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

Presented by Ian Gibb
Prepared by I. Gibb, S. Elphick, V. Smith, V.J. Gosbell, R. Barr

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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) + 5\textsuperscript{th} 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

![Trend of Total Number of Sites](chart.png)
3. The LTNPQS Today

Distribution of Sites across Australia (2006-2007)

Eastern States
Long Term Participants
515 LV Sites
238 MV Sites
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

![Graph showing Voltage Harmonic Trends](image-url)
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

<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV &amp; MV</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply Strength</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong &amp; Weak Supplies</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential, Industrial, Commercial, Mixed</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>City, Suburban, Rural, Remote</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>128</th>
</tr>
</thead>
</table>

2 * Voltage Level * Supply Strength * Load Type * Network Type
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