Power Quality- Trip down memory lane

FEBRUARY 3, 2026

Prof. dr. ir. Sjef Cobben

Department of Electrical Engineering, Electrical Energy Systems

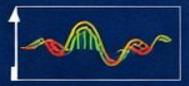
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Power Quality

Power Quality Problems

Voltage Sags

Voltage Swells

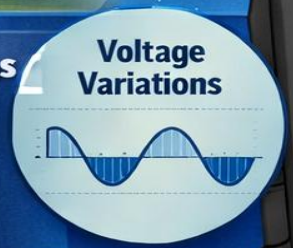


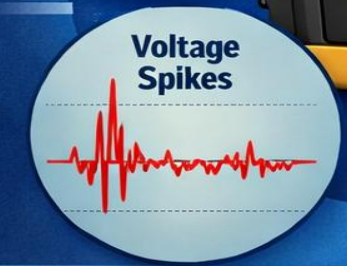
Harmonics

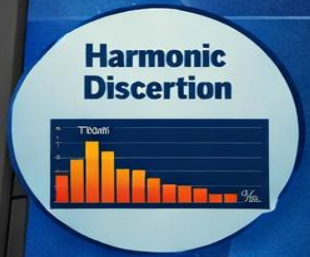
Voltage Spikes

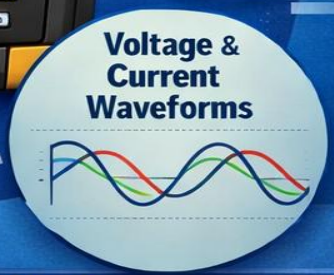
Flicker

Noise









Impacts of Poor Power Quality

Equipment Failure

Data Loss

Energy Waste

Downtime

Solutions for Power Quality

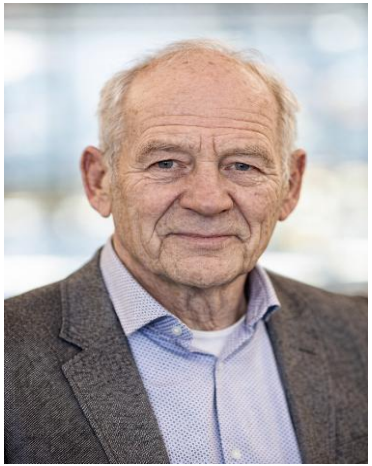
UPS Systems

Filters

Voltage Regulators

Surge Protectors

2011: Part-time professor in Power Quality



What can we learn from the past?	What is important at this moment?	What will the future bring?
Looking back What development in Power Quality has surprised you the most?	Which word do you use most often in your work related to Power Quality?	Looking ahead Which phenomenon do you expect to become the biggest challenge in the next 10 years?

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What development in Power Quality has surprised you the most?

Rise of Renewable Energy & EV Impact

Proliferation of 5G & IóT Devices

Increased Harmonics Issues

(supraharmonics)

Advanced Power Quality Monitoring

Cybersecurity Threats

Grid Resilience Challenges

Chat gpt

Voltage Sags & Swells in Energy Storage

Growing Concerns about Blackouts

Rapid Tech Advancements

Inverters also Improving PQ

EMI & RFI Interference

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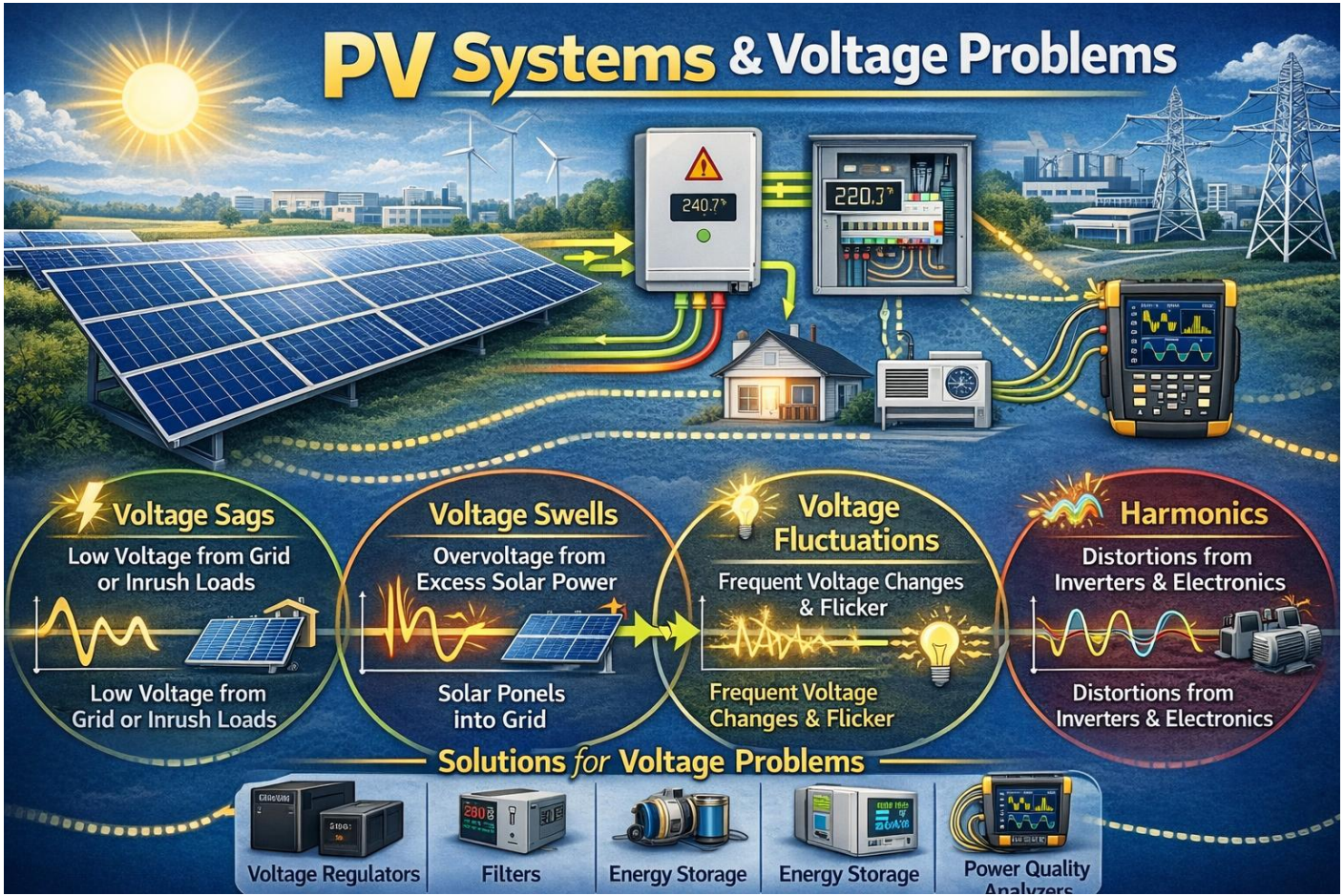
2002: PV and PQ, Interaction and limits



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2007: Power Quality, Implications at the point of connection

Lessons learned from the past

Lessions learned from the past

Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
h	Relative voltage	h	Relative voltage	h	Relative voltage
5	6	3	5	2	2
7	5	9	1,5	4	1
11	3,5	15	0,5	6…24	0,5
13	3	21	0,5		
17	2				
19	1,5				
23	1,5				
25	1,5				

Regulation of harmonics

Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
h	Relative voltage	h	Relative voltage	h	Relative voltage
5	6	3	5	2	2
7	5	9	1,5	4	1
11	3,5	15	0,5	6…24	0,5
13	3	21	0,5		
17	2				
19	1,5				
23	1,5				
25	1,5				

1
0,75

No theoretical reason for low values

All frequencies should be updated

THD perhaps divided in THD_L and THD_H

Higher frequencies -> Lower limits

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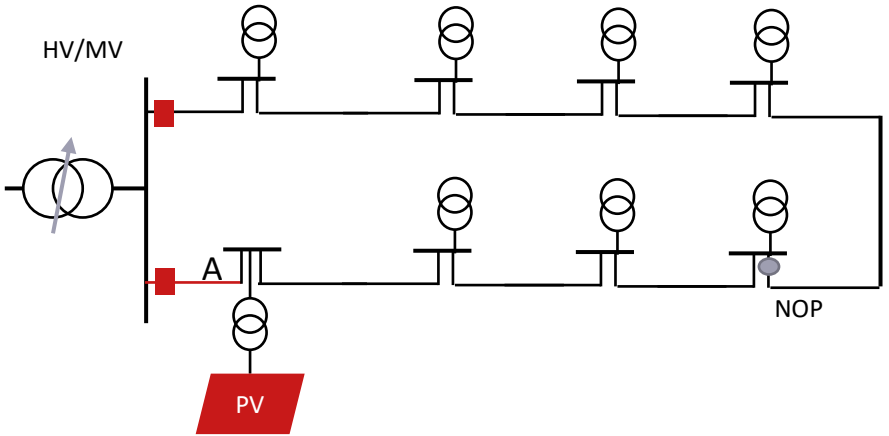
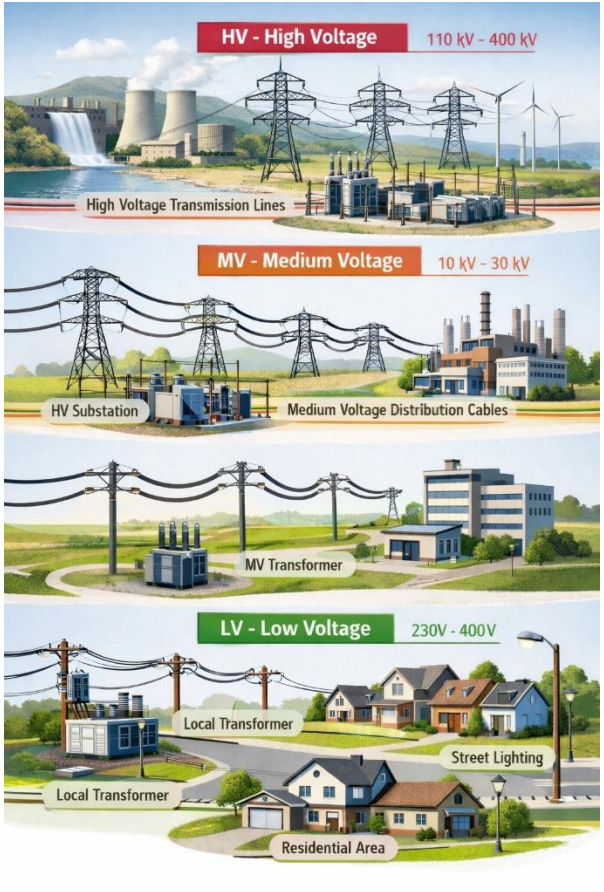
Not always using N-1



PV close to substation (no voltage problem)
Disconnect when cable A is out of order!

Change in grid code!

Lessions learned from the past: The electricity system!

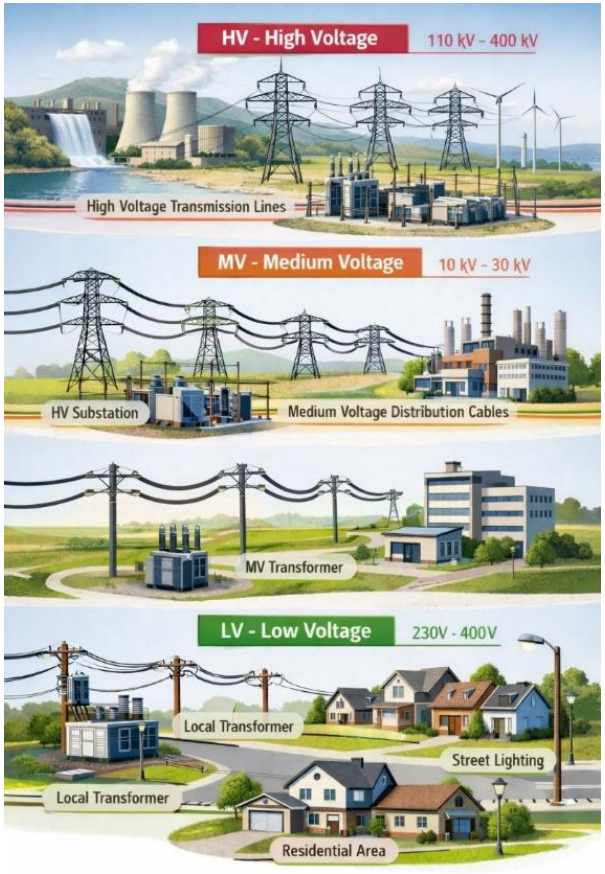


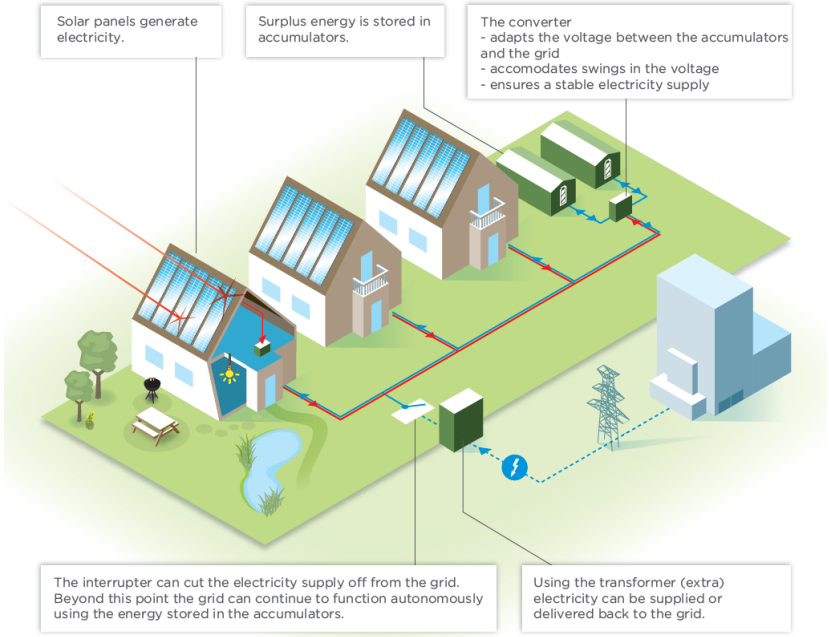
Propagation?

What is happening at the HV-level doesn't stay at the HV-level!

Many distorbers at the LV-level will influence the quality at LV-level the most!

The smart (grid) system includes also the customer





Grid operator: What will be connected to my network
Customer: To what quality network will I be connected?

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What is important at the moment

Unexpected problems

We should do this more

Unawareness

Sjef

Changes: generation of energy

The biggest problem for the DSO at the moment

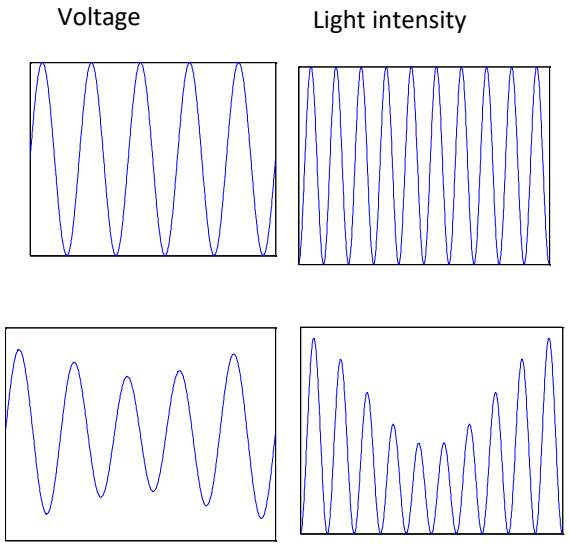
17-05-2022

Zonnepanelen vallen bij 75.000 eigenaren uit tijdens volle zon

3 min. leestijd Delen

Problem with flicker on wide scale

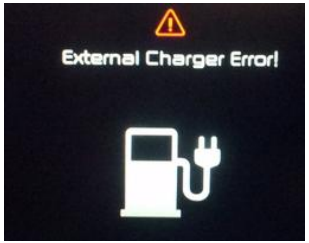
- Voltage variation in the network with frquency around 3,5 Hz, resulting in flicker problem



- More control units in the network
- Less Short Circuit Power

Problems with supraharmonics

- False positive or false negative operation of protection devices
- Interference with power line communication (PLC)
- Failing of cable terminations and connections (in MV/HV)
- Appliance specific problems:
  - Coffee machines, printers, dimmers, touch sensitive controls, internal clocks (77.5 kHz), measuring devices, induction cooking plates, EV chargers



(Tim Slangen)

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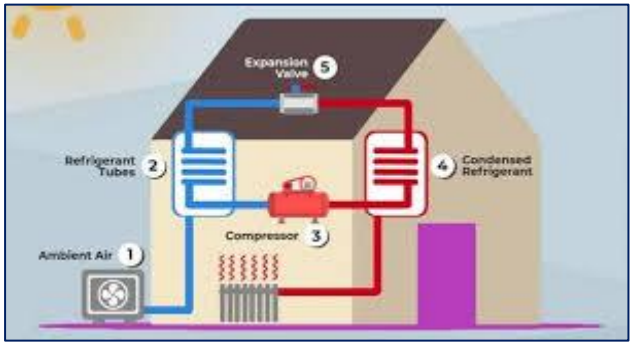
Changes: more and different types of connections



- More flexible loads
- More storage devices
- More power electronics
- Electric boilers
- Heat pumps, PV and EV
- More disturbing loads
- More sensitive loads

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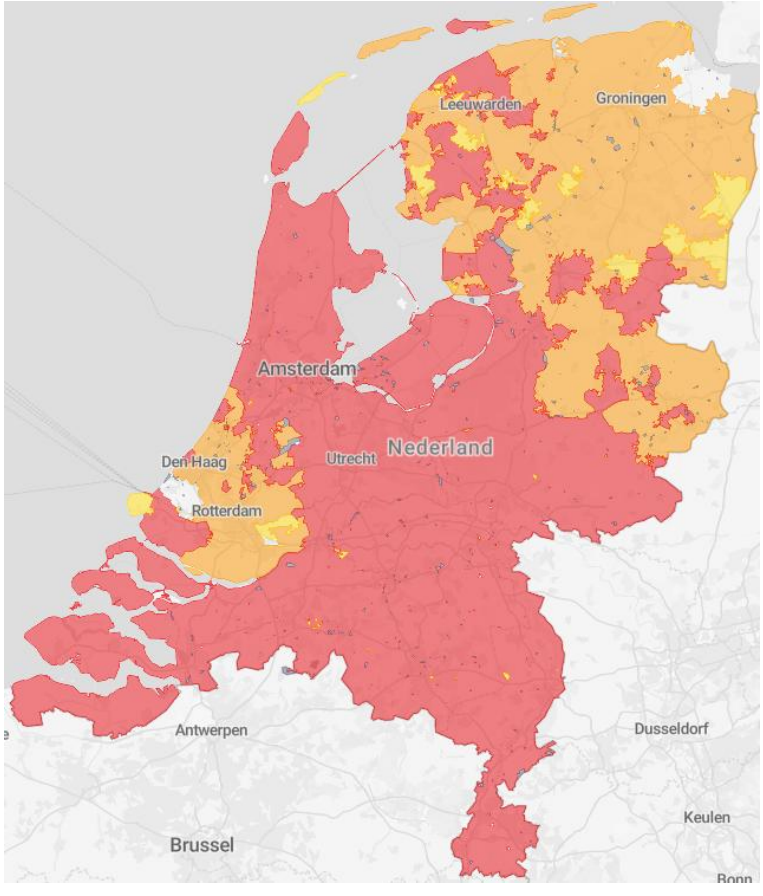
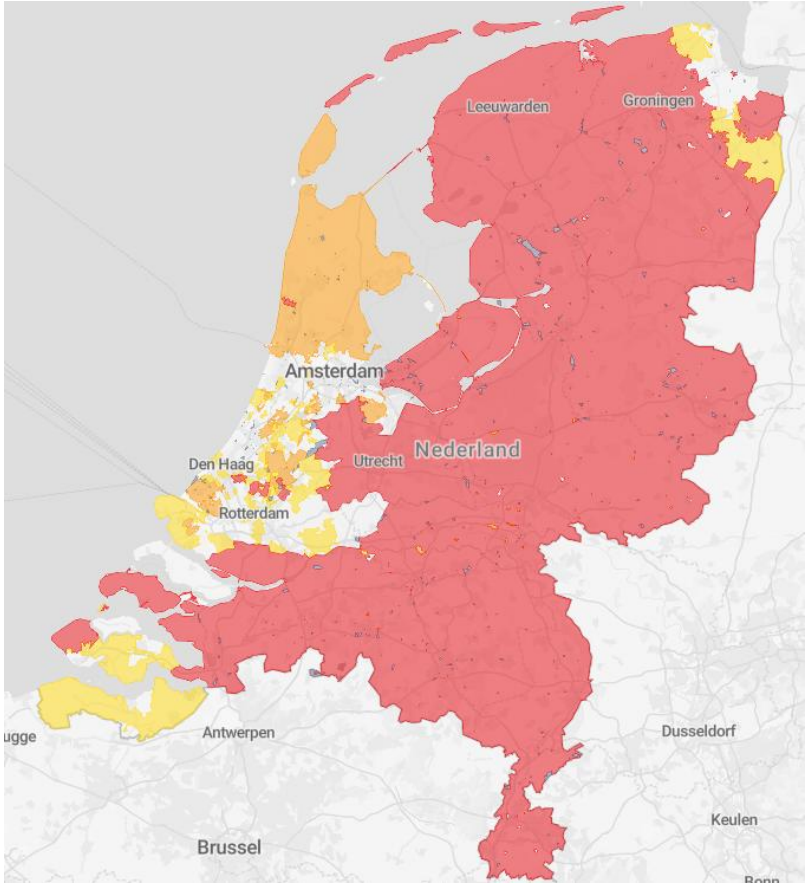
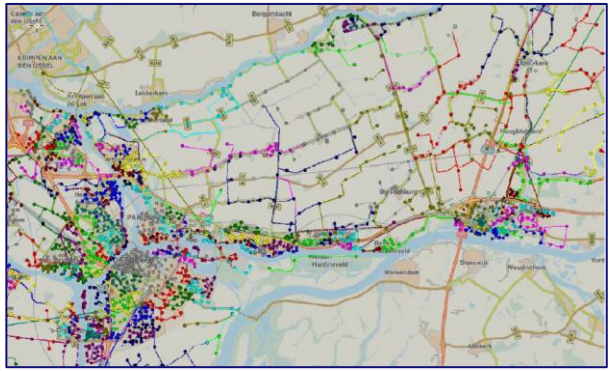
Load

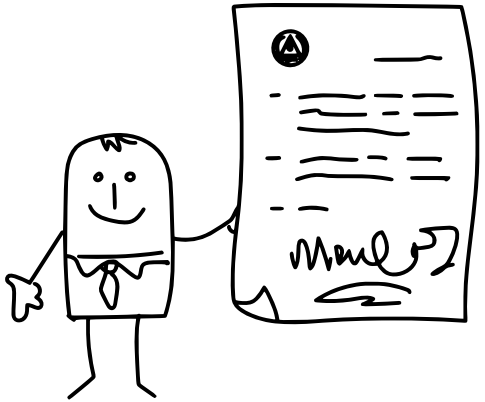


Production



Changes: increased usage of cables/transformers/lines/flexibility….





Flexibility in contracts

More flexibility in regulation

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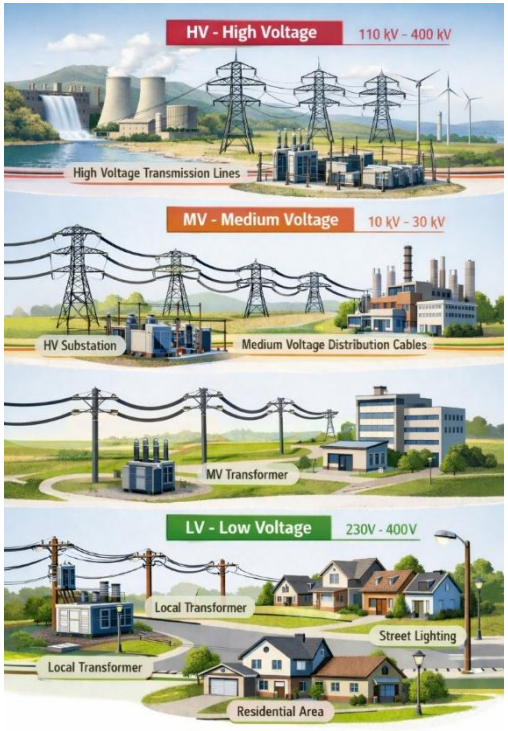
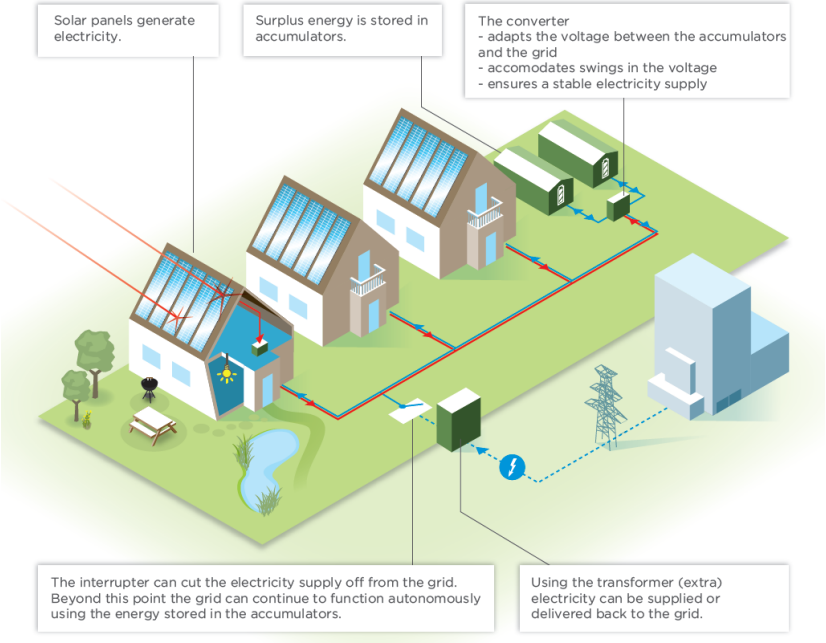
Not 1 solution but a set of different ones





Extending network

Adapting production

Adapting load

Regulation

Normalization

Storage

Prices

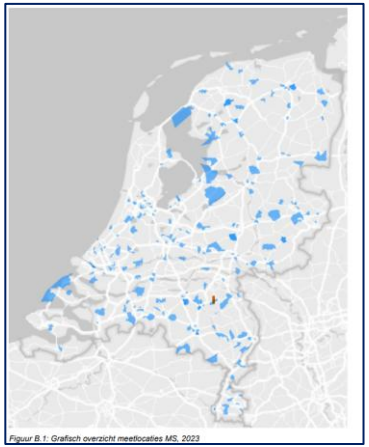
Voltage control

…….

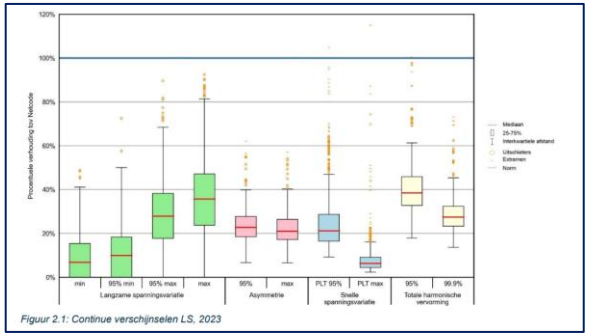
Measurements

- Voltage quality is measured at each voltage level since 90s
- in 2014, 2015 increase in measurements
- network operators publish an annual report

- Changes in campaign: More fixed placed instruments at MV- and LV-level



Figuur B.1: Grafisch overzicht meetlocaties MS, 2023



Figuur 2.1: Continue verschijnselen LS, 2023

Spanningskwaliteit in Nederland

Resultaten 2023

Versie: 2.0
Kenmerk: HY-2024-02
Datum: 17 april 2024

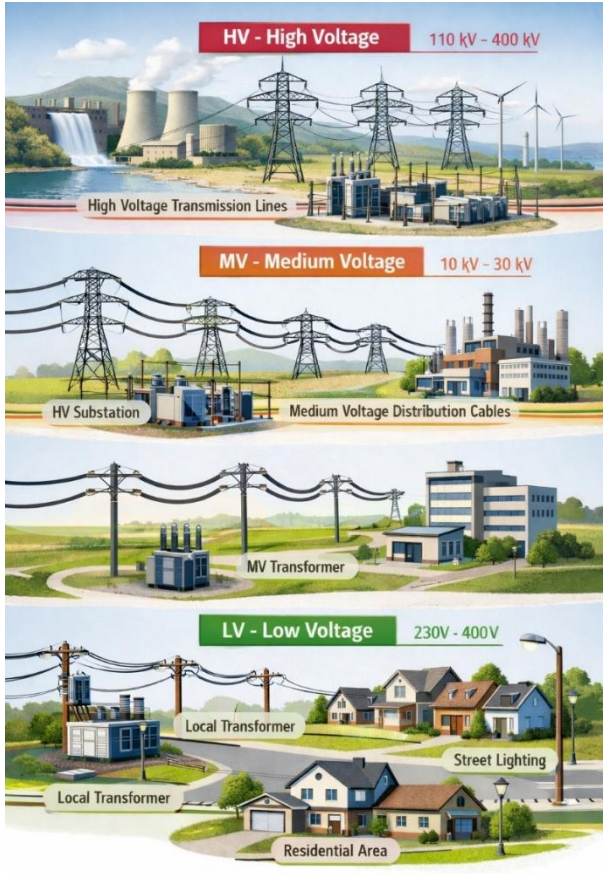
Netbeheer Nederland, vereniging van energienetbeheerders in Nederland

De vereniging Netbeheer Nederland is de belangenbehartiger van de landelijke en regionale elektriciteit- en gasnetbeheerders. Netbeheer Nederland is het aanspreekpunt voor netbeheerders aangelegenheden. De netbeheerders hebben twee hoofdtaken: zij faciliteren het functioneren van de markt en zij beheren de fysieke net-infrastructuur. Lid van deze vereniging zijn de wettelijk aangewezen landelijke en regionale netbeheerders voor elektriciteit en gas. Netbeheer Nederland organiseert het overleg met marktpartijen over aanpassingen van de marktfacilitering. Netbeheer Nederland doet namens de gezamenlijke netbeheerders voorstellen voor aanpassingen van de wettelijk verankerde codes voor onder meer de structuur van de nettarieven. Netbeheer Nederland stelt ook de algemene voorwaarden op voor aansluiting en transport.

Netbeheer Nederland

HyTEPS

Data management: Make optimal use of exsisting data!



Which phenomenon do you expect to become the biggest challenge in the next 10 years?

Harmonics/Distortion

Proliferation of 5G & IoT Devices

Cybersecurity Threats

Renewable Energy & EV Impact

Grid Resiliency

Grid Resiliency

Monitoring

Voltage Sag & Swell

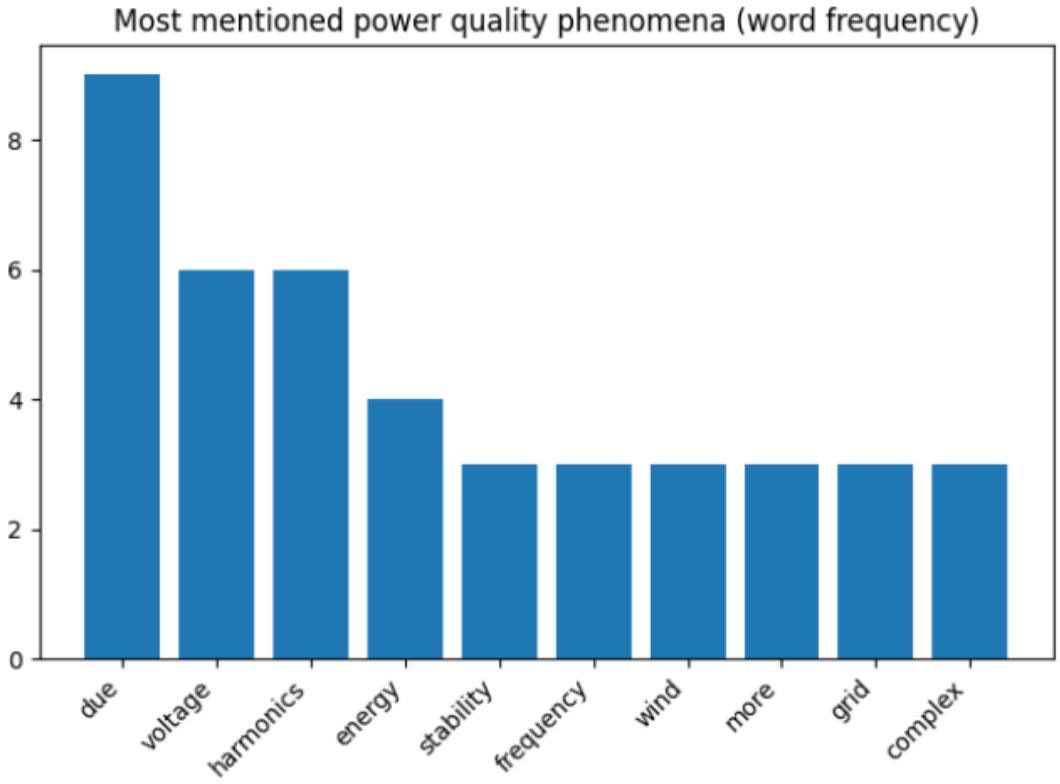
Which phenomenon do you expect to become the biggest challenge in the next 10 years?

Chat gpt

(I did not refer clearly to the exel table)

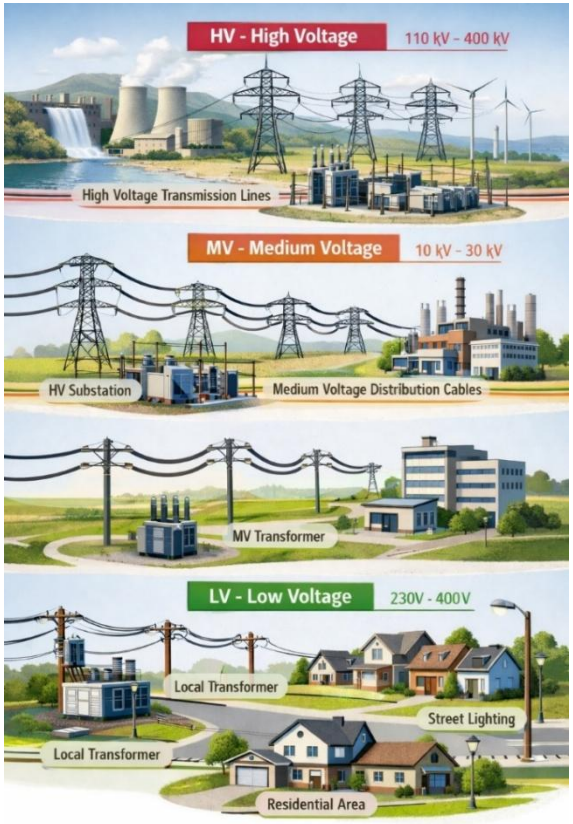
Which PQ phenomenon do you expect to become the biggest challenge in the next 10 years?

Chat gpt

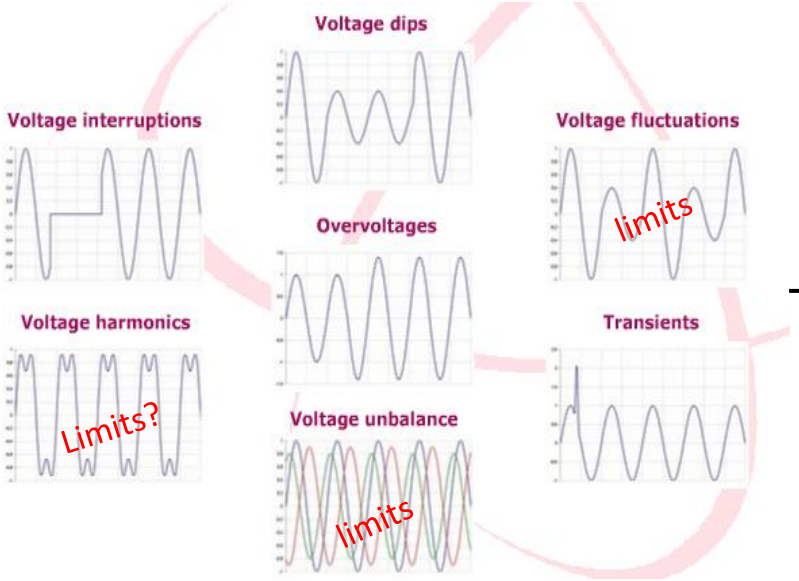


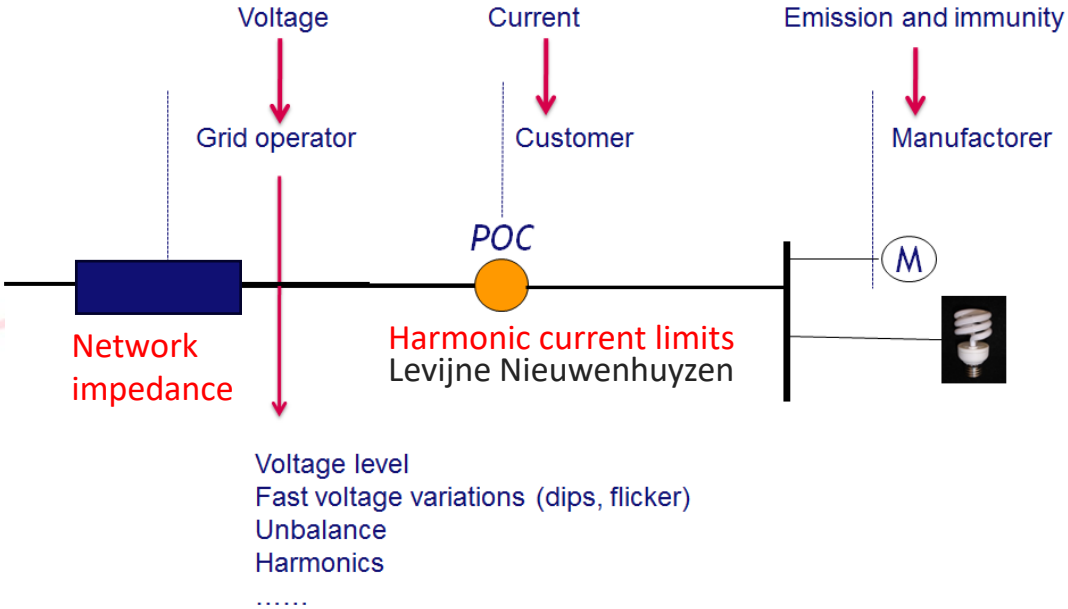
Be careful with AI
Keep using your own brain!

Future developments
More data, look for strategic placement of PQ-meters!



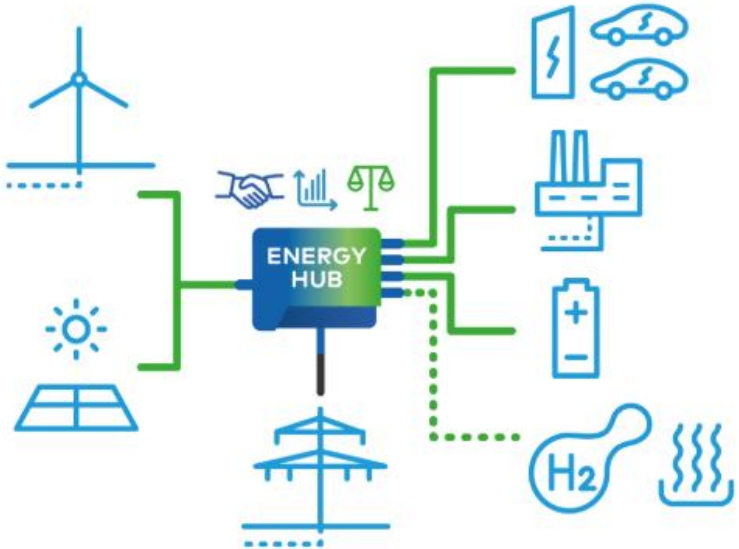
Power Quality: Phenomena and Responsibilities

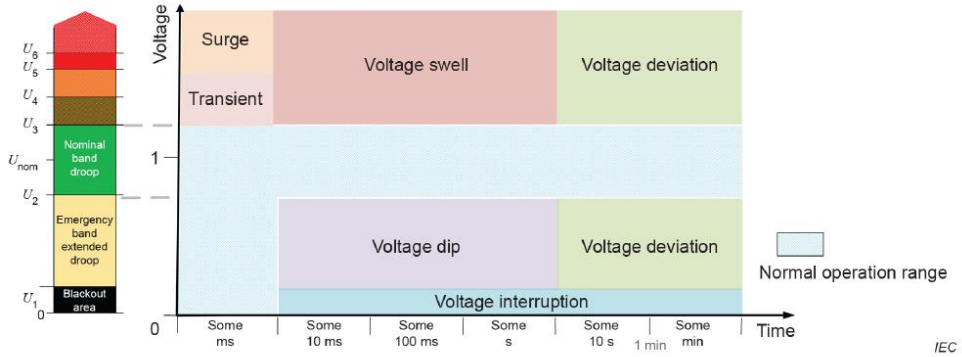




Supraharmonic limits

The energy hub





Leonardo mendes sousa xavier

Grid compliance
DC - Power Quality
Optimalization

Metrology (grid forming converters)

Luiz Felipe A. Silveira

PQ-smart grid lab (LV and MV)

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Education

Course Power Quality Phenomena

- Lectures + instructions
- Practical assignment

The quality you give is the quality you get!

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