CIGRE PQ day: Changing landscape of regulations and power quality monitoring

Rik Luiten, Krado / Netbeheer Nederland
Eindhoven, 3 February 2026

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Introduction: about me

- Married, father of two kids, living in Utrecht, love tennis and movies
- MSc Technology & Policy (TU/e), BSc Electrical Power Engineering (HvA)
- 2009: founder of knowledge and networking group Smart Energy NL
- 2009-2018: manager & consultant Movares Energy
- 2018-now: co-founder & consultant at Krado

Introduction: about Krado

- Krado focuses on the **energy supply sector** and supports clients with challenges at the intersection of technology and policy.
- We are specialized in the fields of **safety, power quality and grid development**.
- Examples of our clients:

Netbeheer Nederland, ENEXIS NETBEHEER, STEDIN, TenneT Taking power further, Cu European Copper Institute Copper Alliance, ProRail

Visser & Smit Hanab brengt energie, WEB BONAIRE WATER- EN ENERGIEBEDRIJF BONAIRE, VNG, provincie Gelderland, Gemeente Amsterdam, GVB

National Working Group on Power Quality

- The working group initiates and facilitates **activities to maintain power quality at the desired level.**
- Three domains:
  1. **PQ-monitoring** at connected parties (LV, MV, HV and EHV), see next slide
  2. **Investigations** (understanding and solving problems and complaints)
  3. **Regulation & standardization** (e.g. Netcode, NEN-EN 50160)

Organisation	Name
Coteq	Maaike Rijkeboer
Enexis	Rick Poulussen (chair)
Liander	Jeroen van Tongeren
Rendo	Marcel Hazenberg
Stedin	Tim Slangen
TenneT	Jeroen van Waes Frans van Erp
Westland	Ricardo Giovetty
NBNL/Krado	Rik Luiten (secretary/ consultant)

Public insight in individual PQ measurements

Spanningskwaliteit | Netbeheer Ne

https://www.netbeheernederland.nl/veiligheid-en-infrastructuur/spanningskwaliteit

Locatie: Lelystad | Jaartal: 2024

Netvlak: HS ☐ | MS ☑ | MD ☐ | LS ☑ | EHS ☐

www.UwSpanningskwaliteit.nl

Netbeheer Nederland

Spanningsniveau	10 kV
Meetperiode	4 maart 2024 t/m 11 maart 2024
Voldoet aan kwaliteitscriteria	Ja

1011 (Amsterdam)

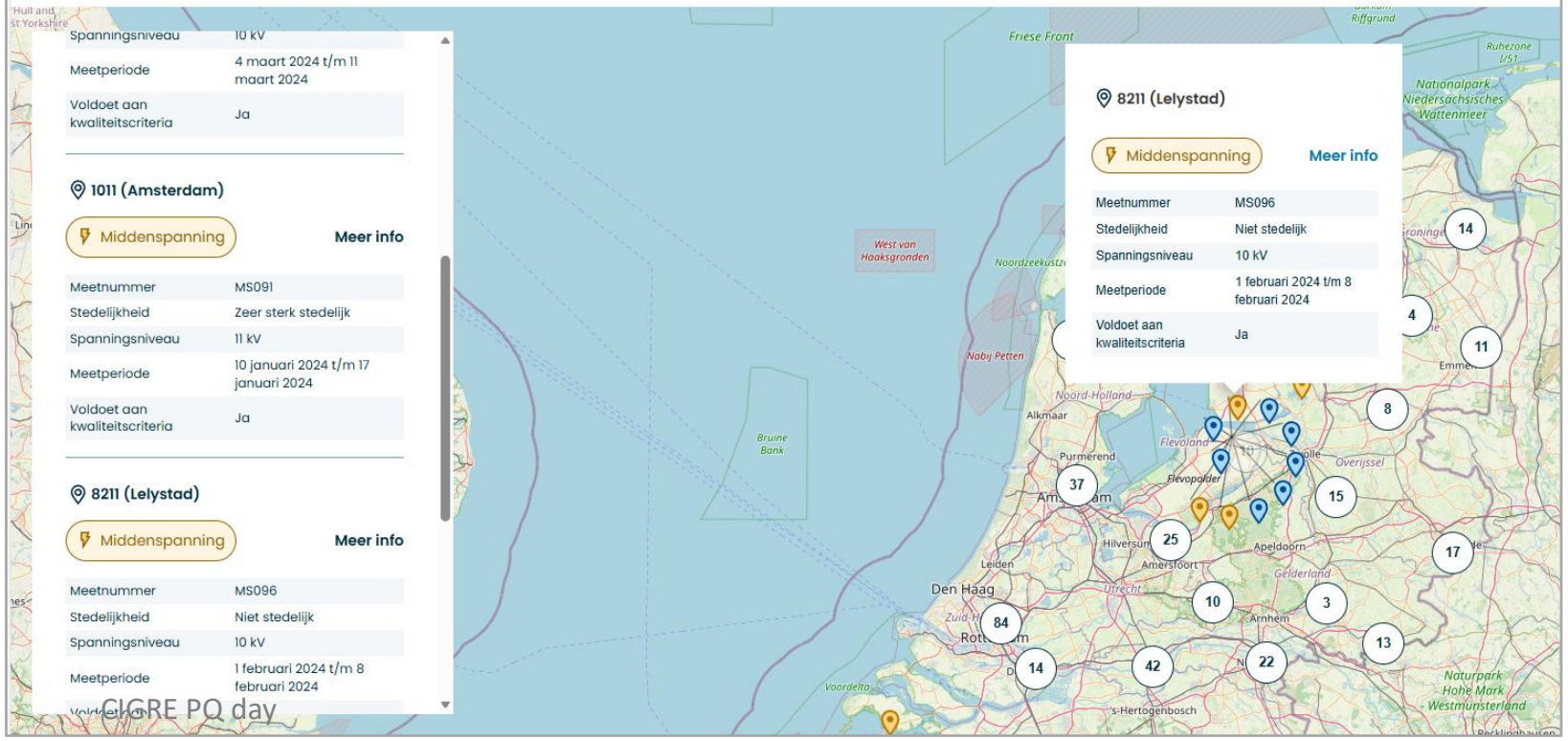
Middenspanning — Meer info

Meetnummer	MS091
Stedelijkheid	Zeer sterk stedelijk
Spanningsniveau	11 kV
Meetperiode	10 januari 2024 t/m 17 januari 2024
Voldoet aan kwaliteitscriteria	Ja

8211 (Lelystad)

Middenspanning — Meer info

Meetnummer	MS096
Stedelijkheid	Niet stedelijk
Spanningsniveau	10 kV
Meetperiode	1 februari 2024 t/m 8 februari 2024
Voldoet aan kwaliteitscriteria	Ja



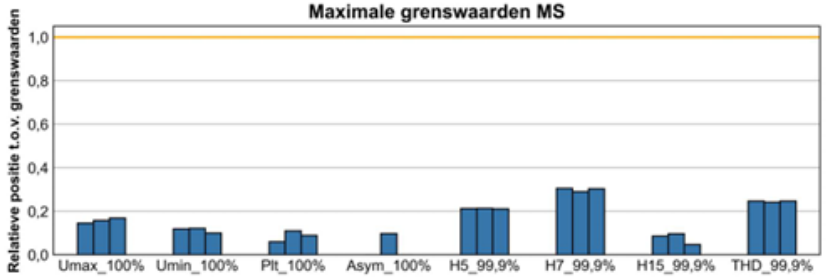
Meetresultaten spanningskwaliteit MS

Gegevens meting	
Meetnummer	MS091
Meetlocatie	1011, Amsterdam
Netbeheerder	Liander N.V.
Stedelijkheid	Zeer sterk stedelijk
Spanningsniveau	11 kV
Meetperiode	10-01-2024 t/m 17-01-2024
Voldoet aan kwaliteitscriteria	Ja

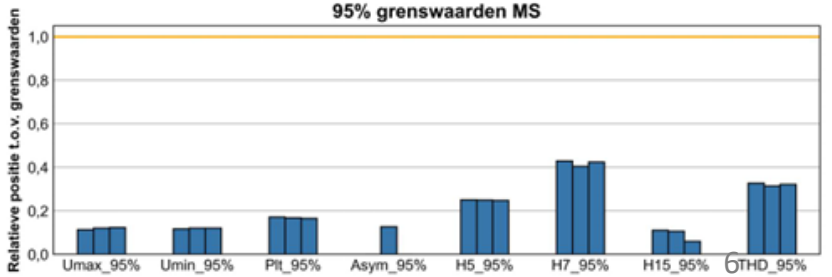
Voldoen de meetresultaten aan de kwaliteitscriteria uit de Netcode Elektriciteit?

Verschijnsel	
Langzame spanningsvariatie	V
Snelle spanningsvariatie (Plt)	V
Spanningsasymmetrie	V
Totale harmonische vervorming (THD)	V
Individuele harmonischen (2 t/m 25)	V

Maximale grenswaarden MS



95% grenswaarden MS



Study commissioned by regulator (1 of 3)

- Study commissioned by ACM (regulator) and carried out by ENGIE-Laborelec in 2023.
- Assessed whether the PQM monitoring program meets current and future needs.
- Mapped (inter)national best practices and developments in power quality.
- Resulted in several recommendations for Dutch system operators.
- Link to the report: click here.

Rapport: Onderzoek Spanningskwaliteit Elektriciteitsnetwerken

Ons kenmerk : LBE3-973173434-4092
Zaaknummer : Laborelec NV – BE0400.902.582
Datum : 29 juni 2023
Auteur : Anne Dabin, Stijn Uytterhoeven, Ralf Bosch
Versie : Definitief
Aantal pagina's : 87

Study commissioned by regulator (2 of 3)

- Good power quality is essential for the functioning of installations connected to the Dutch grids.
- The regulator observed several trends that may influence power quality, including:
  - **Short-circuit capacity** is **decreasing**, because conventional power plants are operating less
  - **Greater unpredictability of power supply** (solar, wind)
  - Introduction of **new types of installations** (e.g. battery stations)
  - **Rising PQ complaints** of customers, mostly LV and MV

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Study commissioned by regulator (3 of 3)

Quotes:

- *"The Dutch grid operators perform high-quality PQM, including measurements, analyses, public data availability, and annual reporting. The Netherlands is clearly among the* ***best in class in Europe*** *when it comes to PQM."*

- ***"However, some points can still be improved…"***

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PQ action plan: introduction

- Based on the study the Dutch system operators have taken action.
- They translated the recommendations into a set of improvement measures, see next slide.
- At the request of ACM, these measures have been consolidated into an action plan.
- This ensures that the understanding of PQ in the Netherlands improves, including how it is affected by the energy transition.

PQ action plan: improvement measures

Selection of improvement measures:

- DSOs: implement continuous PQM
- DSOs : conduct theme-based monitoring
- TSO: improve data quality and availability
- DSOs and TSO: evaluate national PQ limits

Note: some of the measures have already been implemented, others are still in progress.

DSOs: implement continuous PQM

- **Focus on continuous phenomena LV and MV**
- Current situation: time consuming (manual work), no individual annual pattern
- Improved situation: more automated processing, annual data, seasonal trends

Subject	Up to and including 2026	From 2027
Continuous measurements	N/A	LV ≥ 400 MV ≥ 200
Weekly measurements	LV ≥ 250 MV ≥ 250	LV ≥ 20,800 MV ≥ 10,400
New random sample	yearly	5 - 10 years

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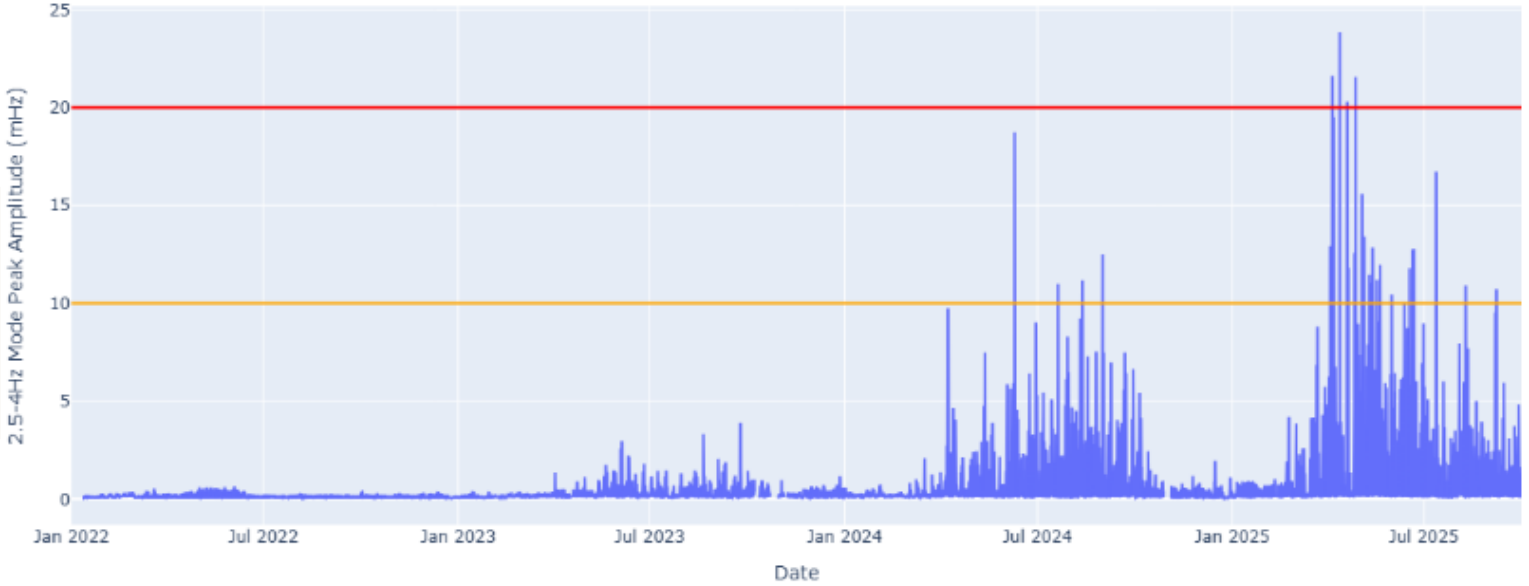
New random sample	yearly	5 - 10 years

Rick Poulussen, next speaker: (more) insights PQM program

DSOs: conduct theme-based monitoring

- Conduct more theme-based monitoring, focusing on ‘hot spots’ and new technologies, such as:
  - Charging points / V2G
  - PV inverters
  - Heat pumps
  - Battery systems
  - 3.5 Hz oscillations (investigation started, presentation **Tim Slangen**)



TSO: improve data quality and availability

- TenneT improved the availability in the last years **from 75% to** more than **90%**.
- Main actions:
  - Connecting all instruments to fiber optics
  - Replacing defective meters
  - Repairing incorrect wiring
  - Improving database management

- **End goal: availability ≥ 95%**
- This is an average, illustrative example =>
- This standard will be included in the national PQM report, starting this year.

TenneT

Voortgangsrapport

Aan ACM en aangeslotenen (deelnemers landelijke bijeenkomst)
Opgesteld Onno Eigeman (TenneT TSO BV)
Gecontroleerd Jeroen van Waes (TenneT TSO BV) & Rik Luiten (Krado)
Kenmerk TT.20251027.001, versie 1.0
Onderwerp **Beschikbaarheid PQ-meetsysteem: voortgang Q3 2025**
Datum 27 oktober 2025

Inleiding en achtergrond
In opdracht van toezichthouder ACM heeft Laborelec in juni 2023 een studie gepubliceerd waarin zij heeft onderzocht of het huidige meetprogramma (PQM) voldeed aan de huidige en toekomstige behoeften. Ook zijn (inter)nationale best practices en ontwikkelingen op het gebied van spanningskwaliteit in kaart gebracht. Op basis van haar onderzoek heeft Laborelec diverse aanbevelingen voor de netbeheerders opgesteld.

Met deze aanbevelingen zijn de netbeheerders vanaf september 2023 aan de slag gegaan. De aanbevelingen zijn vertaald naar verbetermaatregelen die in een plan van aanpak worden toegelicht. De eindversie van dit plan van aanpak is opgeleverd in november 2024 (kenmerk: KR-2023-11281).

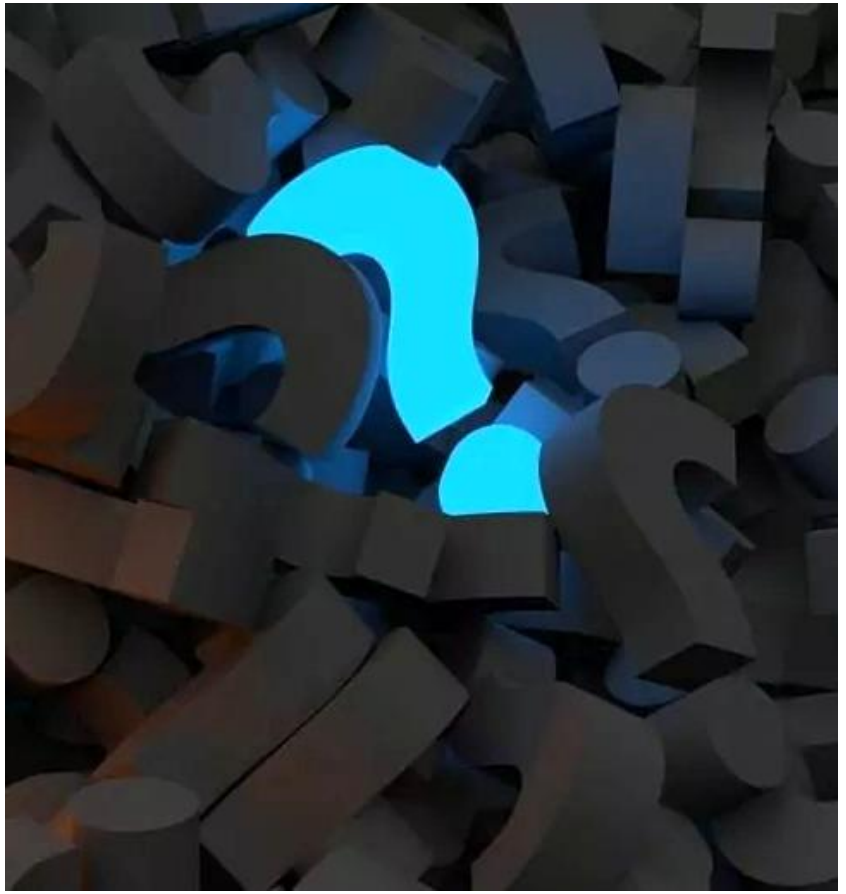
Onderdeel van het plan van aanpak is het sterk verbeteren van de beschikbaarheid van het PQ-meetsysteem in het HS- en EHS-net. Het einddoel is om minimaal een gemiddelde beschikbaarheid te

Instrument	Availability
1	80.0%
2	90.0%
3	100.0%
4	100.0%
Average	*92.5%*

DSOs and TSO: evaluate national PQ limits

Question:

- Are PQ limits in the Netherlands stricter of less strict than those of other countries in the Europe?



DSOs and TSO: evaluate national PQ limits

Quotes study ENGIE-Laborelec:

- *"…the limits in the Dutch Grid Code are stricter than those in other EU countries and EU regulations, both for grid operators and customers."*
- *"The **strict requirements can** sometimes **trigger expensive measures**, such as controlled switching and phase reconfiguration. This may be disadvantageous and can hinder the energy transition."*

Rapport: Onderzoek Spanningskwaliteit Elektriciteitsnetwerken

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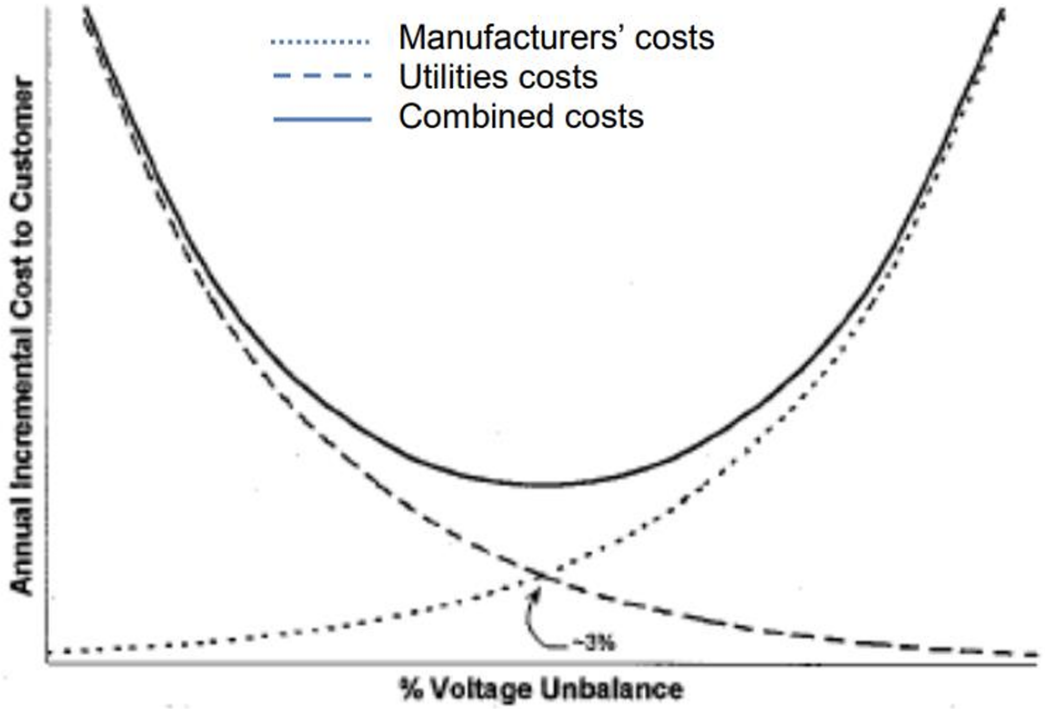
DSOs and TSO: evaluate national PQ limits

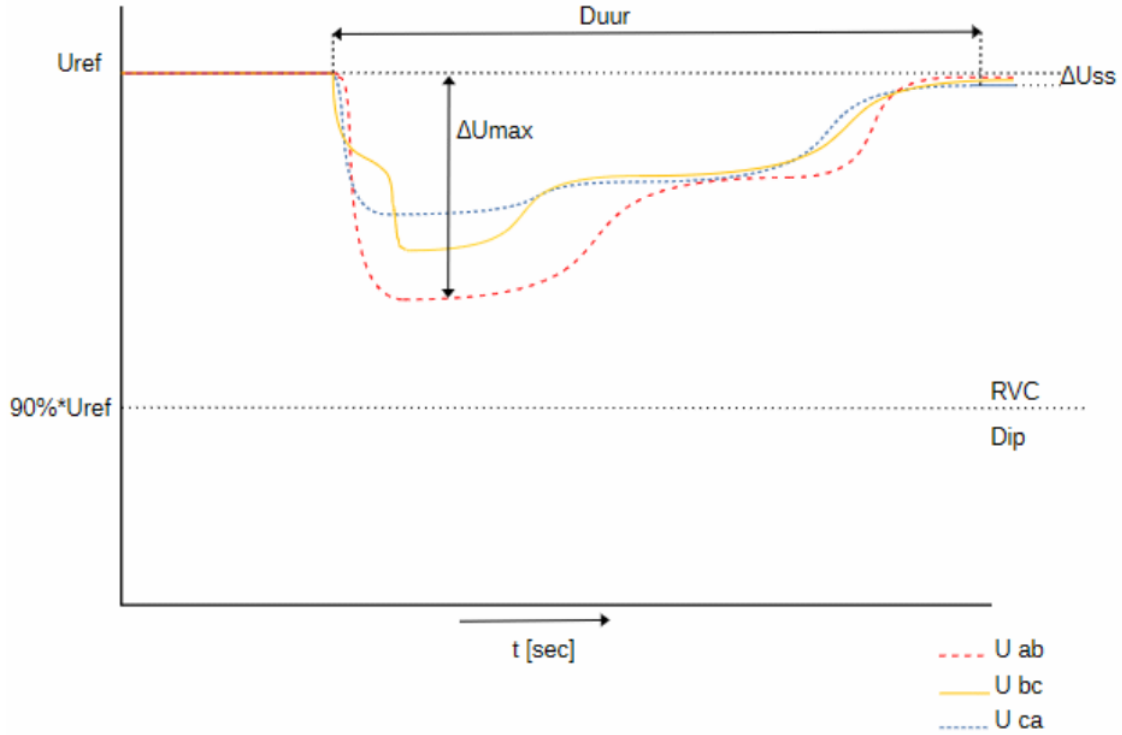
- The requirements in the Netherlands are, in some respects, outdated or stricter in the rest of Europe.
- **Outdated: e.g. harmonics emission limits**
  - PhD started on harmonics, presentation **Levijne Nieuwenhuyzen**
- **Stricter: e.g. rapid voltage changes, flicker (Plt), voltage unbalances**
- Current requirements require (extensive) investments, without major benefits for connected parties.



Source: ENGIE-Laborelec,
Onderzoek spanningskwaliteit elektriciteitsnetten, 2023

Rapid Voltage Changes: definition and causes

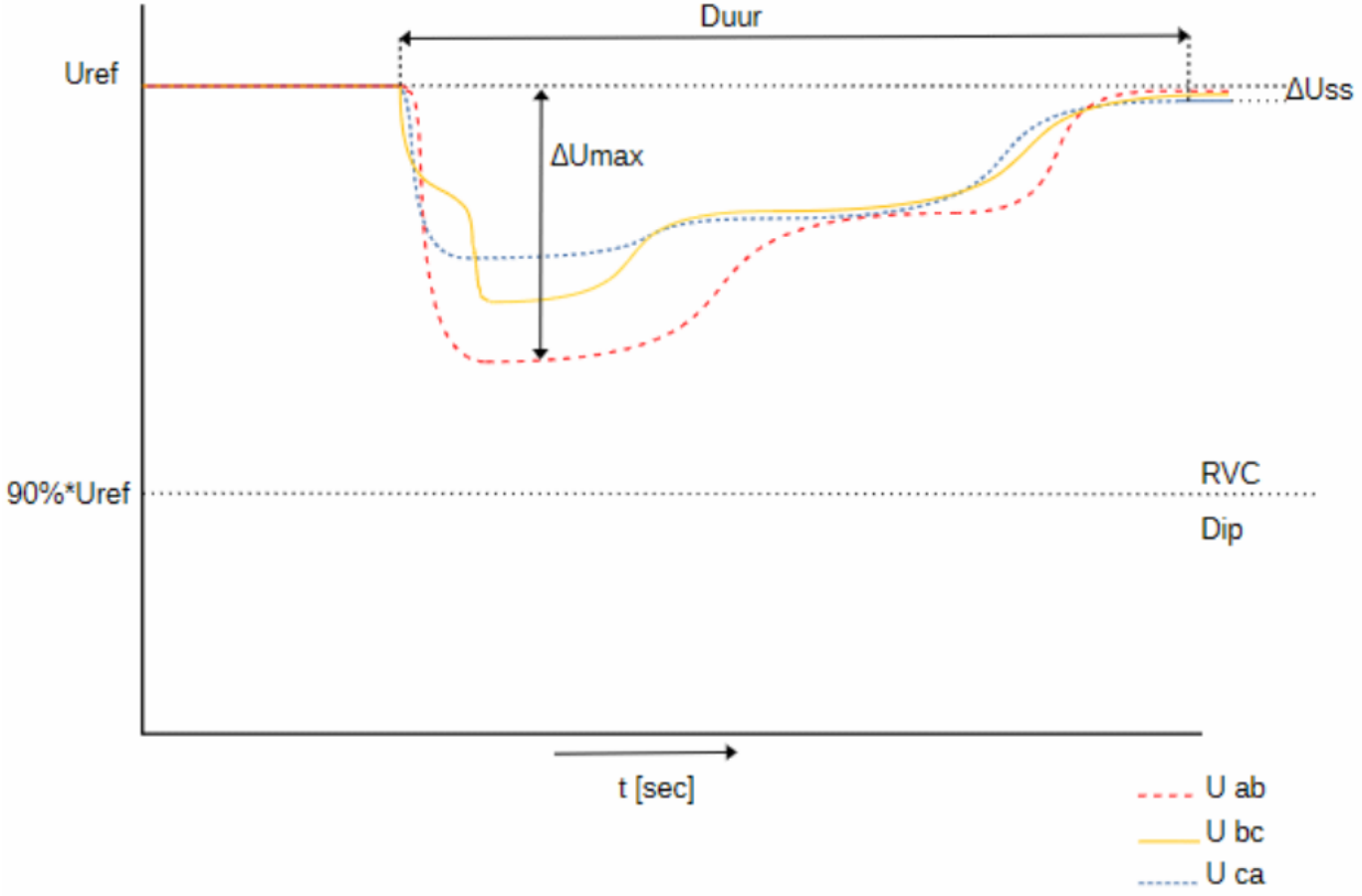
- *Rapid voltage changes: quick transition in RMS voltage occurring between two steady-state conditions, and during which the RMS voltage does not exceed the dip/swell thresholds. [IEC 61000-4-30]*
- Possible causes:
  - Starting motors
  - Switching operations
  - Sudden changes production
  - Short-circuits



Rapid Voltage Changes: Netcode limits HV

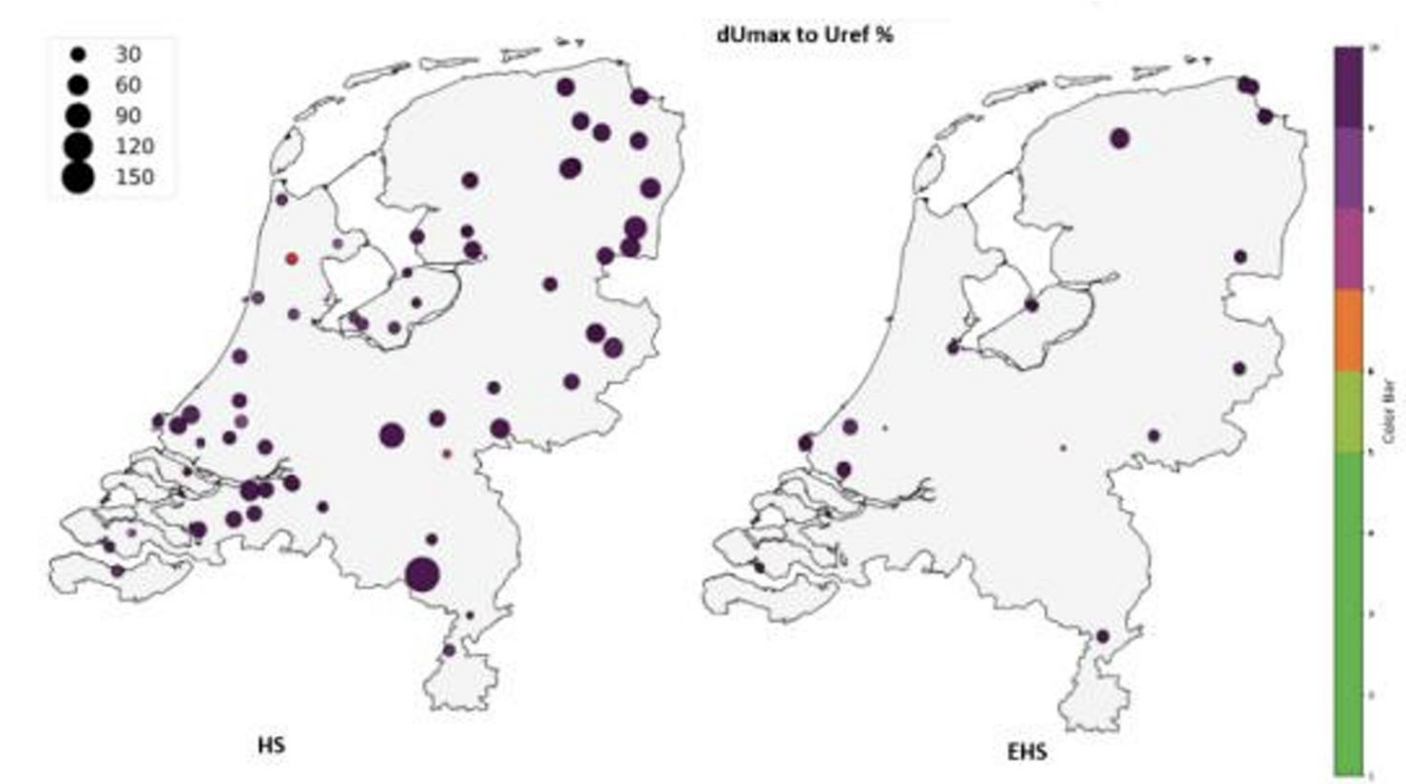
Dutch limits summarized:

- ΔUss is less than or equal to 10% Un
- Limits for normal situation, without outage of major loads, production or circuits:
  - ΔUss ≤3% Un
  - ΔUmax ≤5% Un
- No max number of events, e.g. ≤4/day
- NEN-EN 50160: No limits, only indicative values (3-6%)



Rapid Voltage Changes: exceedances since 2021

- Since 2021: hundreds of exceedances ΔUmax limit each year.
- No complaints received.
- Conclusion after investigation of hot spots and cases: **no identifiable impact of exceedances on customers, zero damages found.**



Source: Aishwarya Vyamajala (TU/e), Assessment of Rapid Voltage Changes, 2023

Rapid Voltage Changes: working group

- Started in Q4 2024: national working group with system operators and connected parties.
- The group advises on revising the requirements for rapid voltage changes (RVCs). What is appropriate and socially responsible?
- Planning:
  - 2026: advice based on (international) investigations, norms and regulation
  - 2027: grid code amendment

Organisation	Name
Netbeheerders	
TenneT, TU/e	Jeroen van Waes
Stedin	Tim Slangen
Liander	Jeroen van Tongeren
Enexis	Rick Poulussen
NBNL, Krado	Rik Luiten
	Hans Wolse
Stakeholders	
ACM	Ibrahim Eroglu
	Chris Kwikkers
TATA Steel	Bert van Hooff
ENGIE	Christian Bouwmeester
Uniper	Dennis de Waal
NXP	Tom Sommers
ProRail	Ron Visser
Vattenfall	Oswin Visser
TU/e	Sjef Cobben

Concluding remarks

1. **Strong foundation**: the Netherlands performs at a high level in PQM, yet the energy transition requires an update of the program.
2. **More monitoring**: continuous and thematic PQ monitoring needed for more insights in the impact of new technologies and seasonal changes.
3. **Regulation**: PQ limits should be proportional. It should be strict enough to ensure a good PQ, but not so strict that they trigger unnecessary investments.
4. **Harmonization**: alignment with European practice strengthens future-proof regulation. Being the ‘best in class’ brings challenges of its own.
5. **Collaboration**: System operators, connected parties, regulators and researchers must jointly shape a practical and balanced PQ regulation. I’m proud that we are doing so in the Netherlands!