ROME, ITALY
12-15 JUNE 2023

CIRED 2023 International
Conference & Exhibition
on Electricity Distribution

Impact of discontinuous measurements on the trend analysis of Power Quality parameters

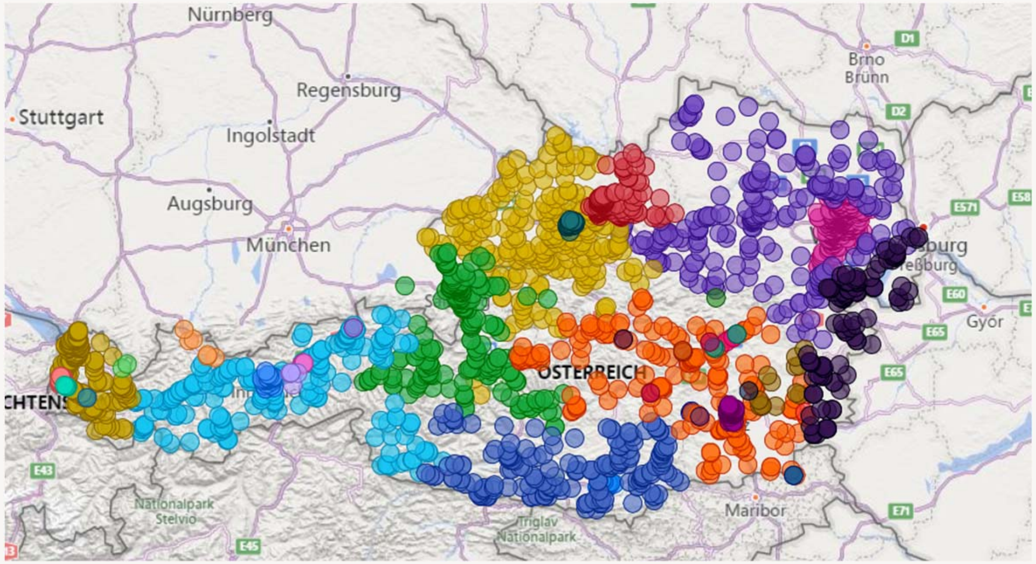
Agenda

- Introduction PQM in Austria
- Motivation
- Trend assessment
- Analysis results
- Conclusion

Introduction PQM in Austria

Full area covering annual PQM

Possible Measurement points
in Austria: More than **5000**



360 mobile 3-week-Measurements (MV) ,
in Austria p.a.

40 seasonal and locally fixed 3-week-Measurements (MV) p.a.

All-the-Year measurement of voltage events
in all substations

One week Measurements – From 2010!!
Three week Measurements- Since 2014!!

Motivation

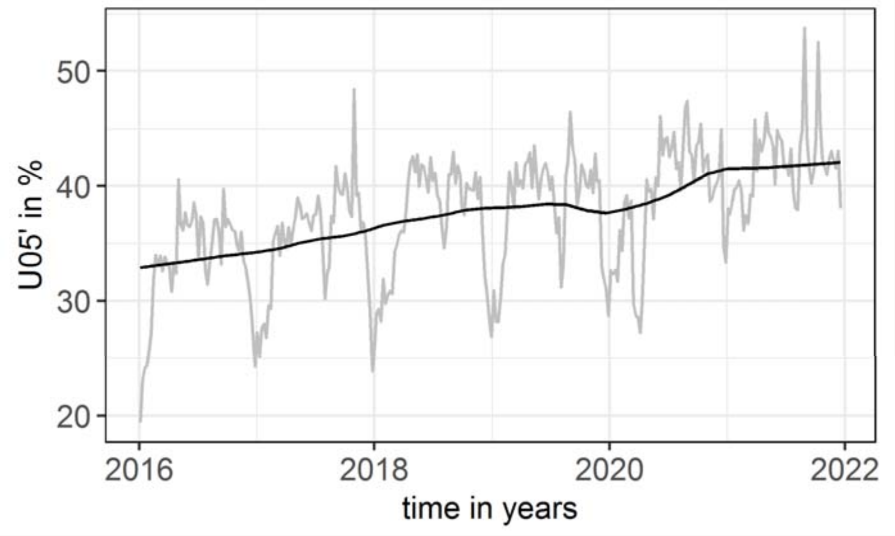
- Fundamental changes in distribution grids
  (e.g. increasing number of modern power electronics)
- Large Power Quality monitoring systems/campaigns
  (e.g. to identify trend developments of Power Quality levels)
- Temporary measurements (yearly repeated) may be legally required
  (e.g. in Austria due to feasibility to measure all sites permanently)

→ Trend assessment based on discontinuous measurements reliable?

Trend assessment

Continuous measurements

- Continuous measurements over multiple years
- Assessment based on weekly 95th percentiles (e.g. as in EN 50160)
- Utilization of the limit in % (e.g. 6% for 5th voltage harmonic)



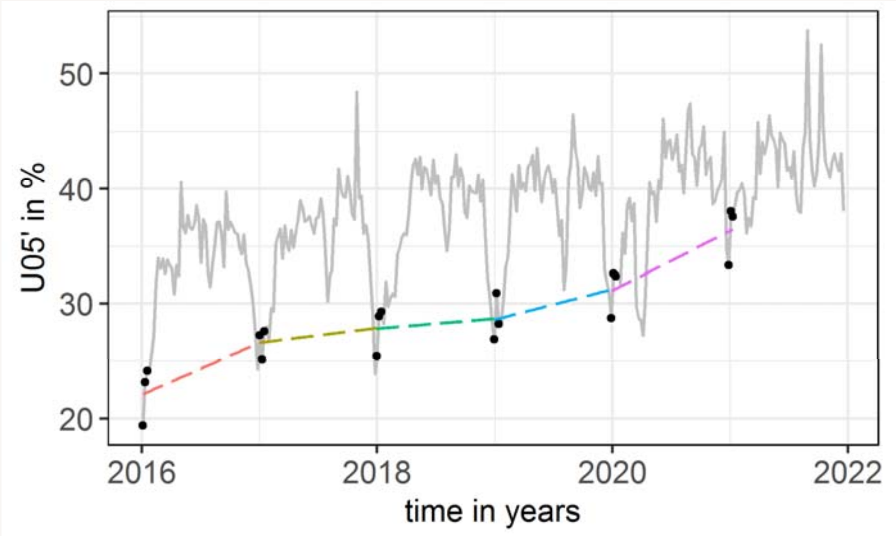
- Seasonal variations (lower emission in winter) with increasing tendency
- Extracted trend component (= reference) using time series decomposition

Trend assessment

Discontinuous measurements

- Temporary measurements:
  - Regularly repeated (e.g. yearly)
  - Fixed duration (e.g. 3 weeks)
- Trend assessment using linear regression between two consecutive measurements
- Resulting yearly trend gains G_{gap} (slope of estimated regression)

Yearly measurements start in 1st calendar week



Trend assessment

Comparison of assessments (1)

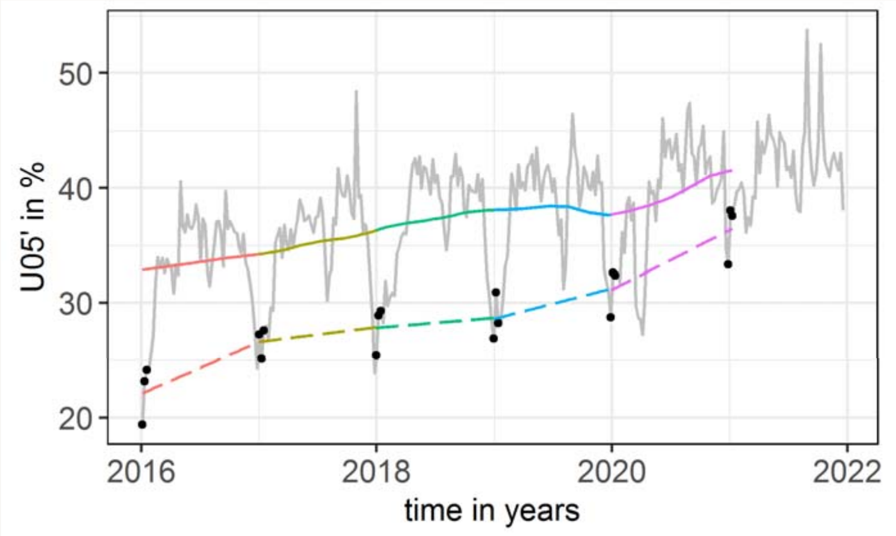
— Comparison of yearly trend gains:
  G_{gap} … discontinuous measurements
  G_{con} … continuous measurements

— Difference between trend gains:
  $\Delta G = G_{gap} - G_{con}$

— Example starting in **CW01**:

- Small differences
- Average difference small ($\overline{\Delta G} = 1.2\%$)

Yearly measurements start in 1st calendar week



Year	2016	2017	2018	2019	2020
G_{gap} / %	4.6	1.3	0.9	2.7	5.4
G_{con} / %	1.4	2.2	1.8	-0.3	3.8
ΔG / %	3.2	-0.9	-0.9	3.0	1.6

Trend assessment

Comparison of assessments (2)

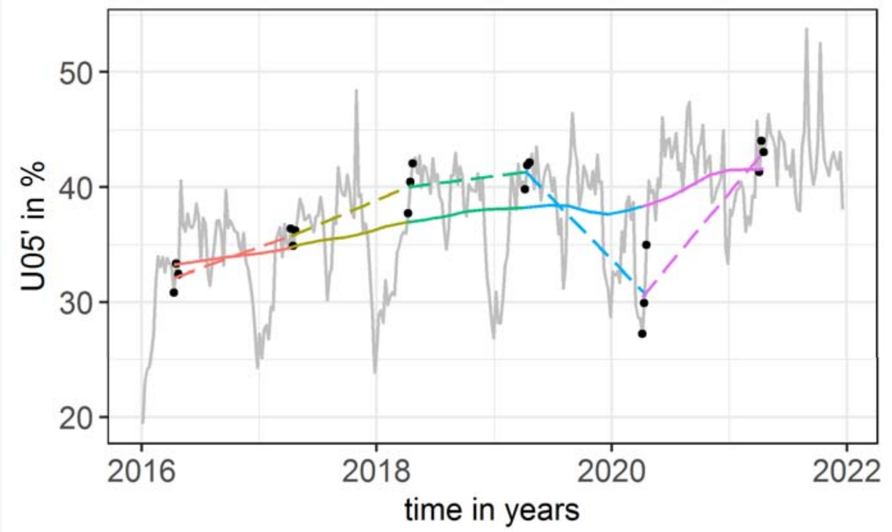
— Comparison of yearly trend gains:
  G_{gap} … discontinuous measurements
  G_{con} … continuous measurements

— Difference between trend gains:
  $\Delta G = G_{gap} - G_{con}$

— Example starting in **CW15**:

- Higher differences
- Average difference small ($\overline{\Delta G} = 0.6\%$)

Yearly measurements start in 15th calendar week



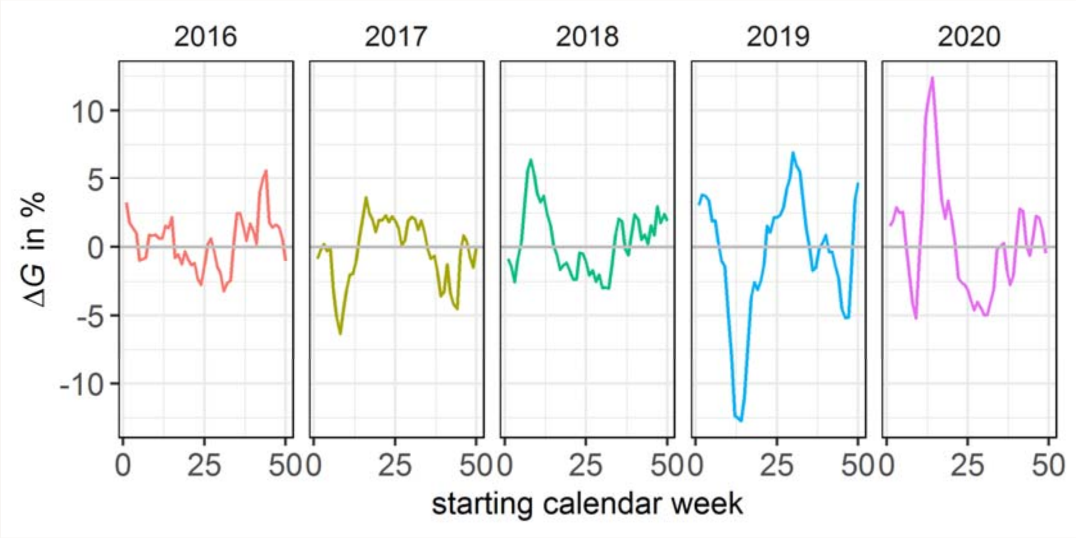
Year	2016	2017	2018	2019	2020
G_{gap} / %	3.8	4.5	1.3	-10.8	12.7
G_{con} / %	1.6	2.3	1.3	0.2	3.3
ΔG / %	2.2	2.2	0.0	-11.0	9.4

Trend assessment

Comparison of assessments (3)

- Resulting trend gains strongly affected by starting calendar week of yearly measurement
- Resulting differences ΔG between trend gains rarely exceed ±5%

Difference between trend gains for different starting weeks



→ Analysis for multiple measurement sites and PQ parameters

Analysis results

Measurement sites and PQ parameters

Measurement sites:

- 23 sites located in rural and urban areas of Austria
- Medium voltage level with 10 kV, 20 kV and 30 kV

PQ Parameters:

- 28 voltage quality parameters (RMS, flicker, unbalance, THD and harmonics of order 2, 3, ..., 25)
- 10 min values for 5-6 years (2016-2022)

Pre-processing:

1. Uncertainty assessment (e.g. max. magnitude error of 10% for harmonics)
2. Calculation of weekly 95th percentiles
3. Impute missing weeks (up to 20% missing weeks and maximum gap of 10 weeks)
4. Selection of suitable time series

→ 866 of 1.886 time series for the analysis

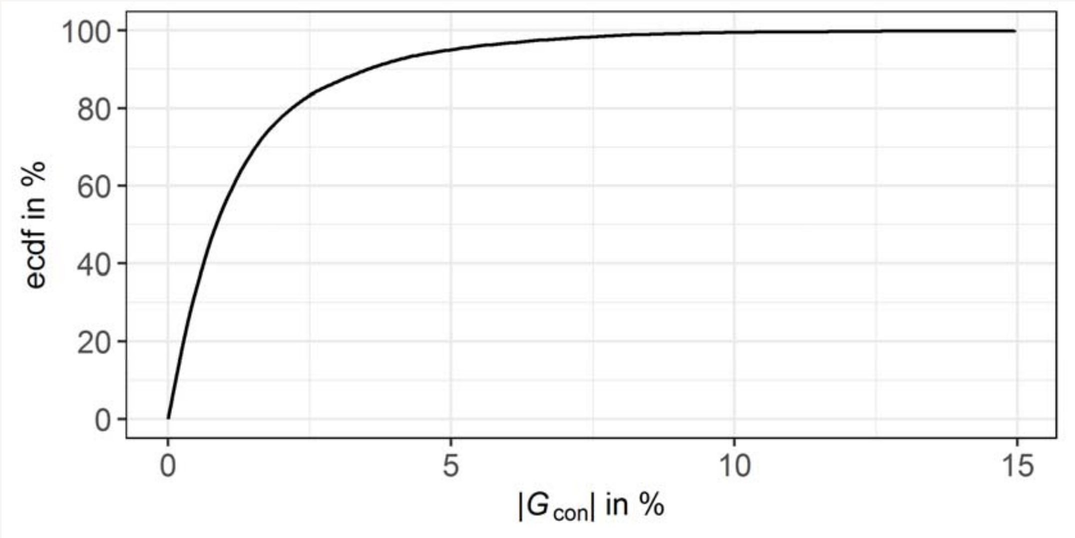
Analysis results

Yearly trend gains

Assessment of continuous measurements:

- Many PQ parameters with (very) low utilization of limits (mostly < 50 % of their limits for EN50160 product quality requirements)
- Yearly increases/decreases for the limit utilization (G_{con}) of all PQ parameters:
  - mostly smaller 5% and
  - never exceeds 15%

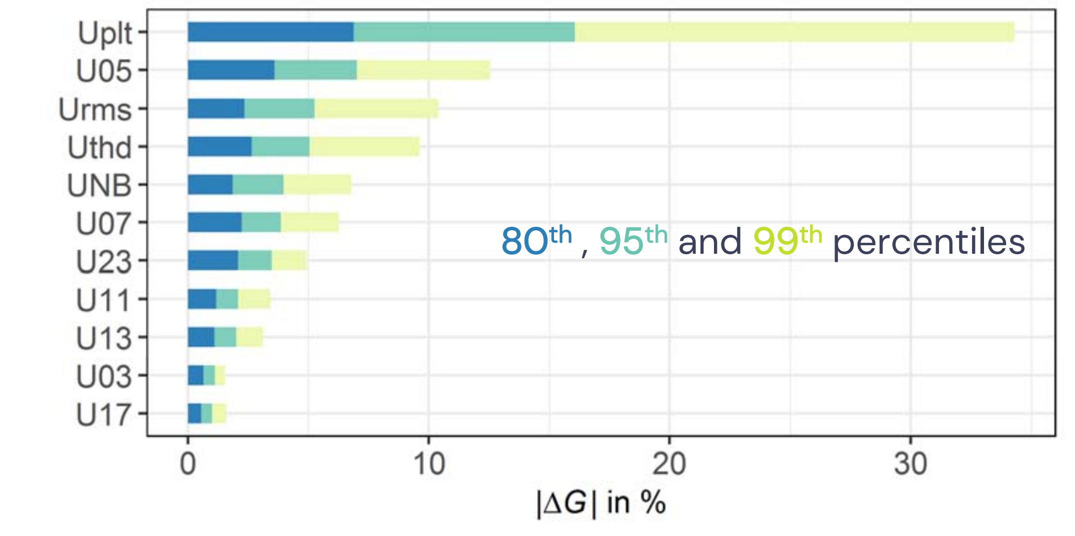
Yearly trend gains based on continuous measurements



Analysis results

Comparison of assessments (1)

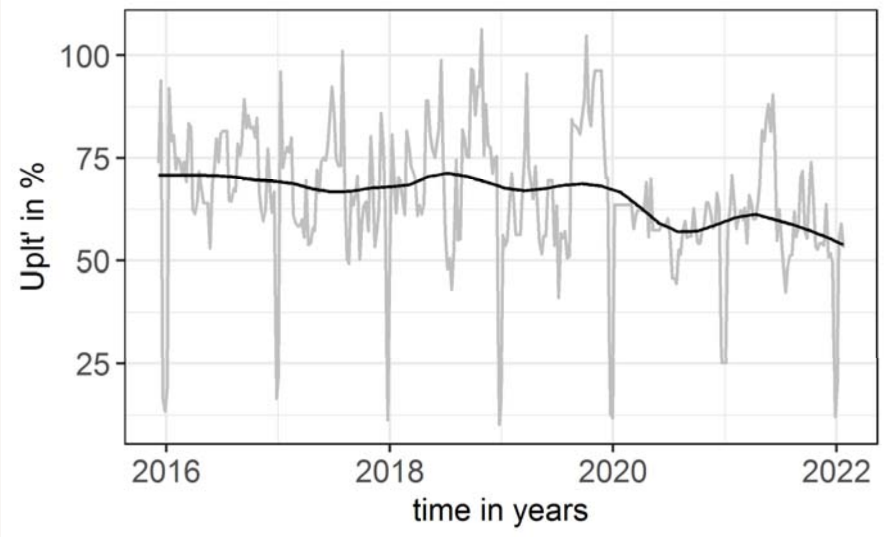
- Absolute difference between trend gains $|\Delta G| = |G_{gap} - G_{con}|$ are small
- Differences for most PQ parameters:
  - Small with $|\Delta G| < 5\%$
  - Mostly $|\Delta G| < 10\%$
- Highest differences for flicker (Uplt)
  - $|\Delta G| < 34\%$ (99th percentile)
  - Maximum of $|\Delta G| = 83\%$



Analysis results

Comparison of assessments (2)

- Highest differences mostly due to single weeks strongly deviating compared to the rest of the year



- Example Flicker:
  - Decreasing trend of limit utilization (limit Uplt = 1)
  - Single weeks with significantly lower values each year → maximum difference ΔG = −46%

Conclusion

Main findings

- Yearly trend assessment based on discontinuous measurements comparable to continuous measurements (most differences $|\Delta G| < 7\%$)
- Measurements should be repeated within same calendar weeks each year
- Misleading large yearly trend gains ($|G_{gap}| > 15\%$) due to single weeks or seasonal effects with unusual high/low values → extend or repeat measurements
- Mostly low limit utilization (< 50% of limits) and typical yearly trend gains $|G_{gap}| < 5\%$

➢ **Trend assessment** only for high limit utilizations:
Step 1) Check limit utilization for defined threshold (e.g. all values > 20% ?)
Step 2) Trend assessment, only if step 1 is true

Thank you for your attention!

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