power Networks considers that there is not a SAPS option that could form a potential credible option on a standalone basis, or that could form a significant part of the credible option, in this RIT-D. In particular, the load requirements of the eastern suburbs interconnected network are significant and could not be supported by a network that is not part of the interconnected national electricity system with the ability to draw on grid-connection generation services.

5 Conclusion

The Northfield substation is a key link in the 66kV interconnected network that supplies Adelaide's eastern suburbs. The condition of its GIS has deteriorated to the extent that there is a material risk of asset failure, which has the potential to lead to significant levels of unserved energy to customers in Adelaide's eastern suburbs. Addressing these condition issues will avoid involuntary load shedding as well as providing significant environmental benefits from avoided leakages of the gas used to insulate the switchgear.

Based on the extent of load reduction or additional supply required in the event that there is a complete failure of the Northfield GIS, non-network or SAPS options are not considered feasible in terms of forming a potential credible option on a standalone basis, or forming a significant part of a potential credible option for this RIT-D.