The Long Term National Power Quality Survey – Benefits, Opportunities and Future Directions

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1. Aims of the LTNPQS

Aims of the LTNPQS

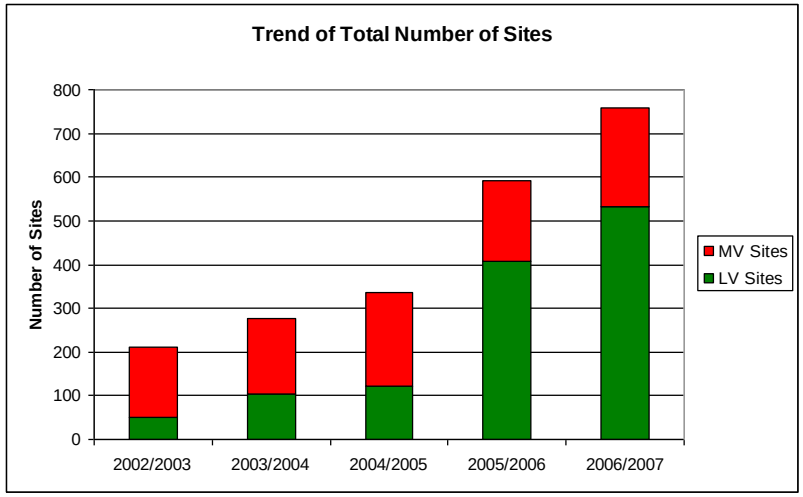
- To understand typical levels of PQ experienced by customers connected to electricity distribution networks in Australia and how they are developing over time
- To better understand how to manage PQ
- To obtain insights into PQ which are useful in dealing with customers
- To provide insight into the establishment of appropriate PQ performance standards

2. History of the LTNPQS

- The current LTNPQS run by the ENA PQ & R Committee in association with UoW was launched in 2002
- Participants select a range of different sites and record measurements from specially installed PQ monitors or smart tariff meters
- Quantities recorded are:
  - RMS voltage (V);
  - Voltage unbalance (U);
  - Harmonic voltage THD (H) + 5th harmonic ; and
  - Voltage sags (S)

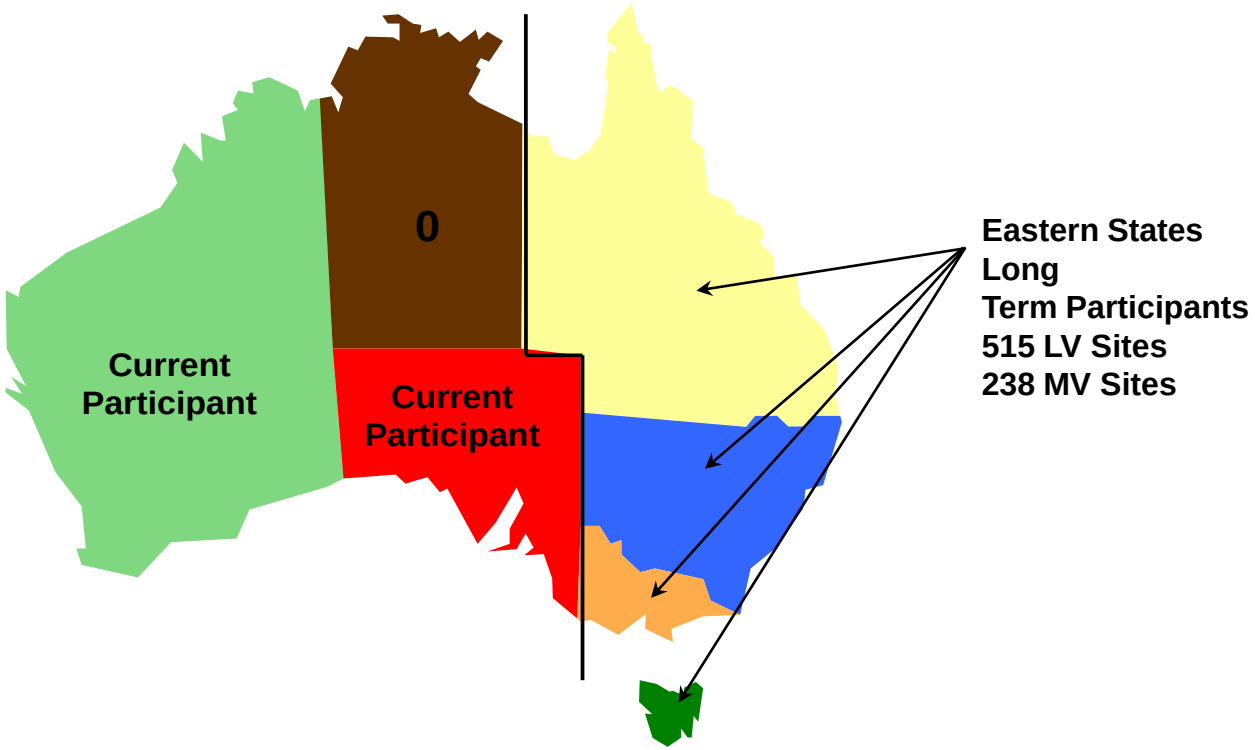
3. The LTNPQS Today

- The Total number of sites has grown continually since project inception
- The project now includes over 700 sites across Australia
- The LTNPQS is now one of the most significant in the world in terms of:
  - what is measured;
  - geographical extent; and
  - years of operation



3. The LTNPQS Today

Distribution of Sites across Australia (2006-2007)



3. The LTNPQS Today

PQ Reporting

- The LTNPQS has been a driver for changes to the PQ monitoring paradigm from reactive to proactive
- The LTNPQS has provided a unique opportunity for development of power quality data analysis and reporting techniques
- Reporting techniques have developed as the project has grown and novel methods for reducing data to usable forms without loss of important detail have been developed
- The large PQ database associated with the LTNPQS has enabled world-leading research into PQ behaviour and PQ reporting

3. The LTNPQS Today

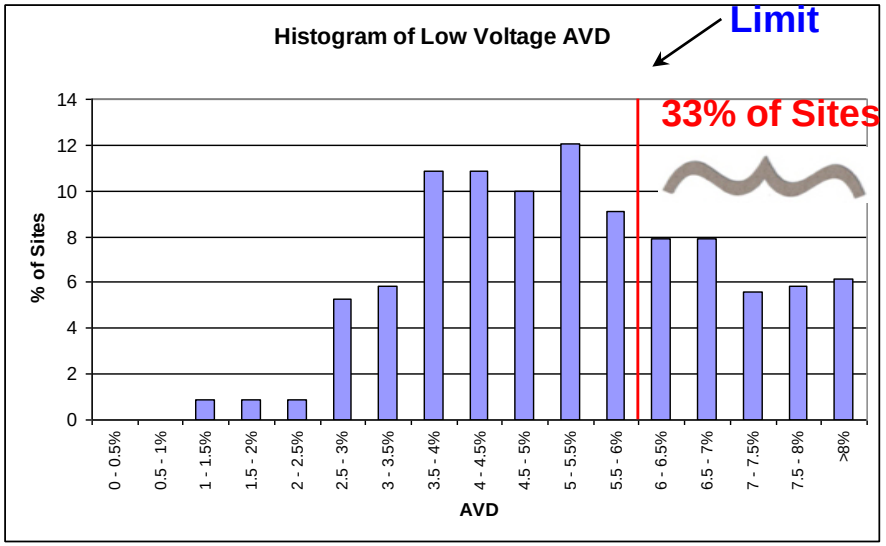
LTNPQS Limitations

- LV sites now dominate – but almost without exception close to supply Tx
- There are very few weak LV sites. This results in an optimistic view of LV network performance and a knowledge gap with regards to PQ at the end of LV feeders where PQ is expected to be worst
- Obtaining some data (e.g. site classifications) can be difficult
- Site numbers are not evenly distributed across all states:
  - LV sites dominate for some states while MV sites dominate others

4. Important Findings

LV Voltage Performance

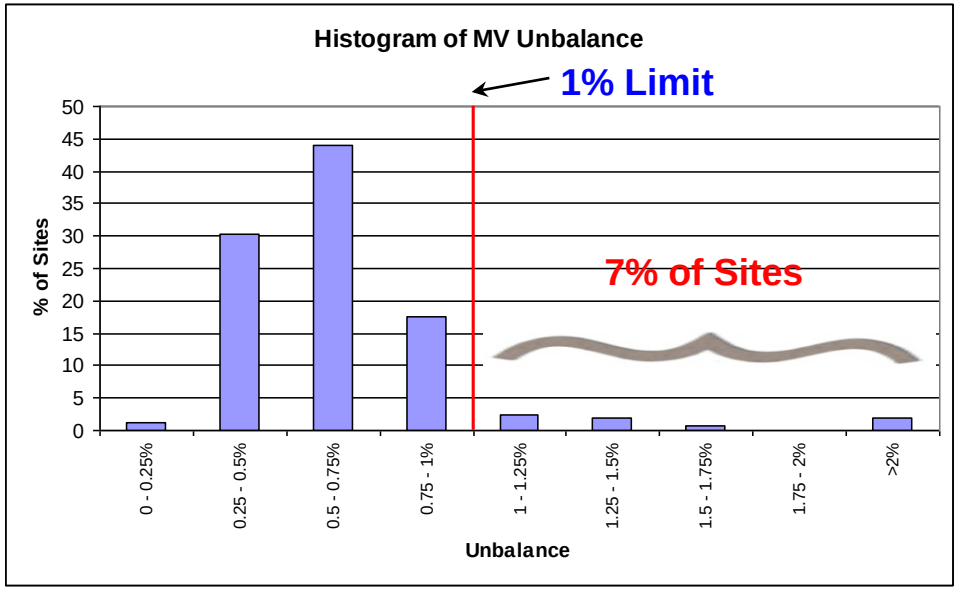
- Absolute Voltage Deviation (AVD) is a measure of deviation of voltage from the middle of the acceptable range (effectively 240V)
- With a LV range of 225.4V – 253V, the AVD limit is 13.8V or 6% of 230V
- Many sites exceed this limit
- Few sites with voltage lower than the range due to under-representation of weak sites



4. Important Findings

MV Unbalance Performance

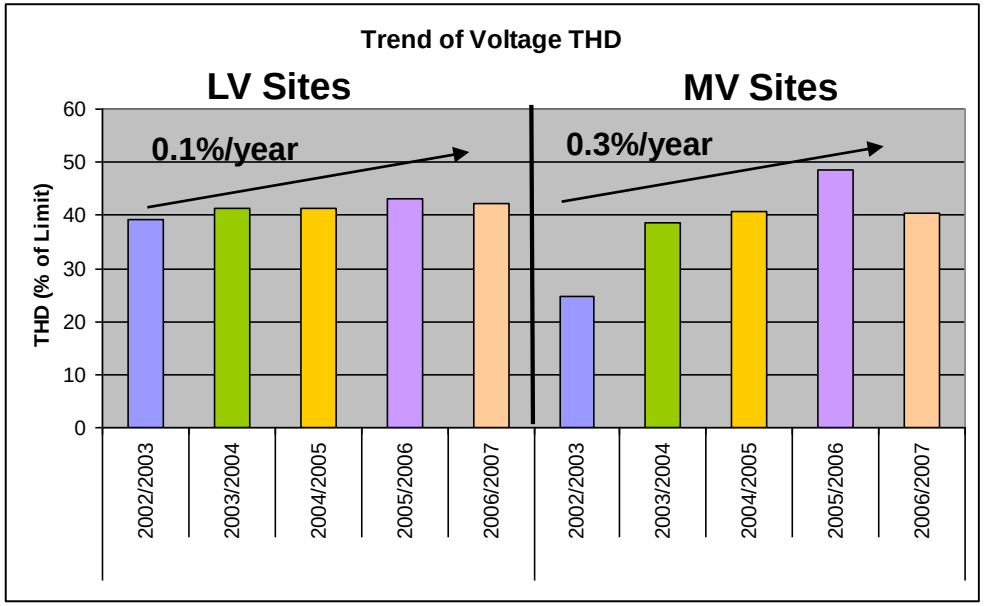
- The ESC in Victoria specifies a 1% unbalance limit (whilst other jurisdictions specify a 2% or 3% unbalance limit)
- 7% of sites are outside the 1% limit
- The industry will need to decide if a 1% limit is realistic, achievable and in line with international best practice



4. Important Findings

Voltage Harmonic Trends

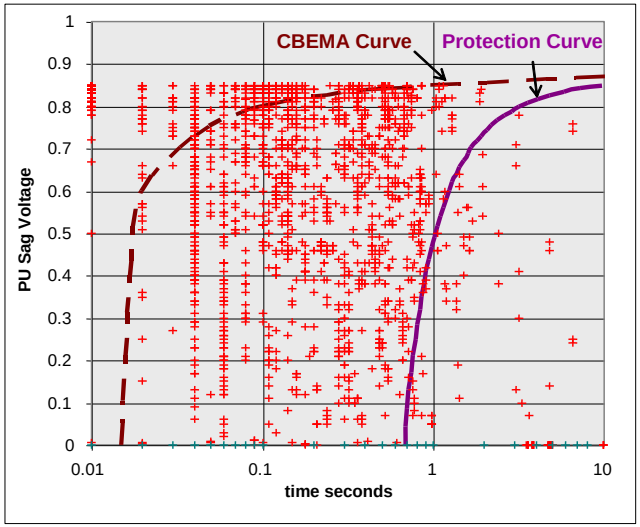
- Generally harmonic levels are acceptable and lower than levels measured in Europe
- Voltage THD levels have been increasing steadily until the last survey in 2007
- It is unclear whether the slowing/reversal of the trend is permanent or temporary



4. Important Findings

Sag Behaviour

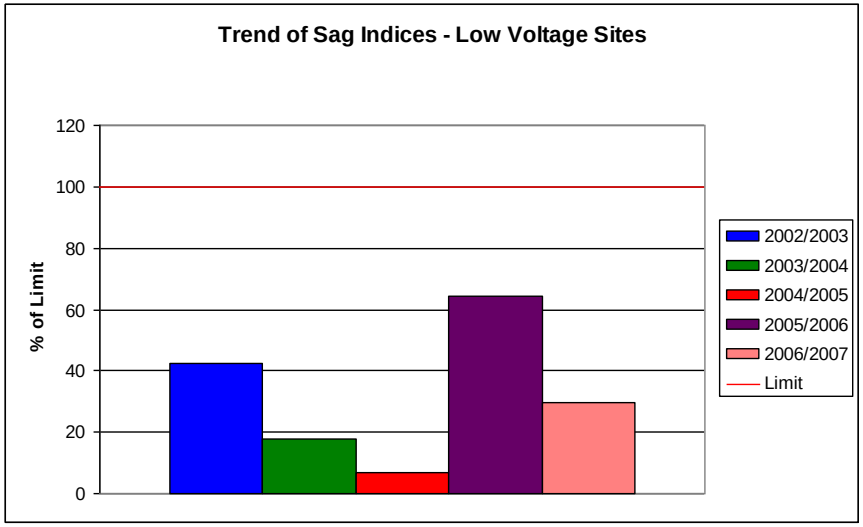
- Investigation of Sag behaviour has shown that:
  - **The CBEMA curve** is unsuitable as a measure of distribution utility performance
  - **The Protection curve**, developed by The University of Wollongong, gives a better idea of utility capabilities



4. Important Findings

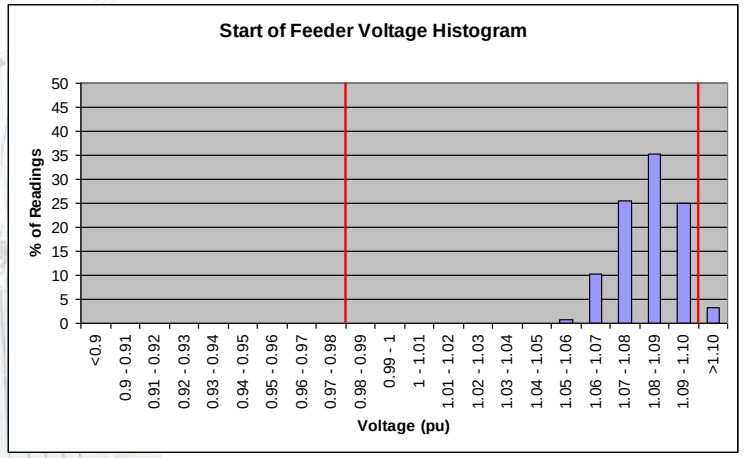
Sag Behaviour continued

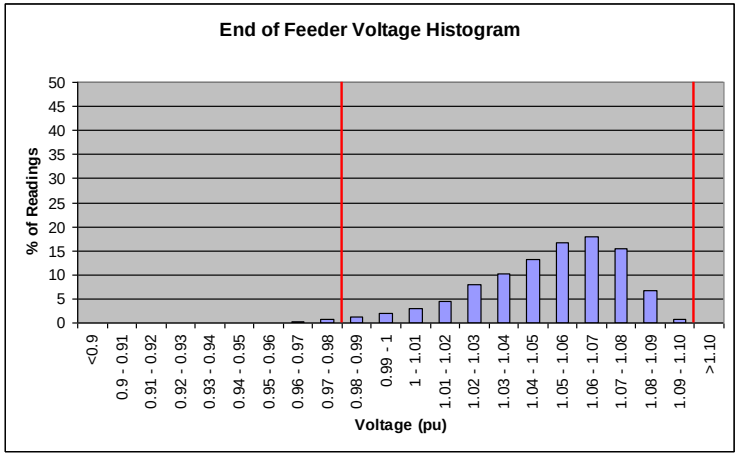
- UoW has developed a single index for annual sag behaviour which is under international consideration
- It can be applied to a site, a distribution network or to find a national average
- The trend of sags indicates wide variation in sag levels due to inconsistent weather patterns
- It may be some years before an appropriate sag limit can be specified



5. Adding Value for DNSPs

The need for more Weak LV Sites





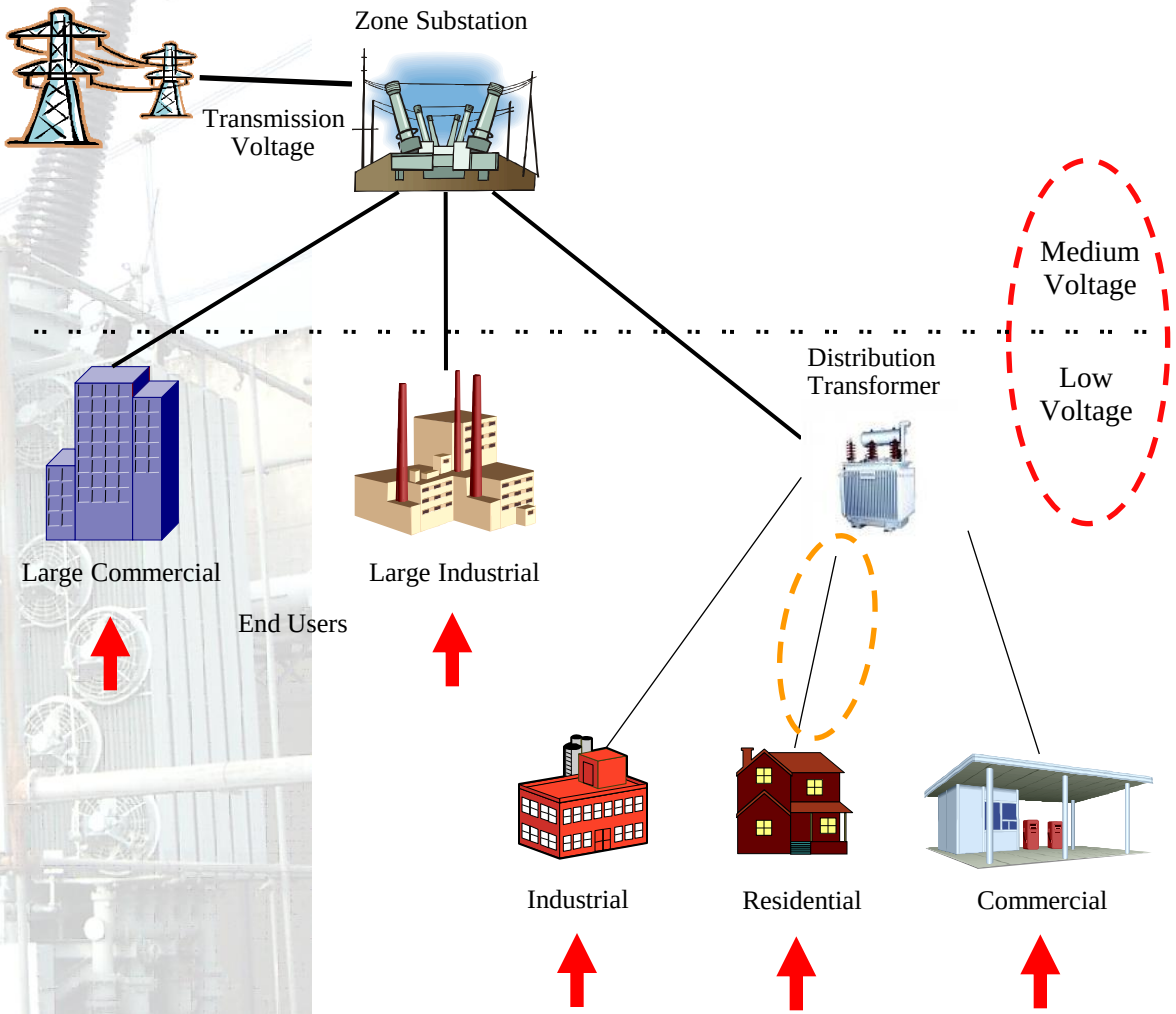
- The solution to the high voltage levels at strong sites may not be as simple as changing taps
- The above graphs shows voltage levels at the start and end of an average overhead LV feeder
- Non-compliance at the end of the feeder is observed at the high and low ends of the voltage range

5. Adding Value for DNSPs

Reporting by Site Classification

- Site classifications are used to compare sites with similar predominant features
- They can also be used to develop an idea of the site numbers required
- This analysis may be more relevant than simple comparisons across the country
- The survey is heavily biased toward **strong sites** from either **suburban** or **rural** networks
- There are few weak sites and few sites from remote networks
- Load types are fairly evenly represented with mixed load being the most common

5. Adding Value for DNSPs



Voltage Level	Sites
LV & MV	2
Supply Strength	
Strong & Weak Supplies	2
Load Type	
Residential, Industrial, Commercial, Mixed	4
Network Type	
City, Suburban, Rural, Remote	4
Total	
2* Voltage Level * Supply Strength * Load Type * Network Type	128

6. Opportunities & Future Directions

Smart Meter Rollout

- The mass roll-out of smart meters will result in increased numbers of potential sites
- Increased site numbers will assist in assuring statistical confidence in results
- Smart meters may redress the shortage of weak LV sites and shortages for other site characteristics
- If monitor positioning is considered carefully there are opportunities to examine how PQ propagates throughout networks

6. Opportunities & Future Directions

Long Term Benefits

- Continued monitoring of harmonic and sag trends will allow understanding of how PQ levels are developing over time
- Long term participation will also show if PQ planning and management strategies being put in place are effective

Enhanced Analysis

- There is scope for more detailed analysis if participants are willing to put extra effort into data handling
  - more precise benchmarking comparing like sites with like sites
  - more rigorous factor analysis than has been possible in the past

6. Opportunities & Future Directions

Enhanced Voltage Reporting

- The development of a new voltage standard has prompted a review of voltage reporting techniques
- Changes will be made to reporting methods for low voltage and medium voltage sites
- Values of 99th percentile (V99%), 1st percentile (V1%) and voltage spread will now be included in high level reporting tables and figures

7. Conclusions

Highlights

- After 6 years of development the LTNPQS is now one of the largest surveys of its type in the world
- The LTNPQS has encouraged distribution network businesses to develop their own initiatives in power quality monitoring systems and practices
- The LTNPQS has lead to:
  - Better understanding of a systematic approach to conducting, analysing & reporting complex PQ surveys
  - Better understanding of the power quality levels on Australian distribution networks
  - Continual advancement in PQ reporting techniques and indices
  - The ability to make informed submission regarding achievable PQ levels

7. Conclusions

Important Findings

- Voltage (specifically high voltage levels) at LV sites has been identified as the disturbance of most concern
- More weak LV sites are required urgently
  - To gain a more realistic understanding of voltage behaviour
  - To be timely for the setting of a new voltage standard now under development
- MV unbalance may be of concern if a 1% limit is seriously invoked
- Harmonics, currently at safe levels, appear to be increasing
- No discernable trend of sags has been identified as yet

7. Conclusions

Opportunities

- The smart meter roll-outs being undertaken by many utility provide an opportunity for increased site numbers and more detailed reporting
- There is scope for more detailed analysis if participants are willing to put extra effort into data handling.
  - more precise benchmarking comparing like sites with like sites
  - more rigorous factor analysis than has been possible in the past
- Increased participation of all distribution network businesses across Australia will give a truly national indication of PQ levels in Australia