Monitoring Recommendations
Appendix L

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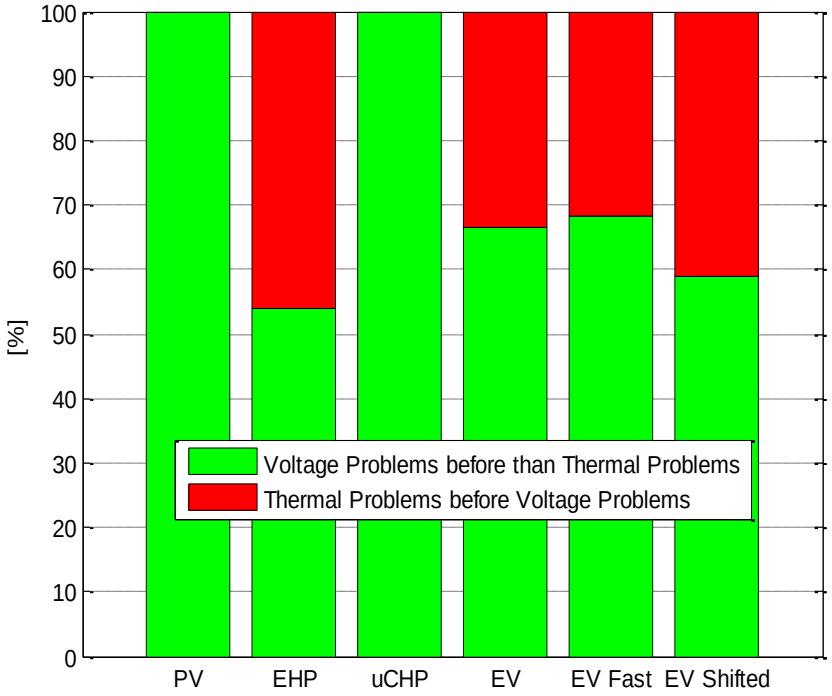
Considerations for Monitoring

1. Parameters to Monitor
2. Sampling Intervals
3. Locations to Monitor
4. Timing
5. Other Aspects

Based on the findings from Appendix F "Performance evaluation of the monitored LV networks" and Appendix I "What-if Scenario Impact Studies based on real LV networks".

1. Parameters to Monitor

- Two of the key metrics adopted in Appendix I are related to voltages and thermal issues.
  - PV: "bottleneck" is voltage
  - EHP: voltage and thermal issues almost 50/50



First technical issue among the feeders with problems (Appendix I)

1. Parameters to Monitor

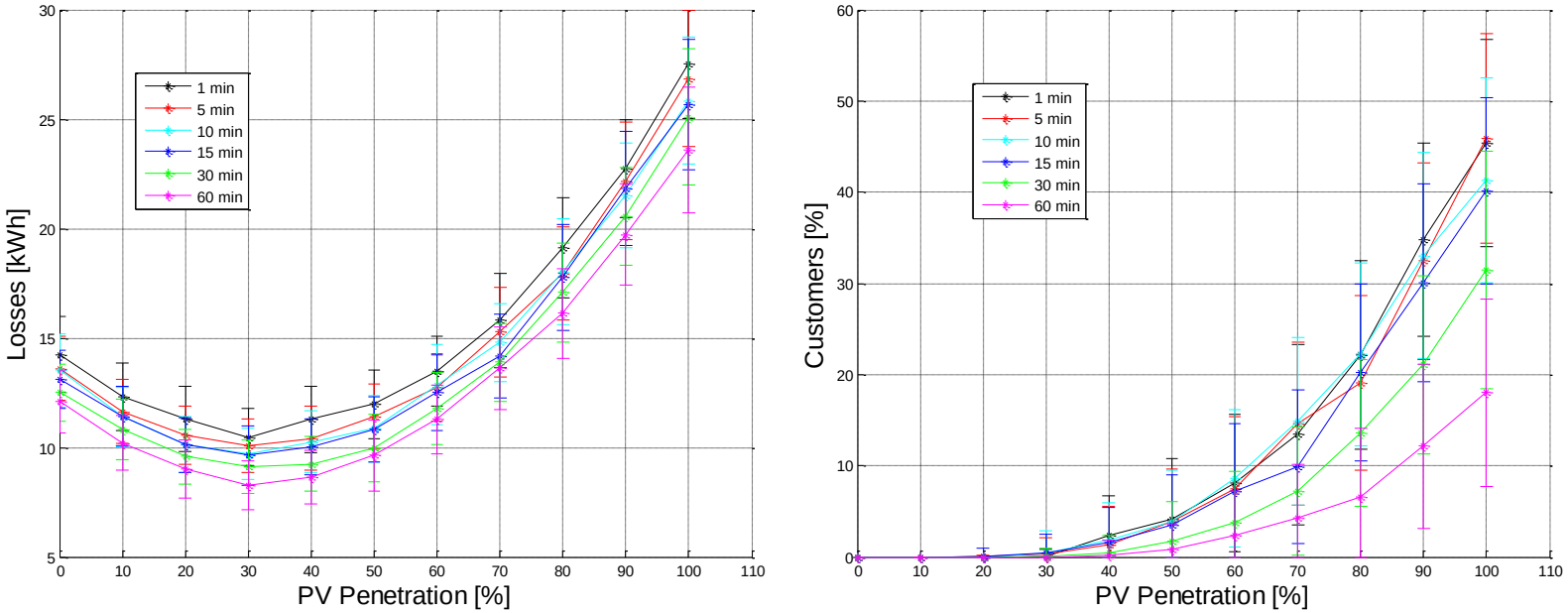
- If the only LCT to be seen in the next few years is PV, then line-to-neutral voltage is a critical parameter to monitor the evolution of impacts. Nonetheless, once EHP or EV are considered, then also currents are required.

Recommendation 1

In the context of a mix of LCT, both line-to-neutral voltages and phase currents (or active and reactive power) at the head of the feeders should be monitored.

2. Sampling Intervals

- Analysis of the effects of different sampling intervals (or data granularity) in the impact assessment.
  - Mean values of 1, 5, 10, 15, 30 and 60 minute intervals for the load and PV generation profiles



Daily energy losses (left) and voltage problems (right) (Appendix I)

2. Sampling Intervals

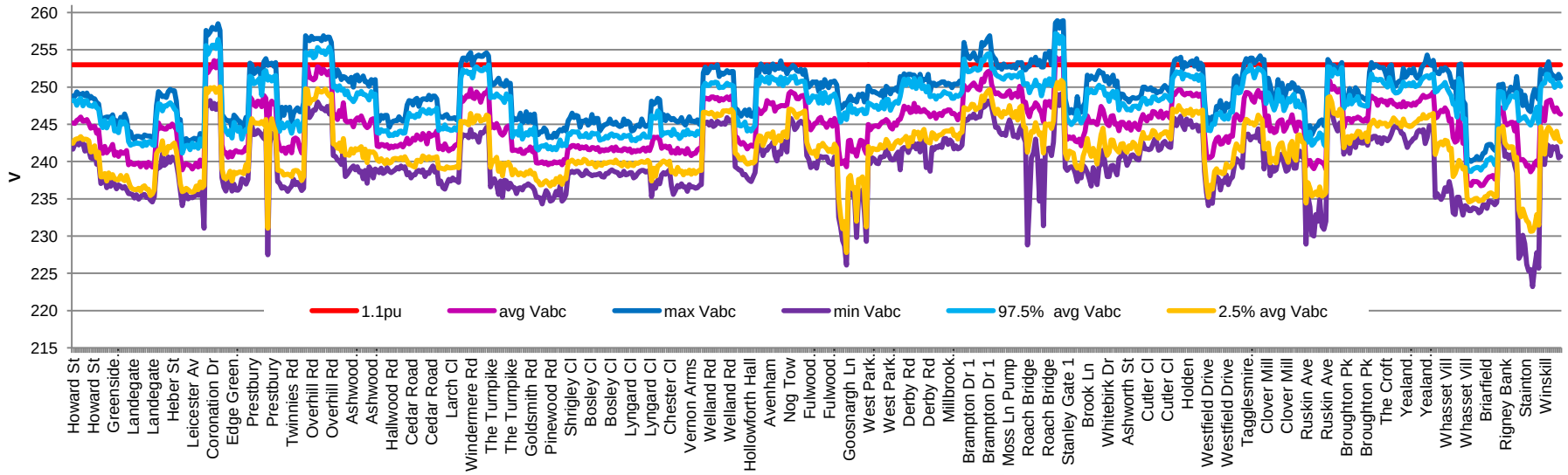
- The effect on the calculation of voltage issues is significant due to the EN50160 requirement of 10 min averages.
  - Benefits from shorter intervals (1 or 5 mins) are not significant
- The effect is not relevant in the utilization level mainly because this index integrates the results in 1 hr.

Recommendation 2

For performance evaluation of the network, the mean values of 10 minute sampling intervals (or close to this) should be adopted to avoid underestimating, in particular, voltage impacts.

3. Locations to Monitor

- The busbar is the most practical and effective location for the monitoring of currents (aggregated effect).
- For voltages, however, it would only work as a proxy if some knowledge of the corresponding feeders exist.



Voltage profiles (Appendix F)

3. Locations to Monitor

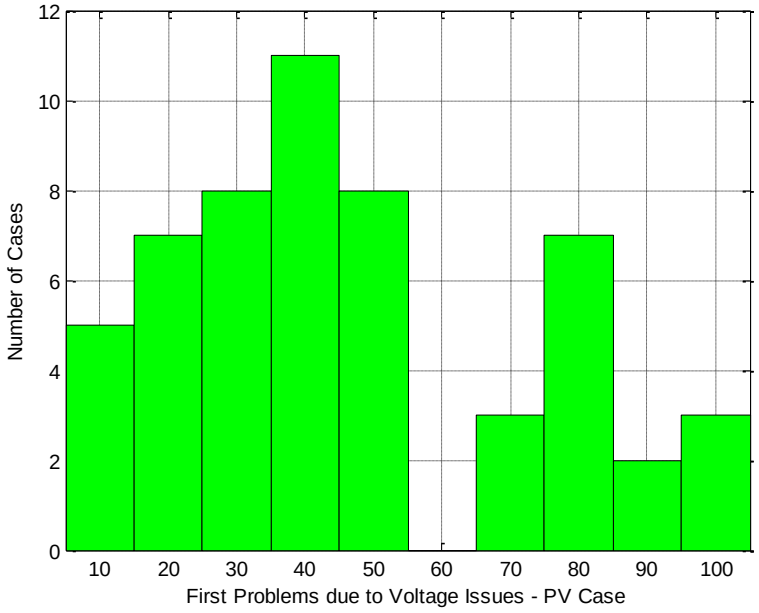
- Thus, for voltages, end points are needed.
  - Mid points do not necessarily bring more critical information although they increase certainty and observability.

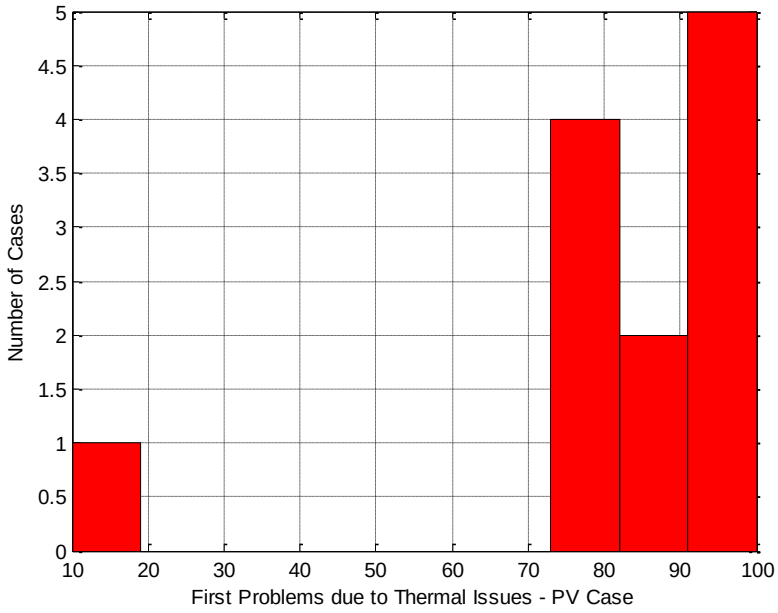
Recommendation 3

For *voltage purposes*, the end points of the corresponding feeders are monitored given that the busbar would only work as a proxy if some knowledge of the feeders exist. However, for *congestion purposes*, currents at the head of the feeders should be monitored.

4. Timing

- Monitors should be placed when a potential problem is likely to happen in the near future. However, voltage or congestion issues depend on penetration levels of LCT and the characteristics of the corresponding feeders.

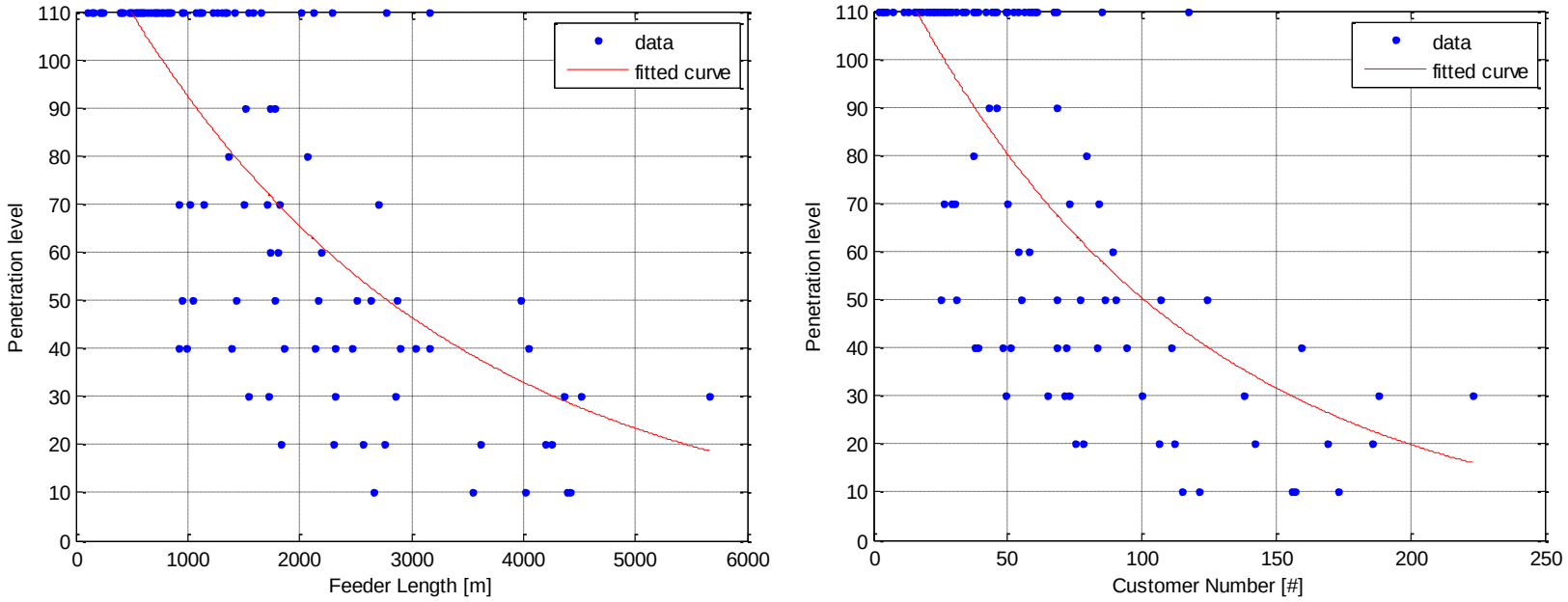




First Penetration Level with Technical Problems – PV Case (Appendix I)

4. Timing

- Appendix I tested a range of feeder metrics for how well they would indicate the LCT penetration level that could potentially result in voltage or congestion issues.



Feeder Length (left), **R2:0.57** and Customer No. (right), **R2:0.57** – PV Case (Appendix I)

4. Timing

- The best performing metric was a combination of total path impedance and the initial utilisation level of the feeder.
- An alternative easier to implement metric (in terms of data) would be a combination of feeder length and number of customers.

Recommendation 4

The correlation metrics proposed in Appendix I (or similar) should be adopted to find the most suitable penetration level of a given LCT for a feeder or LV network for which monitoring is required.

5. Other Aspects

- Although not formally reported via appendices/deliverables, analysis of the monitoring data has shown that total harmonic distortions (THD) of currents and currents through the neutral are significant in many LV networks even without LCT.

Recommendation 5

The monitoring devices to be deployed, particularly at the substation, should ideally also monitor total harmonic distortions of voltage and neutral currents.

Summary

- **Parameters:** Voltage has been found to be a critical parameter for most LCT. However, currents are also as important due to congestion.
- **Sampling Intervals:** 10 minutes is the ideal granularity to avoid underestimating voltage issues (due to EN50160). Less than that is not necessarily beneficial.
- **Location**: For voltages, the busbar is a relative good proxy if networks are known, however the ideal positions are the remote points .
- **Timing**: Monitors should be placed when a potential problem is likely to happen in the near future (correlation metrics).
- **Other Aspects**: THD, unbalance, etc.

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