Title	Monitoring Load and Injection Constraints
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Purpose

This document summarises EA Networks' approach to monitoring load and injection constraints as part of network planning and asset management. It is produced to meet the requirements of Information Disclosure 2024, and this material will be incorporated into AMP 2025 to ensure ongoing compliance with Information Disclosure requirements.

Background

To understand the utilised capacity of the distribution network, its characteristics and loading must be measured and monitored. The data gathered in doing this provides both opportunities and challenges for both existing and new load or injection. This document attempts to describe the level of maturity EA Networks have in the various facets of predicting, finding, communicating and, where applicable, resolving network constraints.

Measuring and Monitoring

EA Networks have a comprehensive SCADA system that provides both loading and voltage data for many parts of the distribution network. The current scope of the SCADA system is limited to equipment in the 66 kV to 11 kV voltage range. The equipment within this scope will typically be monitored to provide a clear indication of capacity utilisation. These parameters are logged at relevant intervals and are available for review and historical trending. Alarms are set to identify high loading and high/low voltages. These alarms give warning of potential constraints. The monitored equipment includes:

- 66 kV circuits,
- zone substation transformers,
- 11 kV or 22 kV feeders, and
- some stand-alone 11 kV or 22 kV switchgear.

Each zone substation has a power quality meter that measures a large range of parameters including substation loading, power factor, current, and voltage measures. Many of the sites have more than ten years of data history.
Urban ground-mounted distribution substations will typically have some form of LV (Low Voltage) maximum demand indicator fitted. These include:

- analogue thermal drag hand meters,
- non-communicating multi-parameter digital meters, and
- communicating PowerPilot meters.

The non-communicating devices are typically read and reset twice a year, while the PowerPilot units are remotely read every ten minutes and provide a wealth of loading and power quality information into a logging database. The twice annual readings are of some use but do not indicate the time, frequency or duration of maximum demand, making its value much less than the continuous stream of PowerPilot data (voltage, current, kW, KVAr, THDv, THDi, voltage balance, current balance, etc).

There are plans to expand the PowerPilot LV monitoring network to include the end of LV feeder devices. This will allow lowest voltages (heavily loaded conditions) to be logged and provide some indication of highest voltages (high injection or low load conditions).

Large new injection sites (>250kW) typically have some form of dedicated power quality metering installed to ensure the connection performs as expected and no power quality issues arise for either the network or the generator.

Future budget has been allowed to source smart meter data in a third-party solution that provides immediate insight into both existing and forecast network capability/constraint at a low voltage level. Some initial contact has been undertaken with retailers and MEPs (Metering Equipment Providers) about provision of both consumption and voltage data, but no contracts have been drafted for data provision. EA Networks have identified some challenges with this process, in that the cost for providing the data sought is not inconsiderable and the contract duration proposed is significant. In EA Networks' view, many issues with distribution network power quality, capacity, and incipient faults (e.g. faulty neutral connections) could be solved by taking a year-long data extraction, addressing all the issues identified, then returning for a subsequent data extraction in several years' time. Data providers do not support this approach, and their longer contract term and high cost of data provision is imposing costs that will add to the burden on network end-use consumers.

Predicting Constraints

Constraints can occur at any level of the distribution network. They are much more obvious at higher voltages such as 66 kV and 33 kV (sub-transmission). SCADA tends to reveal sub-transmission loading in real-time and it becomes readily apparent when approaching either n or n-1 constraints. Reasonably comprehensive modelling of the sub-transmission network and zone substations ensures there are no constraints that occur without warning. The 11 kV and 22 kV distribution network are more dynamic and there can be occasions when n-1 constraints appear during back-feeding, but these are temporary and rare.

The LV network is much less predictable. Consumer choices in retail pricing options and asset purchases can dramatically impact the network without warning. Examples of this are:

- Free power hours which drive the normal diversity of appliance use out of each household and can cause sudden increases in load and/or decreases in supplied voltage. The amount of energy delivered in a day is the same, but a lot of it is provided in one or two hours. This is inefficient - a loss of network energy delivery capacity over a day driven by retailer "herding" consumption into a limited period.
- Electric vehicle charging at home during peak hours. Some owners of EVs do not yet consider time of use electricity cost when selecting EV charging timing, as electric energy is still much cheaper than petrol or diesel even at $0.30 per kWh. This is loss of peak power delivery capacity.
- Roof-mounted solar panels. Although EDBs get a few weeks warning of new domestic solar generation, the impact of a 5kW single phase array can be significant and may require alterations to the distribution transformer tap position. Lowering the LV voltage at the transformer is a permanent loss of load capacity. Instead of ±6% voltage range it changes to +3.5% to - 6% (a loss of 21% of load capacity). No revenue is obtained from solar to replace this lost load capacity – all consumers must pay for its replacement (if needed). Solar generation doesn't typically match peak network loading conditions so will not offset peak demand to compensate for the loss of capacity due to compensating for the voltage issue described above.

It is planned to create distribution network models by extracting the connected GIS network model (to ICP level) and importing it into a third-party network analysis software that can profile both existing and future connection loading/injection. This software will highlight areas of the network that may come under pressure and potentially constrain either load or injection in the absence of network changes or flexibility options. The option to import the network model into a desktop load-flow package is also planned. This will allow detailed analysis of specific loading/injection scenarios where necessary.

EA Networks are reasonably fortunate to have an ongoing underground conversion programme that has given a significant capacity boost to the urban LV network. There are some well-known older underground reticulation areas that have smaller cables, and these will be monitored/analysed as a priority using PowerPilot devices at the distribution substation and the end of LV feeders.

Communicating Constraints

When EA Networks become aware of a potential future constraint, it is noted and any consumer that applies for information about network load or injection capacity will be advised of any relevant constraint issues at hand. More general load capacity constraints are considered for reinforcement as the need becomes imminent and these are typically not exposed to existing connected load consumers as this is simply part of the expected service provided by an EDB.

When a new injection consumer approaches EA Networks for a connection, or wishes to inject on their existing load connection, the specific scenario they present is considered and if there is no constraint a connection option is provided. Should a constraint exist that would prevent their proposal from proceeding, the details of the constraint are explained and the available options to resolve it presented. This may include modifying the proposal or suggesting a flexible solution involving shifting generation (using storage) to a less constrained time. The injector is made aware of the incremental cost principles of Part 6 of The Code and they use this information to consider their proposal.

In the case of a large load connection, any constraint is communicated to the consumer and options will be presented to resolve the situation. This may involve a contribution from the consumer and some delay in completing the necessary works. Smaller load consumers expect to be able to connect in relatively short timescales, and this means EA Networks need to keep ahead of the load growth curve. Typically, any trend in load growth in a local area will trigger consideration of works for the good of all connected load customers and what benefit they may receive from any network upgrades or available flexibility solutions.

Resolving Constraints

Constraints of the supply of load are typically assessed for resolution before the load growth forecasts predict the benefits of intervention (network reinforcement or flexibility options) exceed the cost of constraint. In many cases, the revenue obtained from increasing load will justify some form of early intervention by EA Networks in advance of the constraint becoming apparent to consumers. Large step increases in load from one or a small group of large consumers will in many cases open a dialogue so that plans can be shared, and solutions discussed. Timing of solutions can have a big impact on its acceptability and flexibility will always be presented as a viable option for both the consumer(s) and the network (should such a solution be commercially viable).

Constraints on injection will always be couched in the commercial aspects of funding to resolve it. Because no revenue is obtained from most injection connections, there is no direct incentive to remove that constraint in advance of an injection proposal. Once an injection proposal presents itself, any constraint will be explained and the options for resolution detailed. Almost all of these options will have a cost to implement, and the current approach is to require the injection consumer to fund any resolution of the injection constraint. The alternative is to connect with the constraint and flexibly inject within the limitations of the existing network capacity.

Collective injection from many small consumers will ultimately cause constraint at either LV or distribution substation level, typically caused by voltage limits. Unless there is a simultaneous need for load capacity, it is unlikely there will be a commercially viable case for addressing an injection constraint unless the injectors that benefit are prepared to fund the work. In the case of domestic solar injection this is unlikely. It would be more beneficial to put the funds towards storage behind the meter.