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AURORA ENERGY

INDEPENDENT REVIEW OF ELECTRICITY NETWORKS

EXECUTIVE SUMMARY

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Independent review of electricity networks
Executive Summary

Aurora Energy

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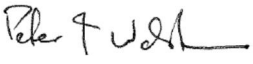
Reviewed by:	Peter Walshe	31 Oct 2018	
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EXECUTIVE SUMMARY

PROJECT CONTEXT

WSP has been engaged by Aurora Energy (Aurora) to undertake an independent review to determine the state of the electricity networks in Dunedin and Central Otago, identifying any critical assets at significant risk of failure. This will allow interested stakeholders to better assess the appropriateness of the planned interventions and investments Aurora proposes to make. The two key tasks for the review, which reflects a consumer focus, are to:

1 Establish an accurate and reliable assessment of the current state of the Aurora networks with particular focus on identified critical assets

2 Having established the state of the network, determine the resulting prioritised risk to consumers.

REVIEW APPROACH

To meet the terms of reference for the review, WSP developed an approach based on assessing the Aurora network from several perspectives:

Resilience – the ability of the network to withstand or recover from high impact, but very low frequency, events such as earthquakes.

Security: whether the electricity network topology provides appropriate capabilities, such as capacity, redundancy and switching capability, to maintain normal supply to consumers.

Performance: an indication of which assets and areas of the network pose the greatest risk to public safety, reliability of supply and the environment based on historical rates and durations of asset outages.

Network risk: the combination of the probability that assets may fail and the consequence of the impact to public safety, reliability of supply or the environment.

Examining security and performance allowed us to focus our review of network risk on key matters. Each of these perspectives is discussed in detail below. The key outcome of the review is the prioritised list of network risk that Aurora needs to consider in their future network management plans and investments.

The project was managed in two stages. The first stage of this project involved an assessment/gap analysis of the extent, reliability and suitability of existing asset data (i.e. age, condition, defect, failure data) that could be used to undertake a risk assessment of the network. Based on the data gaps identified, the second stage then involved scheduling of additional testing and inspection programs in order to close the data / knowledge gaps and enable a risk assessment to be undertaken.

The key tasks undertaken across the two stages were:

1 An investigation into the asset data available

2 Targeted and/or random testing of the asset fleets to validate existing data and to generate new data where gaps were identified

3 Desktop investigation/analysis of all compiled asset data, including both existing data sets and new data gathered

4 Creation and population of asset risk profiles for each asset class

It should be noted that this report is aimed at providing the current state of the Aurora network. It does not include consideration on the interventions and future strategies planned by Aurora. In addition, any matters relating to Aurora's performance against quality standards are excluded from the review scope. The review does not include benchmarking or commenting on improvement actions.

SUITABILITY OF ASSET DATA

WSP undertook an assessment of Aurora's data through a series of interviews with Subject Matter Experts (SMEs) and analysis of the data sets provided. We validated that the information was suitable for use and obtained additional information through site inspections and testing. Each asset class was given a ranking against the data requirements and then assigned an overall data quality score of High, Medium or Low. We identified gaps in some of the asset data and initiated actions to validate or improve the data for this review through on-site inspection.

The table below shows that adequate data and information was available for the review following our inspections and validation. The ranking of Low for distribution cables is caused by the lack of condition data available, however, it is common in industry to have limited data on these assets due to their nature of being buried underground and therefore not able to be inspected. The following table shows an overview of the asset data summarised into key asset categories.

ASSET	FROM AURORA	ACTION TAKEN	RESULT
Support structures	Medium	Site inspections to validate Field testing undertaken	High
Overhead lines – Subtransmission	Medium	Drone survey undertaken Field measurements	Medium
Overhead lines – Distribution	Medium	Drone survey undertaken	Medium
Underground cables – Subtransmission	Medium	No action possible	Medium
Underground cables – Distribution	Low	No action possible	Low
Circuit breakers	Medium	Site inspections to validate	Medium
Distribution switchgear	Medium	Site inspections to validate	Medium
ZSS transformers	High	Inspection results to validate	High
Distribution transformers	Medium	Inspection results to validate	Medium
Protection systems	Medium	Site inspections to validate	Medium

KEY FINDINGS

WSP's review investigated Aurora Energy's electricity network to assess the risks as they relate to network resilience, network security, network performance, and each asset class.

NETWORK RESILIENCE

Network resilience relates to how well the network is designed, from the perspective of the supply chain, to ensure continued supply following very high impact but very low frequency events, natural disasters in particular. Our investigation identified that Aurora's network is subject to several very high impact events, most notably earthquakes and the resultant liquefaction of the ground.

WSP found that most key assets have been installed clear of earthquake fault lines, flood zones, landslide risk zones and tsunamis risk areas. However, it is not possible to avoid these altogether as customers occupy these areas and require electricity.

A review of the most recent earthquakes in Christchurch found that liquefaction of the ground had the biggest impact to network supply as it severely damaged underground cables. Overhead lines are a lower risk as damage can be identified

and repaired more rapidly. Dunedin is in an area that has a moderate to high liquefaction risk, and eight of the nineteen zone substations are supplied by radial underground subtransmission cables. Although these are dual circuits, which provides redundancy, they are located in the same trench and hence can be expected to be impacted equally by a major event. The cable type, ages, deteriorated condition, and installation methods means that these are the highest risk with respect to network resilience.

Maintaining network operations and control is also key to maintaining a resilient network. Aurora currently has two control centres which normally operate separately and provide limited back up for the other. This poses a risk that a major event disabling one will significantly impact operational control of part of the network. This risk is being mitigated through Aurora's 'one network' initiative which involved upgrading the SCADA system to enable each control room to control the entire network.

NETWORK SECURITY

Network security relates to how well the topology and design of Aurora's network can maintain supply to consumers. There are two key aspects to security:

- the ability of Aurora to isolate a faulted part of the network and resupply customers by operating switches to reconfigure the network. Sufficient interconnection will minimise the number of customers experiencing long outage times and hence improve performance
- the ability to take assets out of service in order to undertake maintenance, without creating a large outage area affecting more customers than necessary. Inability to do this means that maintenance of critical assets may be deferred and result in assets not being sufficiently maintained, leading to shortened serviceable life or in-service failure.

WSP found that:

- Zone substations are generally supplied radially from the Grid Exit Points, but by double circuits, so there is an adequate level of redundancy
- Urban feeders generally have good levels of interconnection with adjacent feeders to be able to transfer load, however some parts are radial with no interconnection. These arrangements do not appear different to most other electricity businesses.
- Long rural feeders normally have limited ability to enable resupply via switching, and this is reflected in the security and performance standards set for those feeders. We found that the topology of Aurora's network was appropriate for its geographical location and distribution of customers. To mitigate the risk of a prolonged outage should a single transformer zone substation fail, Aurora has a mobile transformer that can be deployed to restore supply quickly.

NETWORK PERFORMANCE

The long-term network performance was analysed to identify any assets that are displaying an increasing trend in the number of outages. Our assessment was not against performance standards, but to identify where risk to the network was materialising.

We found that overhead conductors, poles and crossarm assets were causing more than 50% of the network outages that were attributed to asset deterioration. There was an upward failure trend evident, although it has ameliorated in the most recent year, likely as a result of the accelerated pole program.

The analysis identified the following critical assets:

- Poles: an accelerated pole program has slowed a declining performance trend that started in 2013. The current state of poles still appears to be in poor condition, indicating there is an elevated level of risk with this fleet.
- Pole top structures: highly related to pole performance with respect to reliability
- Overhead conductor (all voltages): demonstrated to have declining performance based on defects relative to other assets and can pose a high risk to the public when it fails if protection systems do not operate as intended.

— Protection systems: our analysis of outages demonstrated instances when protection systems did not operate and therefore did not mitigate the public safety risk as intended.

Safety performance of the network was generally found to be appropriate, except for risks associated with protection systems. Data obtained from the safety registers identified 35 incidents in the period 2015 – 2018 where a conductor fell to the ground and remained live. We identified that:

— some were on the LV network, with protection by a fuse that did not react to the fault

— some were due to a high impedance HV fault, where a back feed from the energised network circumvents the proper operation of the protection relays

— an estimated 15 faults should have been detected by the protection relays.

Our detailed review of the protection systems supports that there is an issue with appropriate functioning of the older fleet of electromechanical protection relays.

NETWORK RISK

Overall, most assets pose a small risk to public safety, reliability or the environment. The risks posed by these assets are no greater than WSP has observed in other networks in New Zealand and internationally.

WSP found some exceptions:

Protection system assets – these assets are used to detect a failure that results in a flow of electrical current that is larger than normal or a flow to ground (earth faults). Many of these assets are beyond their nominal life, employ obsolete technology and maintenance is incomplete. Five types of electromechanical relays are now an obsolete technology and are consistently losing calibration between maintenance cycles. These relays are used for earth fault and over-current detection. The failure of these relays to operate as intended has resulted in live conductors on the ground not being detected and de-energised. Most observed instances where earth faults were not isolated were found to involve the identified relay types or older electromechanical relays more generally. This supports they are at the end of their serviceable lives. Protection system assets pose a significant safety risk and should be prioritised.

Zone substation circuit breakers – these assets are used to switch the network and are opened by protection systems to isolate faults on the network. The inspection, testing and maintenance of these assets is incomplete. The technology and specific models installed also pose an increased risk. Some oil insulated zone substation circuit breakers were found to present an elevated risk to the network with respect to network reliability and the safety of field crews due to their potential failure mode through arc fault and fire. Many of the specific types of circuit breaker in-service on the Aurora network have been identified in the electricity industry as having an elevated risk of failure.

Zone substation transformers – these assets are located at bulk supply points (zone substations) and used to transform voltage from the high voltage used on the subtransmission network to the medium voltages used on the distribution network. The transformers at two zone substations are in poor condition, although we note that one is currently in the process of being decommissioned. Additionally, transformer tap changers are showing signs of deterioration and some are behind their maintenance schedule, increasing risk of an outage on the associated transformers.

Support structures – these assets consist of the poles, crossarms and insulators that are used to support conductors. The pole inspection program has recently been improved, but has not identified all poles that are in poor condition as it has not yet covered the whole network. Cross-arms are not inspected adequately and many are in poor condition. Some are categorised as high risk due to their location relative to population and probability of failure. Note that while our analysis focuses on a whole of fleet assessment and will identify expected quantities, individual assets requiring remediation will be identified through Aurora's normal inspection and testing program.

Distribution switchgear – these assets are used to switch the distribution network. A significant number are defective and inhibit normal operation of the network, which can lengthen outages experienced by customers and impact the reliability performance of the network. Some models have identified issues which present a safety risk, predominately for

field crews. A significant portion of the ring main unit type switchgear inspected (40%) have oil leaks. Batteries in circuit reclosers do not have a regular replacement scheme. This poses risk that the reclosers may not operate when required.

We used Aurora's risk management approach to classify the identified risks. The table below shows the result.

Overall, we found a high number of risks in the "Red" category, indicating network risk has not been reduced to as low as reasonably practical.

A prioritised list of risks has been developed to provide guidance on where Aurora should focus their attention in maintaining the safety and reliability of the network.