Update on the Australian National Network PQ Survey

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1. Introduction

Motivation for PQ monitoring

1. Allow utilities to be well informed
2. Find minimum levels that are achievable
3. Determine & prove cost-effective strategies for improvement
4. Motivate a more general understanding of PQ

1. Introduction

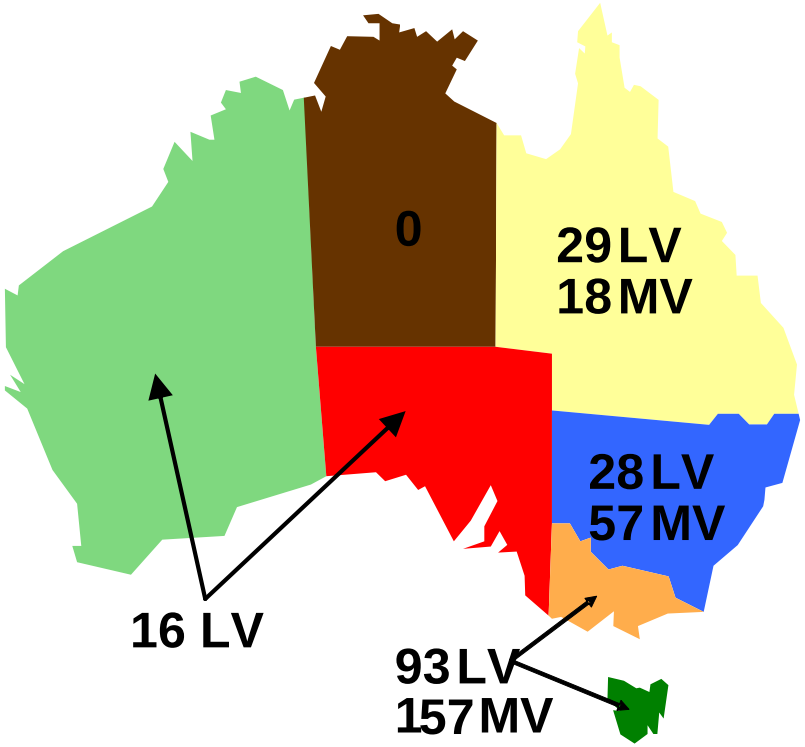
Since 2001: Long Term National PQ Survey

- Long term: full year
- Utilities use own instruments, including smart tariff meters
- Disturbances included are
  - Steady State Voltage
  - Voltage Unbalance
  - Harmonics
  - Voltage Sags
- Data forwarded to UoW

1. Introduction

Sites included in UoW PQ Survey Initiatives

- All sites situated in distribution systems



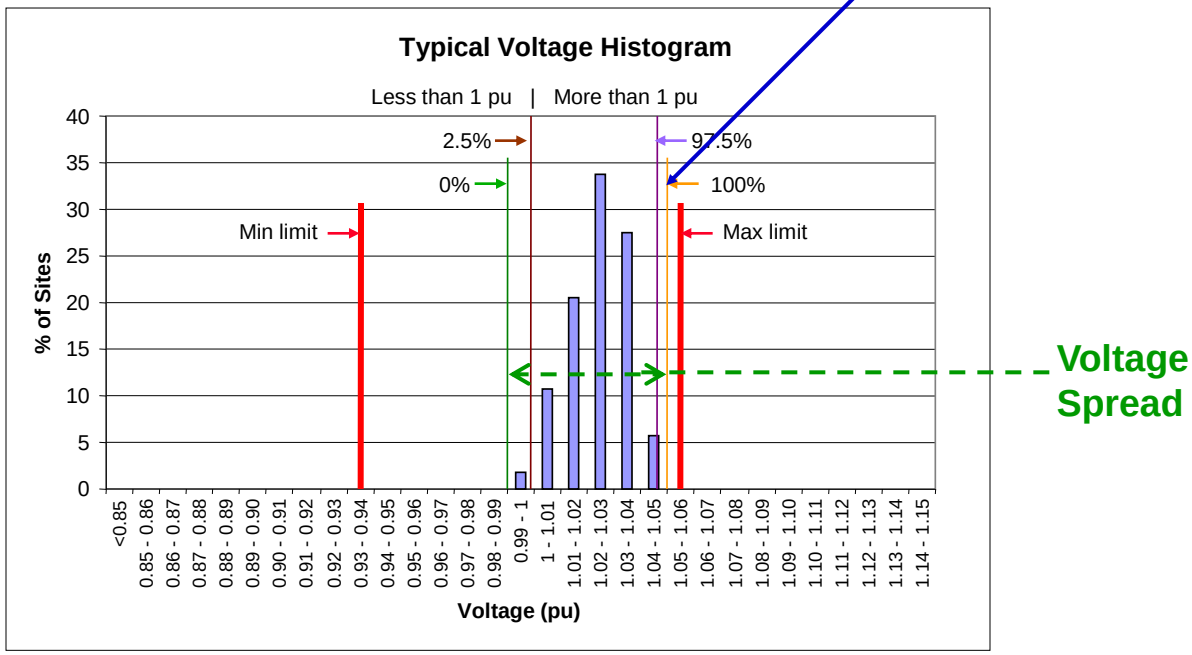
1. Introduction

Outcomes

1. Survey methodology
2. Survey analysis methods
3. Survey reporting
4. Understanding of PQ levels
5. Standards

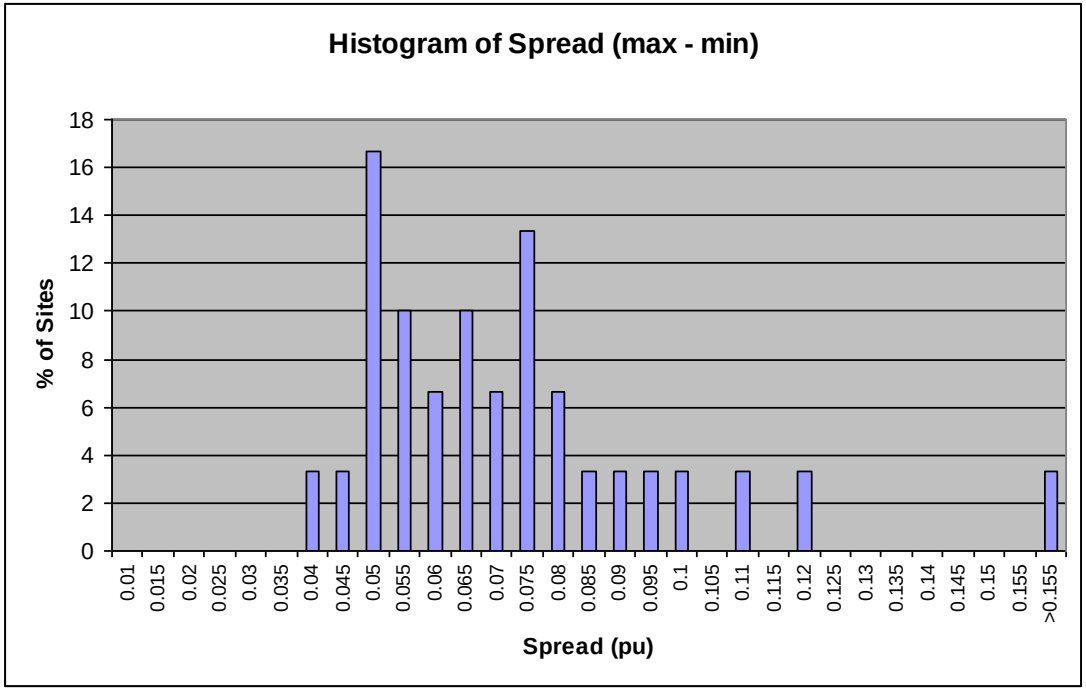
2. Voltage

A. Typical LV histogram



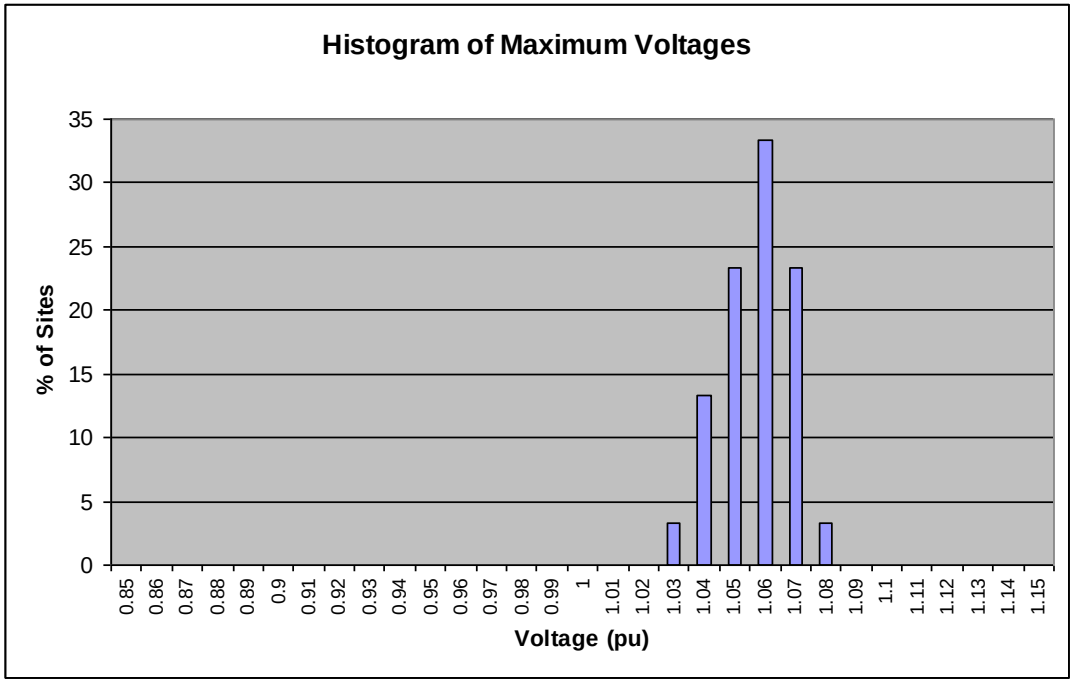
- Note limits, $V_{0\%}$, $V_{2.5\%}$, $V_{97.5\%}$, $V_{100\%}$
- Key parameters are
  - measure of **Peak voltage** – e.g. $V_{100\%}$
  - measure of **Voltage spread** – e.g. $V_{100\%}$-$V_{0\%}$

B. LV Results - Spread



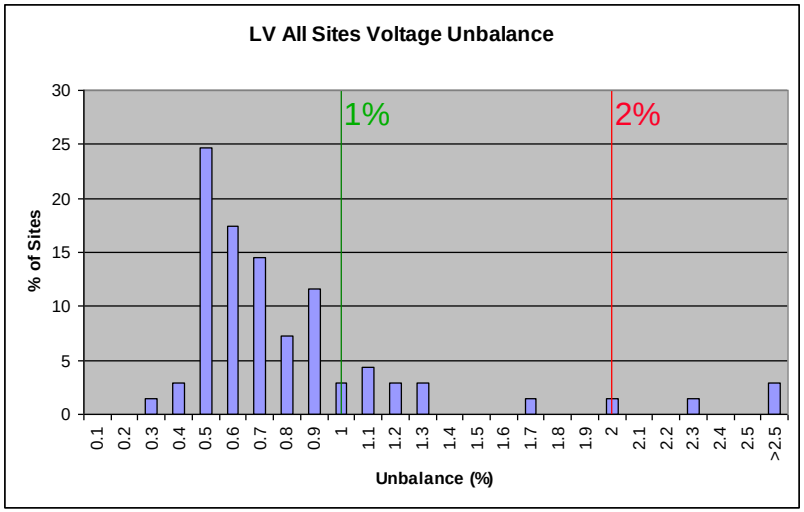
- Spread is within 12% band
- Could be greater at downstream sites!

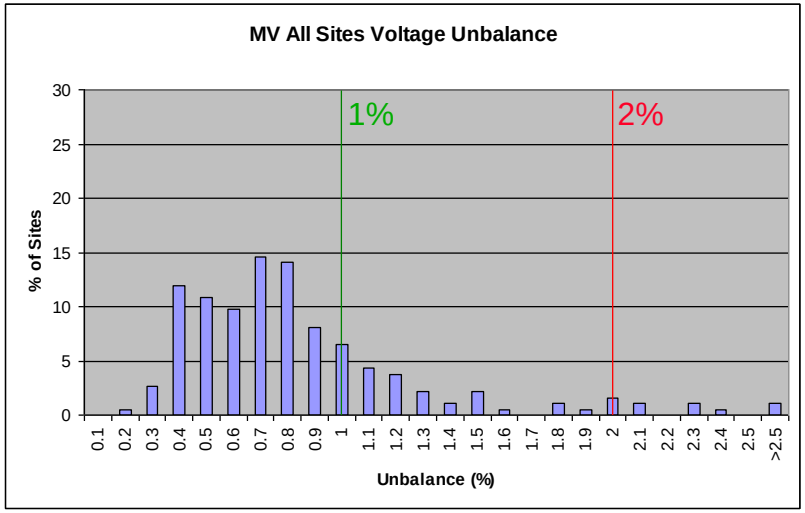
C. LV Results – Peak voltage



- Maximum voltage is higher than expected at many sites
- Can they be reduced? - downstream measurements needed to clarify

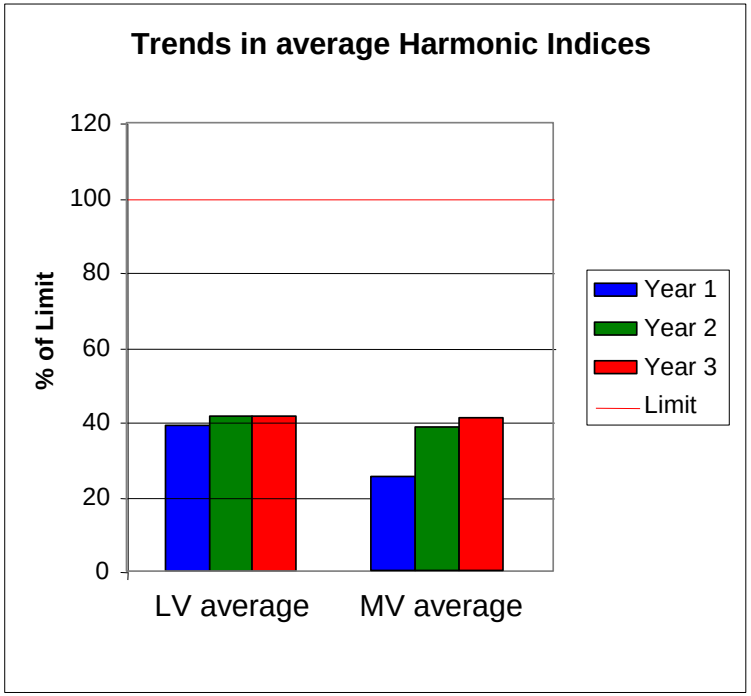
3. Unbalance





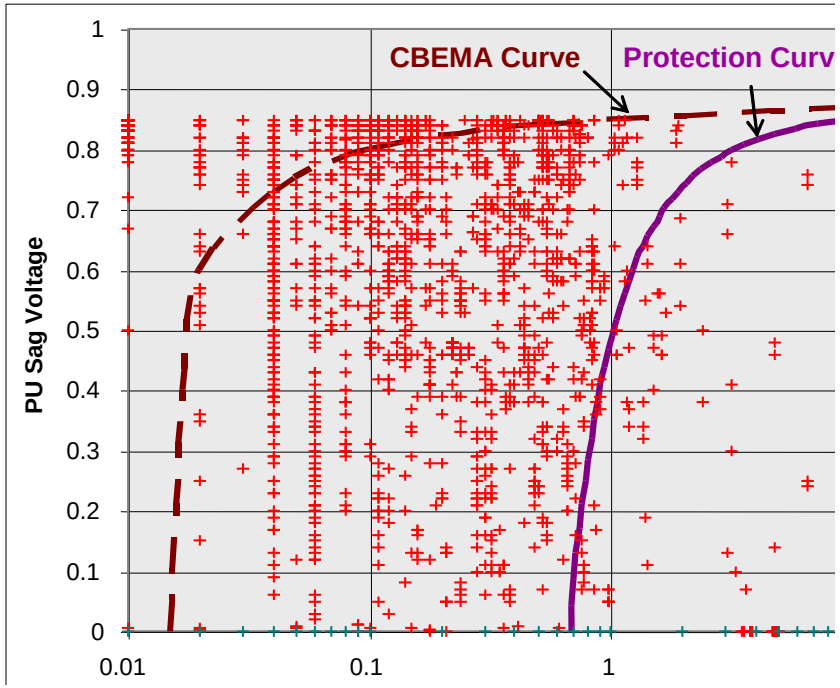
- Apparent anomaly of lower values at LV than MV
- 1% limit is not achievable at a significant fraction of sites

4. Harmonics



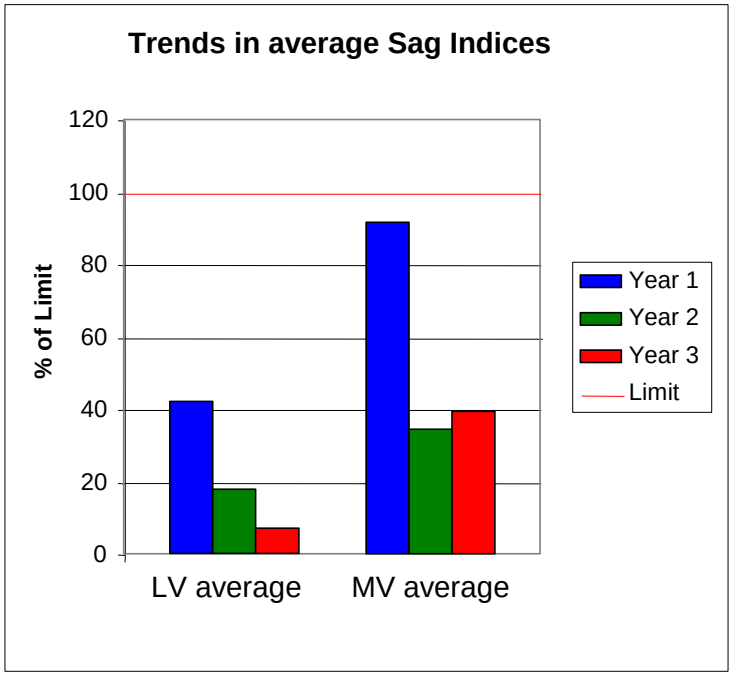
- LV & MV THD about 40% of limit values
- LV increases at 0.1%/annum consistent with overseas reports
- MV increases at about three times the LV rate

5. Sags



- **CBEMA curve** is unsuitable as a measure of distribution utility performance
- **Protection curve** gives a better idea of utility capabilities

5. Sags



- Decrease in line with severe weather events
- Lack of strict annual repeatability requires many years of data to establish reasonable utility limits

6. Customer Severity Index

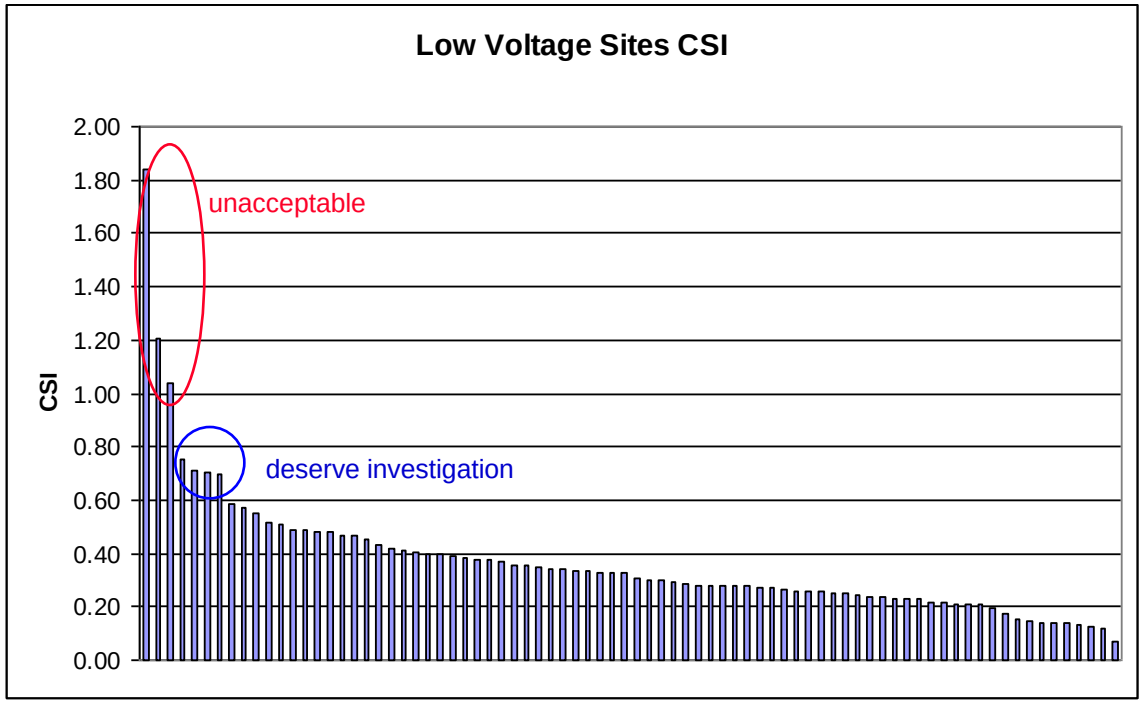
Definition

- Aim to find a single measure for the overall impact of all measured PQ disturbances on customers
- Steps
  1. Need a common comparison: normalise all indices relative to maximum acceptable levels
  2. Assume **V**, **U**, **H** impact is a thermal effect, varies as square
  3. Assume **S** impact is linear
  4. Then $\mathbf{CSI = 0.25 \times (V^2 + U^2 + H^2 + S^1)}$

V: Voltage index
U: Unbalance index
H: Harmonic THD index
S: Sag index

6. Customer Severity Index

LV Result



- Generally a continuous trend
- A few really bad sites seem to be atypical & deserve further investigation

7. Site Classification

A. Basis

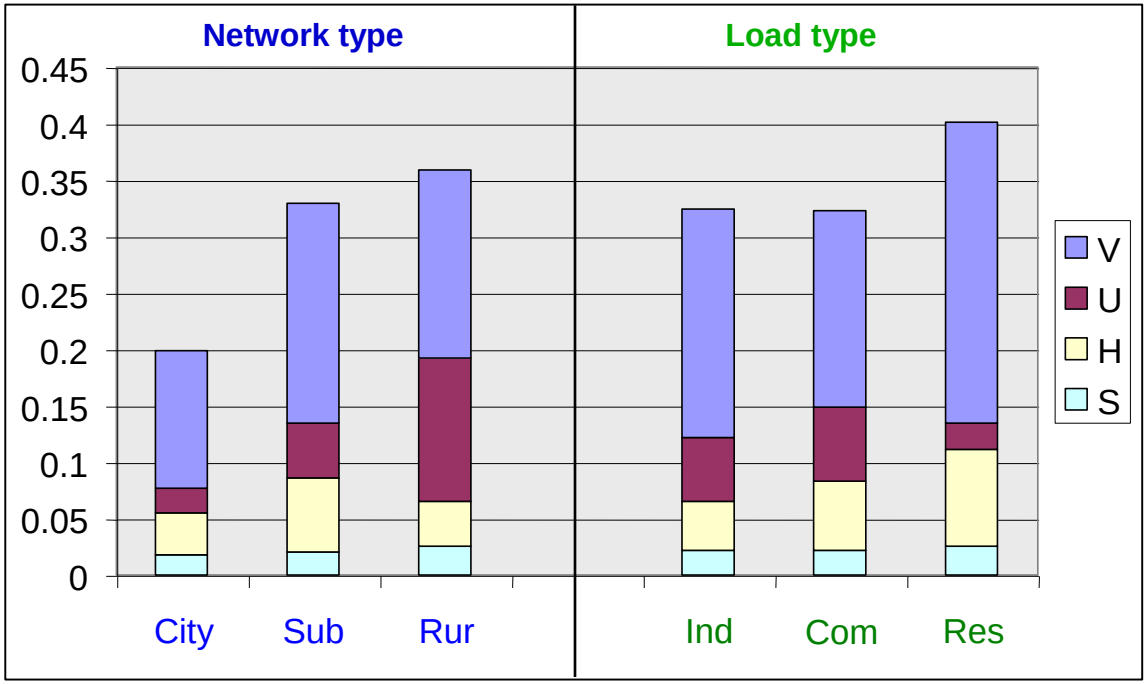
- Sites can be classified by

Network type	Load type
City	Residential
Suburban	Commercial
Rural	Industrial

- Are there significant differences between the PQ levels in these site types?

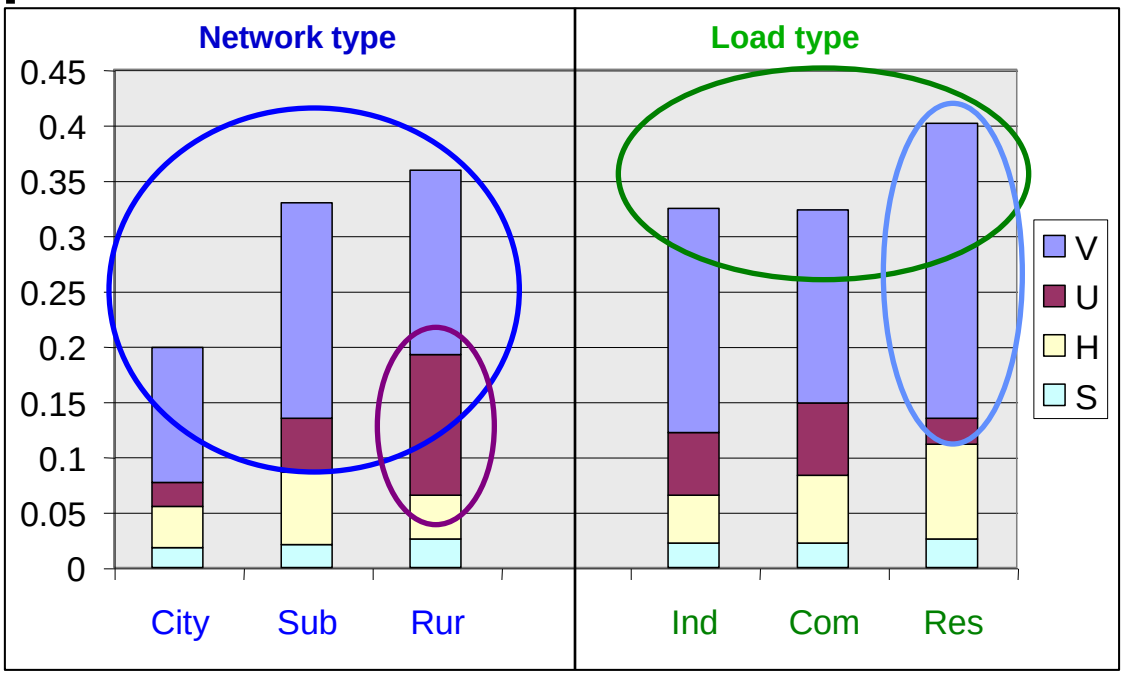
B. Comparison for LV sites

- Find average of **V**, **U**, **H** & **S** for each site classification
- Determine overall effect using **CSI**
- Show **CSI** & its components by means of stacked bar graph



7. Site Classification

B. Comparison for LV sites ….



- All classifications have **acceptable CSI**
- CSI Variation between **Network types** is **2:1**; between **Load types** is **1.2:1** - hence ***Network type*** is more important classification
- **Voltage** is largest contribution to CSI, especially at **Residential** sites
- Next largest contribution is **Unbalance**, especially at **Rural** sites

Highlights

1. **Systematic approach** to conducting, analysing & reporting complex PQ surveys has been developed
2. **Voltage**
   - Maximum values seem excessive at some sites
   - Need some weak LV sites before final conclusions
   - Future voltage standards could benefit from statistical considerations
3. **Unbalance**: 1% limit is not achievable at many sites
4. **Harmonics** could be an issue in a decade or so

Highlights

5. **Sags**
   - Effort needed in developing & promoting sensible equipment immunity standards
   - More years of data required to establish long term performance
6. **Customer Severity Index** can give overall PQ disturbance measure allowing simple identification of worst sites
7. **Site classification**
   - At LV, voltage is the most important issue needing addressing
   - The problem is largely independent of Load Type
   - It depends somewhat on Network type, being significantly less at City sites

***** End *****