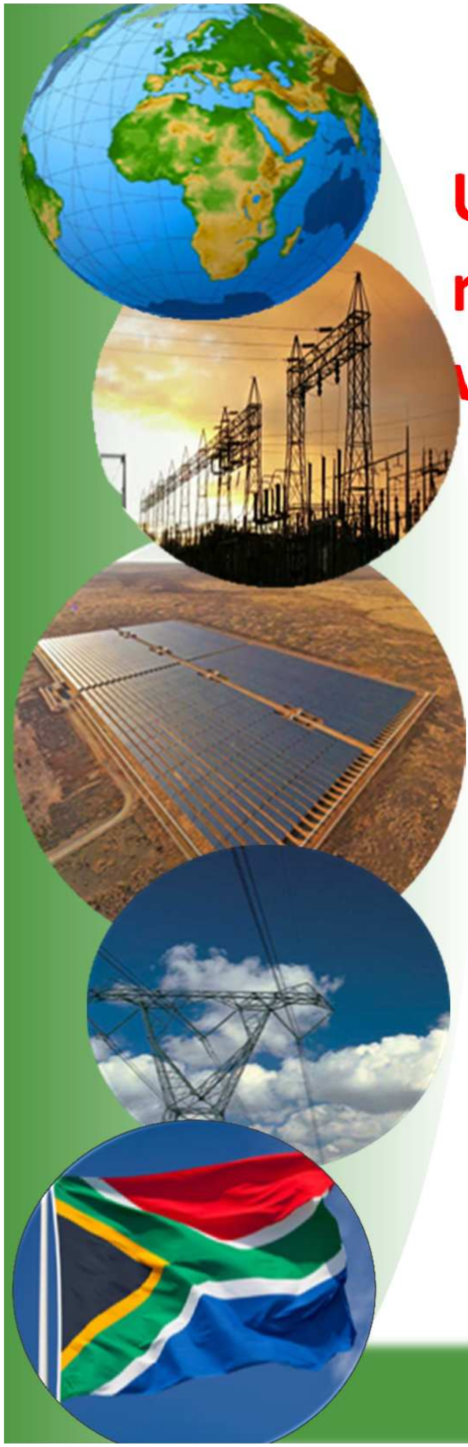

Understanding the impact of embedded renewable generation and its interaction with local load in the time-domain

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Background

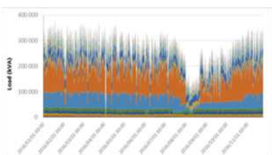
Existing Network Planning Methodology

- Network adequacy studies have been limited to deterministic peak load studies; requirements for strengthening and firm network status are determined in this way.
- Local supply-demand relationships are changing on a minute-to-minute scale with the consideration of embedded renewable generation, resulting in very different asset utilisation than is modelled in ‘worst case scenario’ Network Planning studies.
- There is a need to understand the impact of embedded renewable generation and its interaction with local load within the time domain.

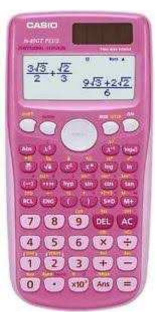
Study Methodology

Measured 30-min load data

Measured 30-min embedded generation data

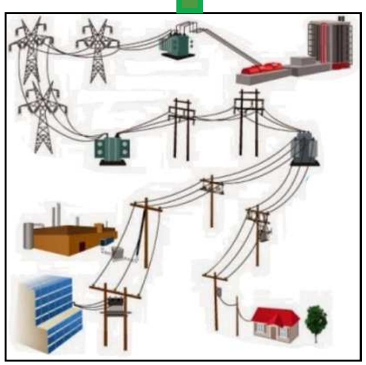


Averaged for hourly data points



Time domain power system analysis

8784 simulations run via DPL time-sweep script

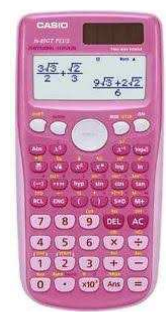


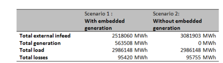
Thermal loading and local asset utilisation

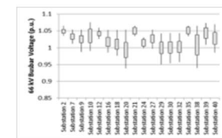
Energy and technical losses within the load pocket

Busbar voltage regulation

Post processing

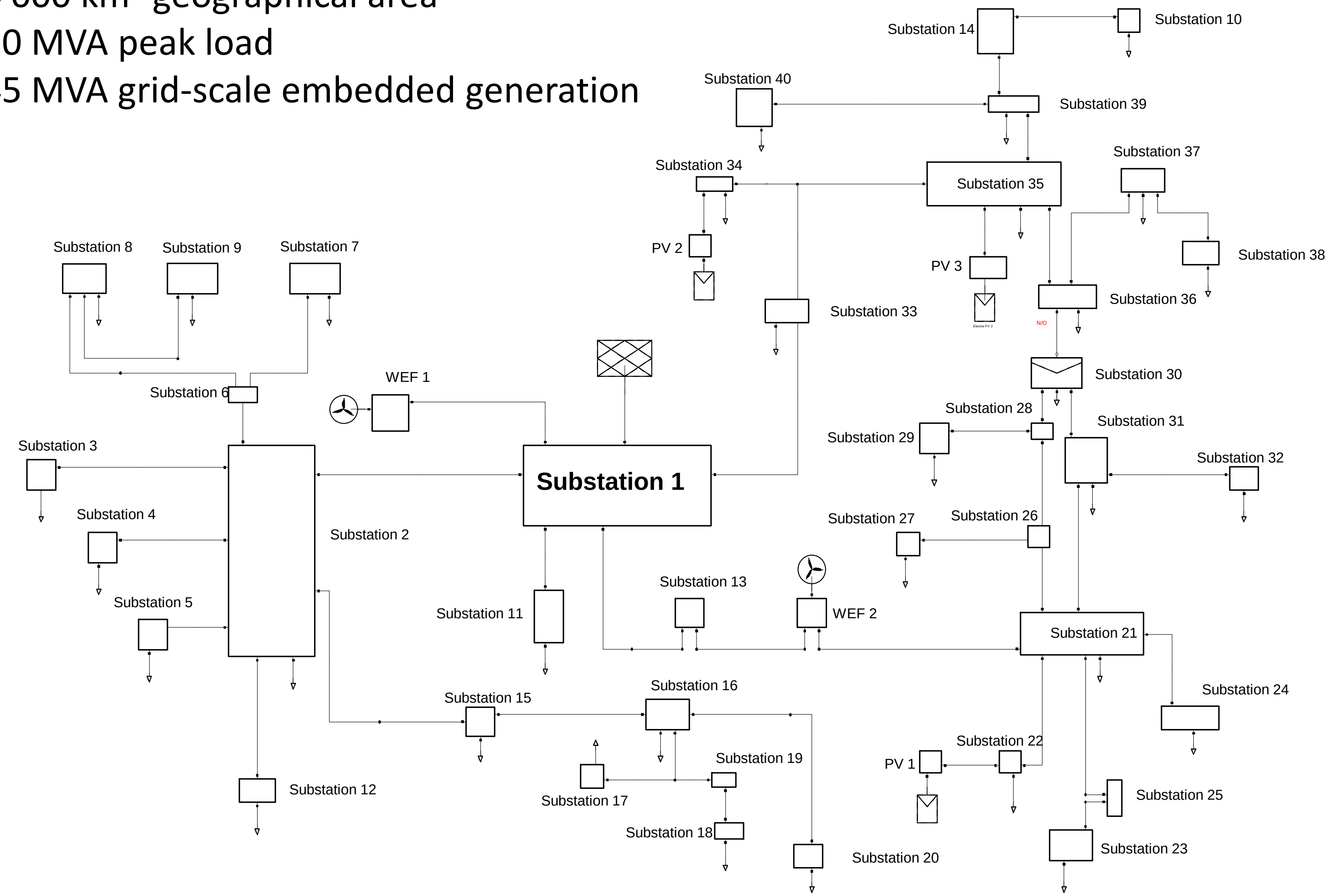






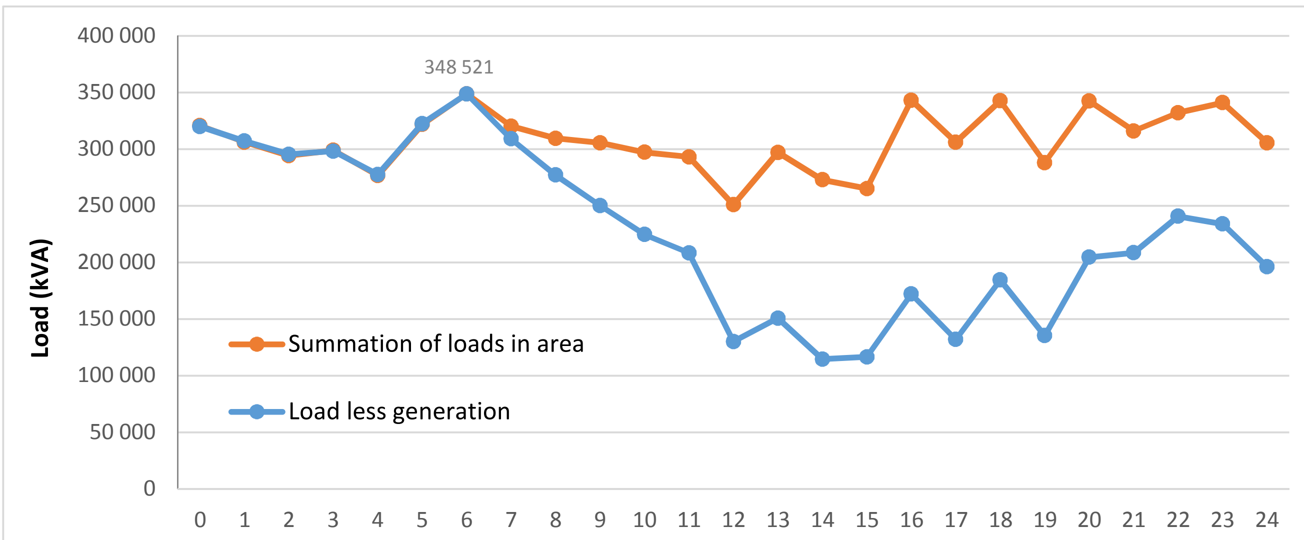
40-substation sub-transmission study network

- 14 000 km^2 geographical area
- 370 MVA peak load
- 245 MVA grid-scale embedded generation

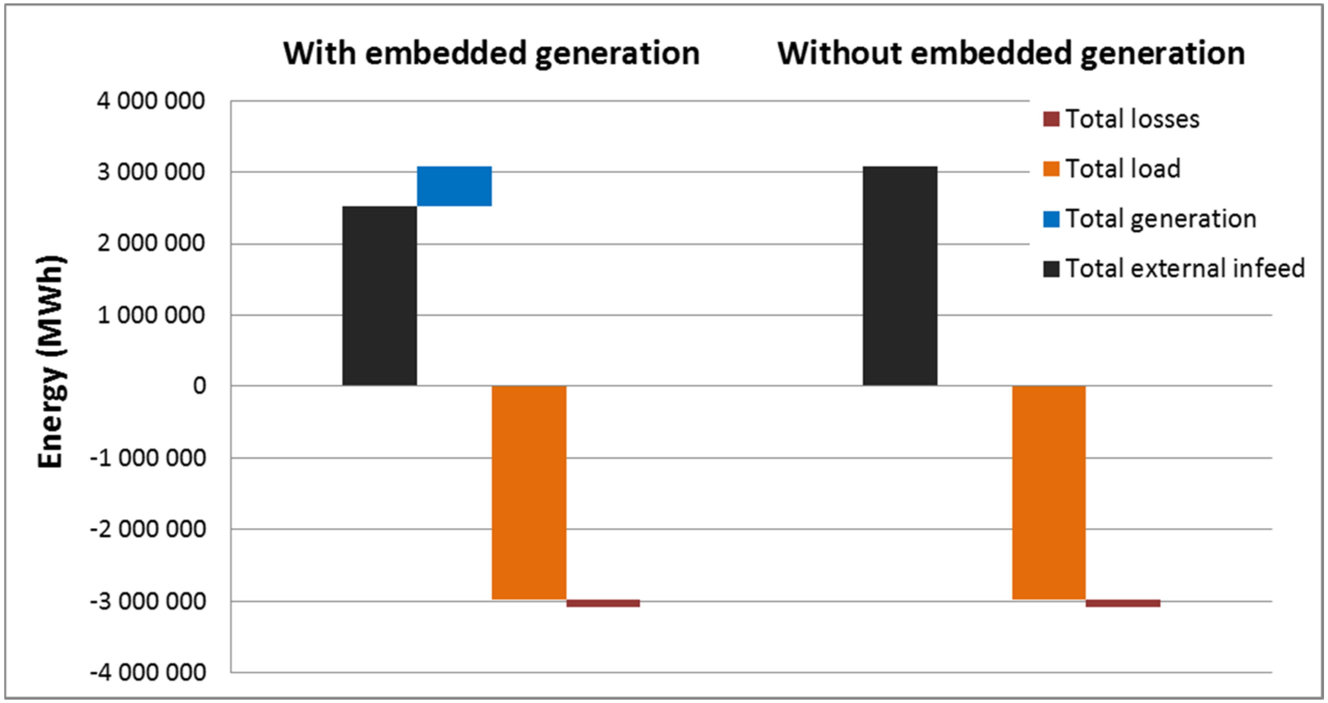


Results – Utilisation of assets

- Despite the high EG penetration, it is anecdotally evident that the intermittent nature of the wind and PV generation in this area cannot always be relied upon to reduce peak load.
- Despite this, there are periods where a consistent average hourly upstream asset utilisation reduction of at least 100 MVA was enjoyed on the network.

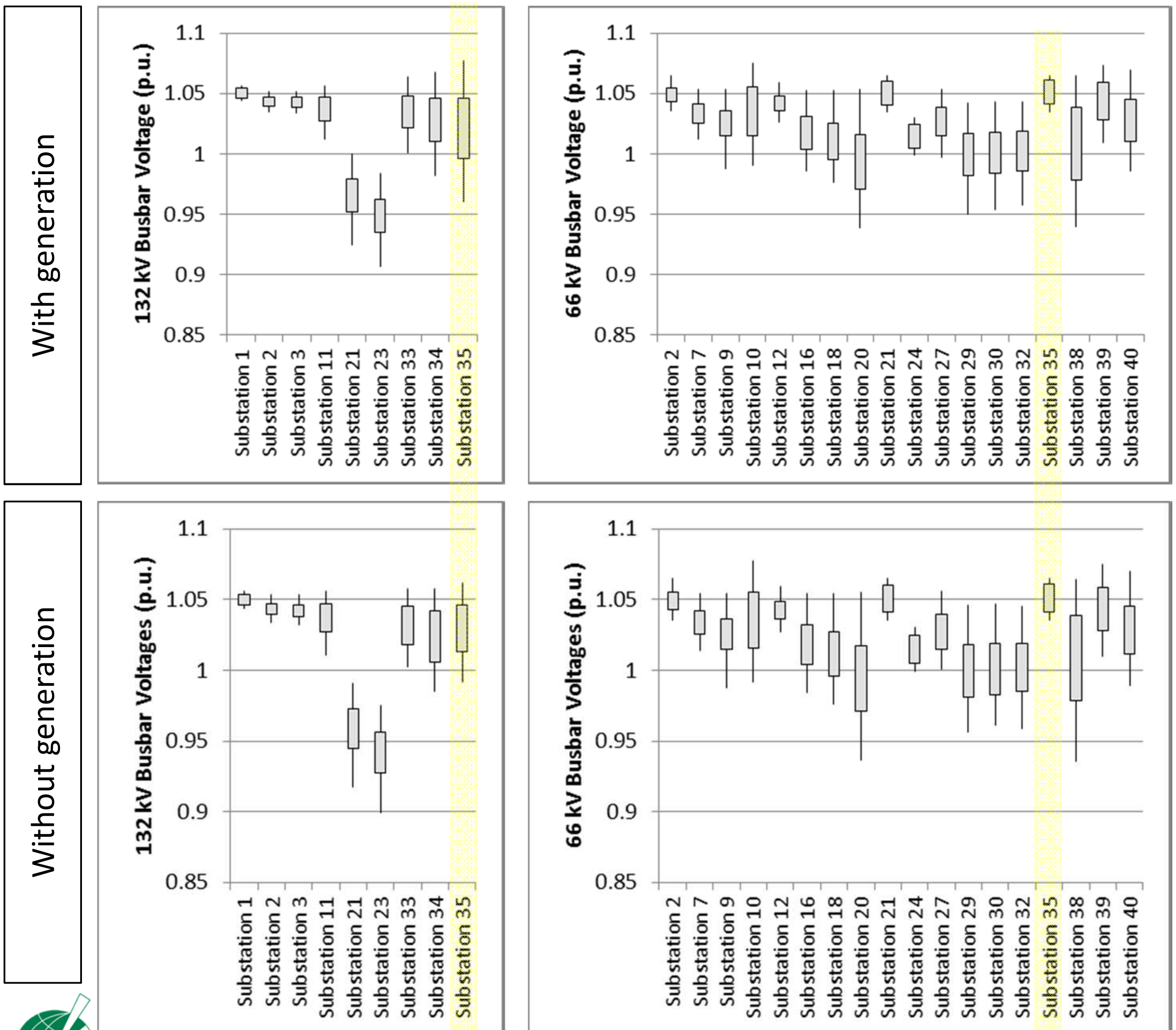


Results – Energy and losses



- Local generation supplies 19% of the energy needs in the area over the year, which, unsurprisingly, reduced the sub-transmission losses; but only by 335 MWh – a very small number (approximately 0.01%, on a loss figure of approximately 3%).
- The simulation case does not show the change in transmission system losses, as this is represented by an external grid.

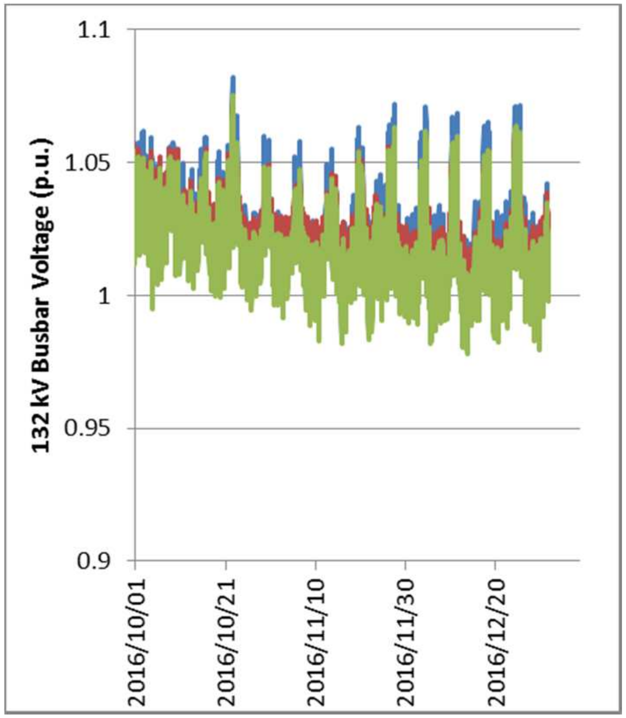
Results – Voltage regulation



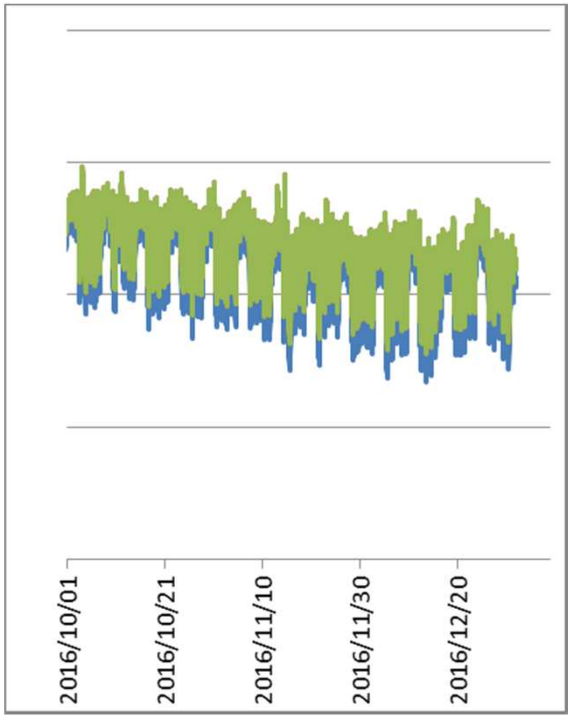
- Little difference in the plots of the two scenarios.
- Particular attention was given to busbars at Substation 35, as this is an area which is known to be susceptible to low voltages
- Ideal and very narrow regulation at Substation 1 may be mis-representing the situation occurring in the field.

Results – Voltage regulation cont…

A closer look at Substation 35 (Oct – Dec 2016)



With generation



Without generation

- Presence of embedded generation results in a much broader spread of voltages, and increases the maximum voltage (which repeats regularly, on weekends during the daytime).
- Likely results in much more aggressive tapping on the 132/66 kV transformers to maintain the 66 kV busbar voltage within its narrow band.

Conclusions

- This method of analysing a network using a sequence of time-domain studies has provided interesting data for analysis.
- Whilst embedded generation in this area has the potential to make thermal capacity available on existing network assets, deterministic planning will prevent use of this capacity if it is not certain to be available.
- The presence of embedded generation within this local load pocket was confirmed to decrease the sub-transmission losses experienced on the network, however, only to a very small extent. Extension of simulations to the upstream transmission network could be beneficial in identifying additional loss reduction due to the reduced external infeed into this load pocket. Additionally, this study could be extended to analyse losses at locational marginal points on the network to determine how the introduction of additional generation at any given point may decrease, and at some point even increase the losses on this network.
- Whilst having a less noteworthy effect on voltage regulation than expected, the inclusion of embedded generation does appear to increase the spread of operational voltages simulated close to infeed points. This likely leads to increased frequency of downstream transformer tapping, which places additional strain on transformers in the field. Also, elevated voltages may lead to additional stress on insulation of system components.
- Additional validation of the model against voltages recorded in the field may be necessary in order to place greater confidence in study results.

Conclusions cont…

- The sections of this study focusing on asset utilisation and voltage regulation both show that the fluctuating nature of the distributed renewable generation decreases its potential local value, leaving promising prospects for net load-smoothing, for example by **battery energy storage**. Being able to even out the fluctuations in generation may allow for more certain availability of unused network assets and therefore higher asset utilisation. Distributed storage for voltage support may also reduce the spread of voltages experienced at generation infeed points and downstream, and therefore improve power quality to customers and decrease tapping operations on transformers.

Questions?