Addressing reliability requirements in West Toowoomba Substation

Final Project Assessment Report

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Executive Summary

Ergon Energy Corporation Limited (Ergon Energy) has prepared this Final Project Assessment Report (FPAR) in accordance with the requirements of clause 5.17.4(p) of the National Electricity Rules (NER).

It follows a determination made by Ergon Energy that there is not a non-network option that is a potential credible option, or that forms a significant part of a potential credible option to address the identified need at West Toowoomba substation. Ergon Energy has published their notice under clause 5.17.4(d) of the National Electricity Rules. In brief, this FPAR includes information relating to the following matters:

- A description of the identified need Ergon Energy is investing in;
- The assumptions used in identifying the need;
- A description of each credible option assessed by Ergon Energy
- Identification of Ergon Energy's proposed preferred option, including:
  - details of the technical characteristics;
  - the estimated construction timetable and commissioning date;
  - indicative capital and operating cost;

Ergon Energy is responsible, under its Distribution Authority, for electricity supply to the West Toowoomba area in southern Queensland. The West Toowoomba area serves approximately 8,923 customers and is located approximately 2km to the west of the Toowoomba central business district (CBD). The region is supplied by T116 Torrington (TORR), T043 South Toowoomba (SOTO), ME005 West Toowoomba (WETO) and T235 Toowoomba Central (TWCE) substations. The West Toowoomba substation is connected to the 33kV feeders from TORR and SOTO.

A number of assets in the substation are nearing end of life and are planned to be replaced. A detailed Substation Condition Assessment Report (SCAR) has been prepared and recommends the replacement of a number of 11kV circuit breakers, isolators and relays. The substation was originally built in 1945 and its last upgrade was in the 1970s. Due to the arrangement of the 11kV switchyard and the asset condition, in-situ replacement of these assets has been deemed unsafe and extremely costly. The preferred option is to replace the current outdoor switchyard with an indoor-type 11kV switchroom.

Ergon Energy currently owns two vacant blocks to the north of the existing substation. These blocks will be used to extend the substation for the preferred option of establishing a new indoor 11kV switchroom. The outdoor 11kV switchyard will be decommissioned once the new switchroom is established and there will be sufficient space for all future replacements of the 33kV assets to take place.

An internal review has not indicated any feasible non-network alternatives. Consequently, a Non-Network Options Report has not been prepared in accordance with rule 5.17.4(c) of the National Electricity Rules. This document is being published as the Final Project Assessment Report under NER clause 5.17.4(d).
1. Addressing reliability requirements in West Toowoomba Substation

West Toowoomba Zone Substation (WETO) provides electricity supply to approximately 8923 predominantly residential customers in the Newtown and Wilsonton areas. There are approximately 640 industrial customers consisting of a hospital, shopping centres, schools and other retail / offices complexes.

West Toowoomba Substation was originally built around 1945. The last major upgrade of the substation occurred in the early 1970s. The substation is a 33/11kV substation and is a crucial part of the Toowoomba electricity supply network. There are four incoming 33kV feeders, two from South Toowoomba T043 bulk supply substation and two from Torrington T116 bulk supply substation. WETO is normally supplied from Torrington T116 substation.

Past load on West Toowoomba substation has been an average of 24MVA, however, after the commissioning of the new Toowoomba Central (TWCE) substation in 2016, the load at West Toowoomba has not exceeded 21MVA.

A number of assets in the substation are nearing end of life and are planned to be replaced. The earliest up for replacement are the oil circuit breakers on the seven 11kV feeders, three 11kV transformer circuit breakers, airbreak switches and a number of relays.

The National Electricity Rules (NER) requires that, subject to certain exclusion criteria, a regulatory investment test for distribution (RIT-D) project to address an identified need must be subject to a RIT-D. Ergon Energy has determined that the installation of new 11kV assets and associated infrastructure should be subject to a RIT-D. This FPAR has been prepared by Ergon Energy in accordance with the requirements of clause 5.17.4(d) of the NER and it sets out the reasons for Ergon Energy's determination, including the methodologies and assumptions used.
2. Forecast load, capacity, and network characteristics

2.1. Restoration timeframes and safety net

2.1.1. Safety net requirements

A fundamental requirement of Ergon Energy’s Distribution Authority D01/99 is to comply with Safety Net targets that seek to effectively mitigate the risk of low probability – high consequence network outages to avoid unexpected customer hardship and / or significant community or economic disruption.

Under the reliability standards, Ergon Energy is no longer required to provide full N-1 security of supply on the 33kV network that supplies West Toowoomba Substation. Instead, a set of supply restoration targets, known as the ‘Service Safety Net Targets’ apply. The Safety Net targets seek to limit the severity (and thus the hardship experienced by Ergon Energy customers) following a “credible contingency” for loads up to the 50% probability of exceedance (PoE) forecast.

Under the Safety Net, Toowoomba is classified as a “Regional Centre” and has the following restoration targets. The load unserved must be:

1. Less than 20MVA after 1 hour
2. Less than 15MVA after 6 hours
3. Less than 5MVA after 12 hours
4. Fully restored within 24 hours

2.1.2. Safety net contingency plan

Table 1 shows the Safety net contingency plan for West Toowoomba Substation.
Safety Net Contingency Plan

Note: This plan was developed to ensure Safety Net compliance for a credible event occurring on the day of (forecast) maximum demand for a normal (POE50) year. It does not necessarily represent the “best” contingency (i.e., the plan that results in the smallest number of lost customer minutes/unsupplied load). Most events will occur when demand is less than the forecast MD. In these cases, some actions such as shedding large customers, deploying Nomads/Pegasus units, etc. will not be necessary to achieve SN compliance and it will be up to the co-ordinator to decide on what is best. Where the event occurs on a day where demand is higher than the forecast MD, SN compliance may not be possible—in which case, best endeavours is all that is required.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Failure</th>
<th>Consequence</th>
<th>Actions</th>
<th>SN Minimum Timeline</th>
<th>Typical Timeline</th>
<th>Safety Net Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Transformer 33/11kV</td>
<td>The demand supply capacity can be carried by the remaining two power transformers according to the peak load in 2017-2018 (&lt;20MVA).</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
| | | | | | | | Full supply restored: N/A N/A N/A N/A
| 2 | 33kV or 11kV bus zone | Total loss of supply to WETO substation; supply capacity reduced to N-1 rating | 1. Isolate faulted bus section and restore supply via two transformers Transfer Holberton St FDR (WETO) to Willowburn FDR (NOST) a. Close AB4706 or AB17983 b. Open CB3984 Approx. 2.0MVA shifts during peak time interval AND 2. Transfer 11kV Hursley St Fdr (WETO) to 11kV McDougall St Fdr (TORR) a. Close ABS13616 b. Open CB3983 (Approx. 3.0MVA shifts during peak time interval) 3. Transfer 11kV Lendrum Street Fdr (WETO) to 11kV Hill Street Fdr (TWCE) a. Close AB613586 b. Open CB3985 (Approx. 1.5MVA shifts during peak time interval) 4. Isolate faulted bus section and restore supply via two transformers Transfer Holberton St FDR (WETO) to Willowburn FDR (NOST) a. Close AB4706 or AB17983 b. Open CB3984 Approx. 2.0MVA shifts during peak time interval | 1 hr | 4 hrs | N/A | N/A | N/A | N/A | N/A |
| | | | | | | | Full supply restored: 1 hr 4 hrs | Complaint |
| 3 | 33 kV Pole failure | Another 33kV line can continue to supply the load of the substation (<20MVA). | N/A | N/A | N/A | N/A | N/A |
| | | | | | | | Full supply restored: N/A N/A N/A N/A

Table 1 West Toowoomba Substation Contingency Plan

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1 4 hours is typical timeline to restore the failure on 33/11kV bus
2.2. Network characteristics

2.2.1. Geographic region

The geographic region covered by this RIT-D is in Toowoomba area. Figure 1 shows the geographic network of West Toowoomba Substation. Middle Ridge (MIRI) Substation is the bulk source supply point for the Toowoomba area.

![Figure 1 West Toowoomba Geographic Sub transmission Network](#)
2.2.2. Existing supply system

Toowoomba area is supplied by the H14 Middle Ridge (MIRI) Substation. In Toowoomba city area there are seven zone substations, Kearneys Spring (KESP) Substation, South Toowoomba (SOTO) Substation, West Toowoomba (WETO) Substation, East Toowoomba (EATO) Substation, Toowoomba Central (TWCE) Substation, North Street (NOST) Substation, and Torrington (TORR) Substation. There are four 33kV feeders connected to WETO substation, two are connected to SOTO - 33kV Vacy Street feeder and 33kV Hampton Street feeder and two are connected to TORR – 33kV Racecourse feeder and 33kV Wyalla Street feeder. In normal configuration WETO is supplied from TORR. The two 33kV feeders CBs at SOTO are normally OPEN. Figure 2 shows the systematic diagram of 33kV network around WETO substation. (Note – WETO is supplied from SOTO at the time due to contingency at TORR.)

![Figure 2 West Toowoomba Schematic Subtransmission Network](image)

2.2.3. Loading - historical and forecast

Figure 3 shows the historical load of WETO and load forecast for the next ten years. It shows that in the year of 2014-2015 WETO had the peak load of 27MVA and the forecast will keep at the level of 22MVA. Figure 4 shows the daily maxima for WETO from 2015 to 2018 and it shows clearly that after the commissioning of TOCE in 2015-16 the peak load at WETO dropped to under 20MVA in 2017-18. Figure 5 shows the load duration curve of WETO from 2015 to 2018. Figure 6 shows...
the load duration curve of WETO from 2017 to 2018. It clearly shows that the maximum load dropped significantly after the commissioning of TOCE in 2015-16.

Figure 3 WETO Load History and Forecast

Figure 4 Daily Maxima for WETO (2015-2018)
Figure 5 WETO Load Duration Curve (2015-2018)

Figure 6 WETO Load Duration Curve (2017 - 2018)
2.2.4. Distribution network limitations

The historical worst case feeder utilisations for WETO 11kV feeders along with the existing feeder ratings are shown in Figure 7. It may be noted here that there was only one instance in the last two years (2017-18) where the following 88 – 94% feeder utilisation was reached. The typical load forecast for WETO is flat (Figure 4: 50 POE), and there are options to shift load from WETO to the new Toowoomba Central 110/11kV substation, North Street, South Toowoomba and to Torrington substations. However, the scope of works under this FPAR proposes to uprate the feeder exit cables to the new substation design standards which specify a minimum continuous current rating of 315A or 6MVA.

Figure 7 WETO 11kV feeder utilisation

3. Proposed preferred network option

Option 1: Replace existing 11kV switchyard with indoor 11kV switchroom in a prefabricated / modular building

This option involves establishing a new 11kV switchroom with indoor-type 11kV switchboard and circuit breakers as per the Z7-32 standard. The 11kV indoor equipment will be fitout in a prefabricated / modular building. All the 7 existing 11kV feeders and 3 transformer 11kV circuit breakers will be transferred over to the new 11kV indoor switchroom. The existing 11kV switchyard will be decommissioned and scrapped / recovered. Removal of the existing 11kV switchyard will address the issues of aging 11kV plant and equipment.

The new indoor 11kV switchboard will have:

- 9 x 630A feeder panels
- 2 x 2500A incomers
- 2 x 1600A bus ties
- 2 x 1600A bus risers
One of the new 11kV feeder panels will be used as a transformer panel to take supply from all 3 x 10MVA existing transformers.

Figure 8 and Figure 9 provide geographic and schematic diagrams for Option 1.

This option will ensure the continuation of reliable supply of electricity to 8,923 customers close to Toowoomba CBD. It addresses all the safety issues posed by aging plant to personnel and members of the public. The estimated capital cost of this preferred option is $9.38M. Annual operating costs associated with this new capex are estimated to be around $46,900 per annum (assumed to be 0.5% of the capital cost).

Figure 8  Geographic view of WETO substation
4. Assessment of non-network solutions

4.1. Required demand management characteristics

A viable demand management solution must be capable of reducing the unsupplied load to <20MVA for the 2 hours required for restoration of supply in the event of an unplanned substation outage due to a bus outage to be considered a viable alternative solution. Current loading at ME005 West Toowoomba substation is between approximately 15 and 20MVA and is under 15MVA 95% of the time (2017-18 Load Duration Curve). In terms of a bus zone fault the typical timeline for restoration of the bus is 4 hours. In peak load times where total substation load may increase beyond 20MVA, 5MVA of load shift is available at the very minimum to Torrington, North Street and Toowoomba Central substations. Regional Safety Net restoration target of under 15MVA after 6 hours can be met by restoring supply to the bus zone which typically can take 4 hours.

Load growth at West Toowoomba is forecast to be relatively flat, load transfers are available to Toowoomba Central, Torrington and North Street substations and so demand management reductions in load are not required under safety net criteria.

As per the SCAR report, failure of one or more 11kV OCBs is also a plausible contingency. In fact, the explosive failure of an 11kV OCB could result in damage to other nearby 11kV assets. A failure of multiple aged 11kV OCBs could result in unsupplied load to the 11kV feeders. Unsupplied loads in this case could be restored by load transfers and local generation, if required. This contingency would still be safety net compliant. However, the replacement of the faulty circuit
breaker in-situ is not considered technically and commercially feasible. The 11kV switchyard is also located close to a main road and adjacent to a footpath. The aging assets have been identified as posing a risk to the network, to personnel in the substation and to the members of the public.

To be considered a feasible option, any unsupplied load reduction must be technically feasible, and commercially feasible.

Ergon Energy estimates that the construction timeline for the preferred option is 17 months, with assumed commissioning during 2020-21. Ergon Energy intends to commence work on delivering the preferred option 1 in 2020 (in particular, we intend to commence design in mid-2019 and commence construction in April 2020).

Any feasible non-network option must also be able to be implemented in sufficient time to satisfy the identified risk to public and the network due to the aged 11kV assets for deferral of the network investment.

4.2. Demand management value

Ergon Energy’s Intelligent Grid Systems Customer Interactions (IGSCI) Team has assessed the potential demand management options required to defer the network option and to ensure that the solution is technically and commercially viable, and delivered within the required timeframe. Ergon Energy considers a number of demand management technologies (discussed below) to determine their commercial and technical feasibility to assist with the identified need at West Toowoomba substation.

4.2.1. Demand Management (Demand Reduction)

Energy efficiency and other demand reduction measures such as power factor correction, load control etc. have been assessed as not technically viable at West Toowoomba zone substation. Therefore, reductions in demand will not help to improve restoration times for the number of unmet load hours. Demand management is also considered an insufficient measure to address the risk posed by the constant loading of the aged oil-type 11kV circuit breakers.

4.2.2. Demand response

Four methods utilising demand response technology for deferring network investment are: call off load (COL), customers embedded generation (CEG), large scale customer generation (LSG) and customer solar power systems.

4.2.2.1. Customer Call off load (COL)

COL is an effective technique for deferring network investment where the need is for a short time period. This is however not the case in West Toowoomba, where the load lost from a failure of an 11kV OCB can be temporarily restored by load transfers to other 11kV feeders. The in-situ like-for-like replacement of a failed 11kV OCB is not a technically and economically feasible option, as most of the 11kV assets in the 11kV switchyard are at end of service life.

There are a small number of Large Customers in the West Toowoomba area but the businesses are not suited to call off load (hospital, large shopping centre). This option is therefore assessed
as technically not viable as it will not defer the West Toowoomba network investment and does not address the risk of on-load aging 11kV oil-type circuit breakers.

### 4.2.2.2. Customer embedded generation (CEG)

CEG is another effective technique for deferring network investment where the need is for a short time period. The primary driver for investment in West Toowoomba zone substation is the age of the 11kV assets which includes 7 feeder circuit breakers, 3 transformer circuit breakers and a number of isolators and relays. A short-term deferral of network investment by using customer embedded generation will not be a technical or financially feasible option.

This option has been assessed as technically not viable as it will not address the identified network requirement.

### 4.2.2.3. Large scale customer generation (LSG)

There are no large-scale generators available in the West Toowoomba distribution area. Some small customer embedded generation is available at the Clifford Gardens shopping centre and other individual commercial customers. As discussed in the previous section, this is insufficient to adequately postpone network investment at West Toowoomba substation.

The 11kV distribution network at West Toowoomba substation carries a load of 15-20 MVA. The 11kV assets at the substation are at end of life and pose a risk to the network, personnel in the substation and to the public because of the switchyard’s proximity to the footpaths. LSG measures, if they were available, might reduce demand on the substation assets for a short period of time, so this will be a temporary measure at best to reduce demand during peak load periods.

This option could potentially reduce demand, but has been assessed as technically not viable as the generation is not available all year and therefore may not contribute to satisfy the identified risk at West Toowoomba substation.

### 4.2.2.4. Customer solar power systems

Business customers with large solar arrays are deemed to present a significant opportunity for targeted load control or load curtailment if coupled with a Battery Energy Storage System (BESS). Contracting such customers is attractive as they represent a larger load across a fewer customers and therefore are cheaper and easier to engage and contract.

The West Toowoomba supply area is predominantly comprised of residential customers. Only a small percentage of customers in this supply area have solar photovoltaic (PV) systems and possibly none have a BESS. PV systems with BESS present a future portfolio opportunity for potential demand response but currently this supply area has a very limited solar/BESS penetration. Solar customers without a BESS will not meet the technical needs of the demand reduction as their solar contribution may not be available when the network un-met need is required.

In terms of the unsupplied load at West Toowoomba, load curtailment opportunity is not technically feasible.
5. Conclusion

Based on the demand management options considered above, it is not considered possible that sufficient demand management measures could be feasibly implemented to technically and economically defer the network investment required at West Toowoomba to replace the aging 11kV assets. The network investment in this case is driven from the risk posed to the network, personnel and public from the collective aging of the whole 11kV switchyard. Demand reduction to defer this project is not viable. Ergon Energy’s Demand Management / Channel Advocacy group has concurred with this recommendation.

Consequently, a Non-Network Options Report has not been prepared in accordance with rule 5.17.4(c) of the National Electricity Rules. This document is being published as the Final Project Assessment Report under NER clause 5.17.4(d).