Federatie van technologiebranches

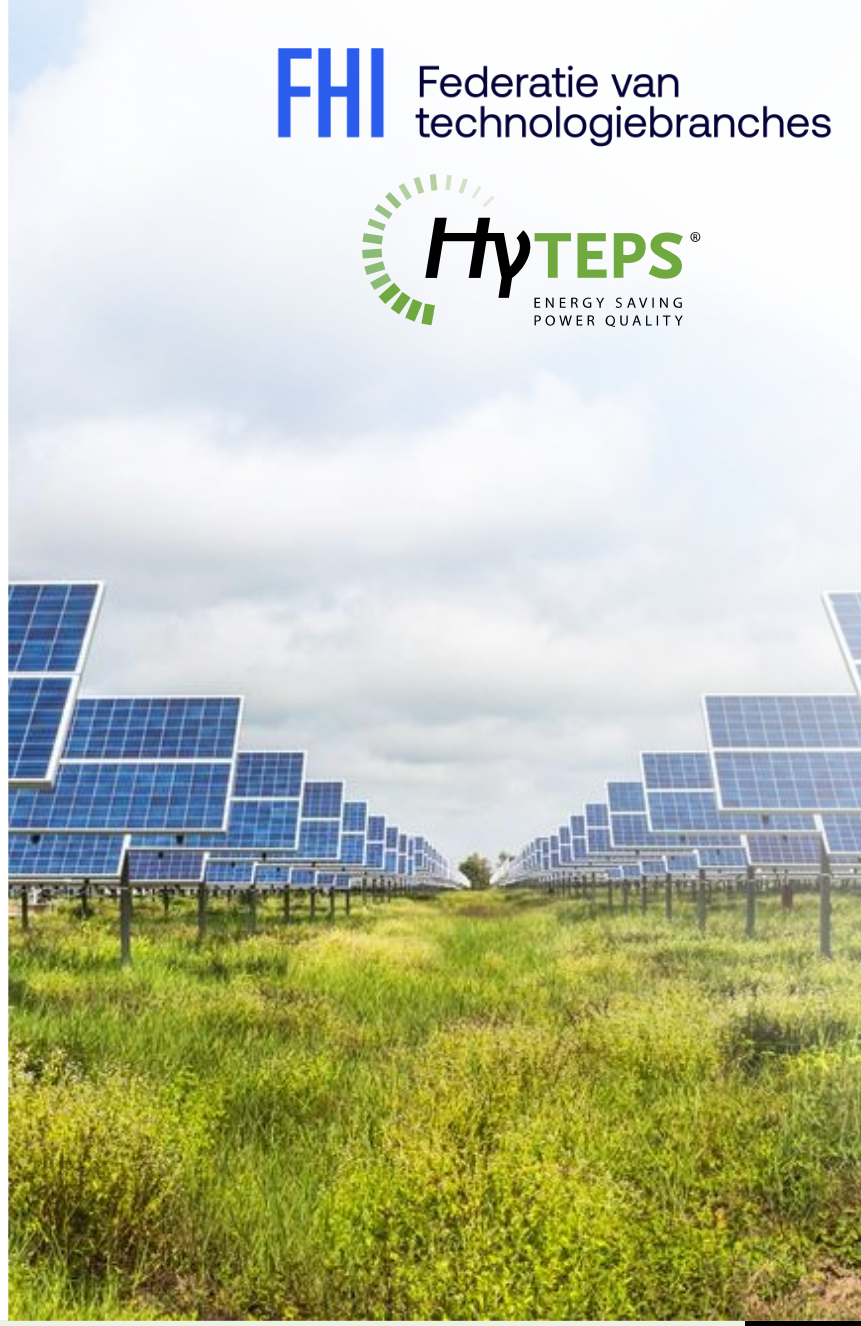
HyTEPS®
ENERGY SAVING
POWER QUALITY

Digital Twins for Power Electronics-Driven Industrial Grids

Managing harmonics, stability and grid compliance in modern installations

28-5-2026

Index



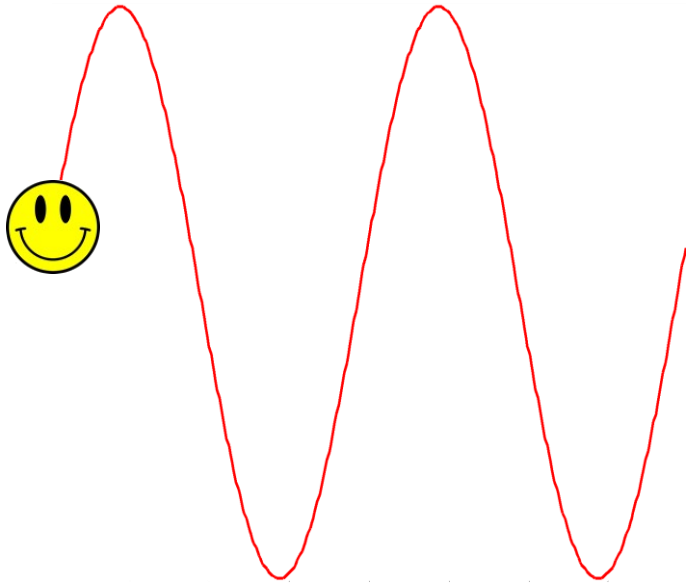
The changing industrial power system

From rotating momentum to a converter-based dominated system

Why this matters

Power quality is no longer a fixed property of the system

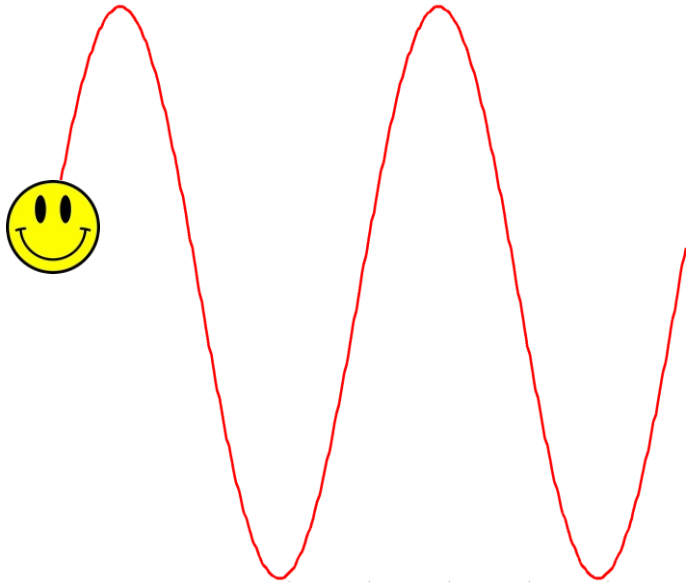
- Harmonic distortion

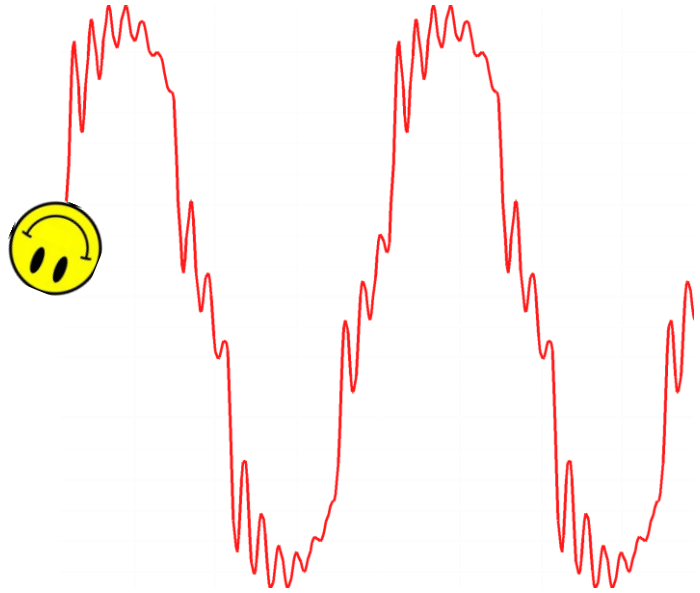


Why this matters

Power quality is no longer a fixed property of the system

- Harmonic distortion





Why this matters

Power quality is no longer a fixed property of the system

- Harmonic distortion
- Resonance phenomena

Source: https://www.youtube.com/watch?v=4jk9H5AB4lM

Why this matters

Power quality is no longer a fixed property of the system

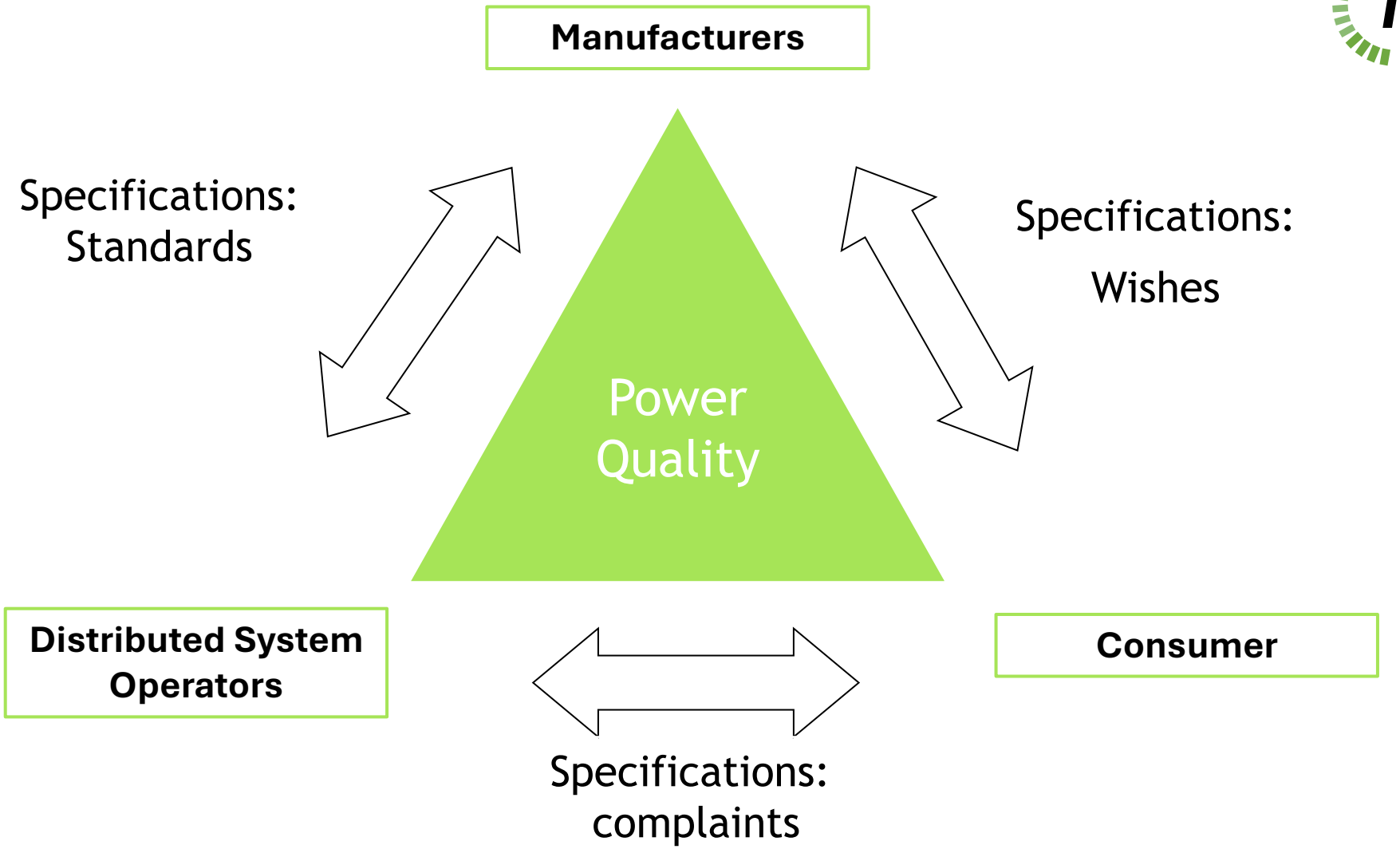
- **Harmonic distortion**
- **Resonance phenomena**
- **Small-signal instability**, arising from interaction between converter control loops
- **Phase-Locked Loop (PLL) interactions**, where weak or distorted grid voltage leads to inaccurate phase tracking and potential control oscillations
- **Weak grid operation**, where high grid impedance reduces system damping and increases sensitivity to disturbances
- **Low Short Circuit Ratio (SCR) conditions**, due to limited fault currents from inverter-based resources power system protection will not trip
- **Nuisance tripping**, caused by protection systems responding to harmonics, transients, or control-induced oscillations rather than actual faults

Why this matters

Power quality is no longer a fixed property of the system

- **Harmonic distortion**
- **Resonance phenomena**
- **Small-signal instability**, arising from interaction between converter control loops
- **Phase-Locked Loop (PLL) interactions**, where weak or distorted grid voltage leads to inaccurate phase tracking and potential control oscillations
- **Weak grid operation**, where high grid impedance reduces system damping and increases sensitivity to disturbances
- **Low Short Circuit Ratio (SCR) conditions**, due to limited fault currents from inverter-based resources power system protection will not trip
- **Nuisance tripping**, caused by protection systems responding to harmonics, transients, or control-induced oscillations rather than actual faults

Responsibilities



Traditional Measurements

Advantages

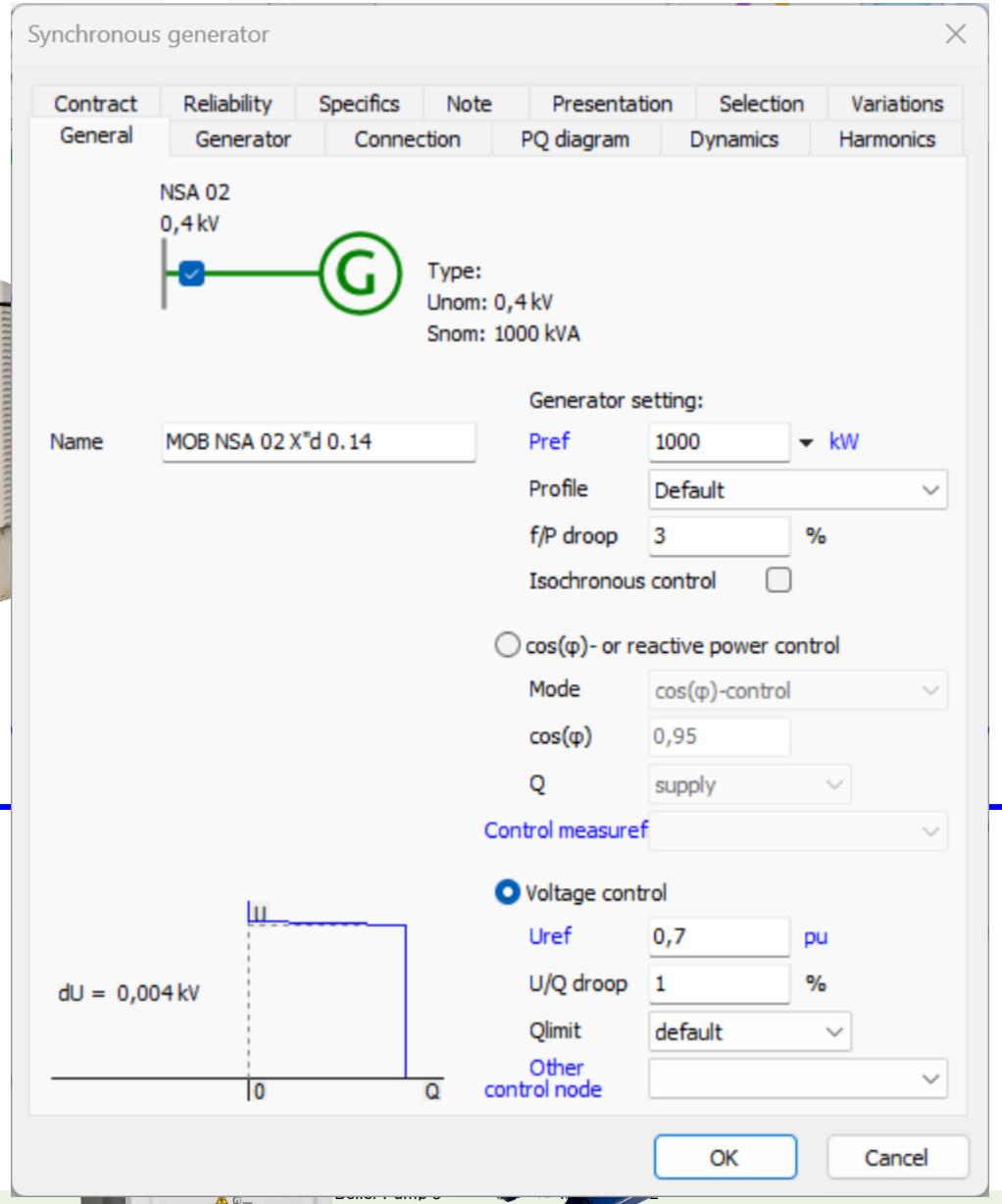
+ Real-world behavior
+ Validation of existing issues
+ Compliance verification
+ Event recording

Limitations

– Snapshot in time
– Limited scenario coverage
– Difficult to identify root cause interactions
– No predictive capability

Digital Twin

Power Sytem Modelling

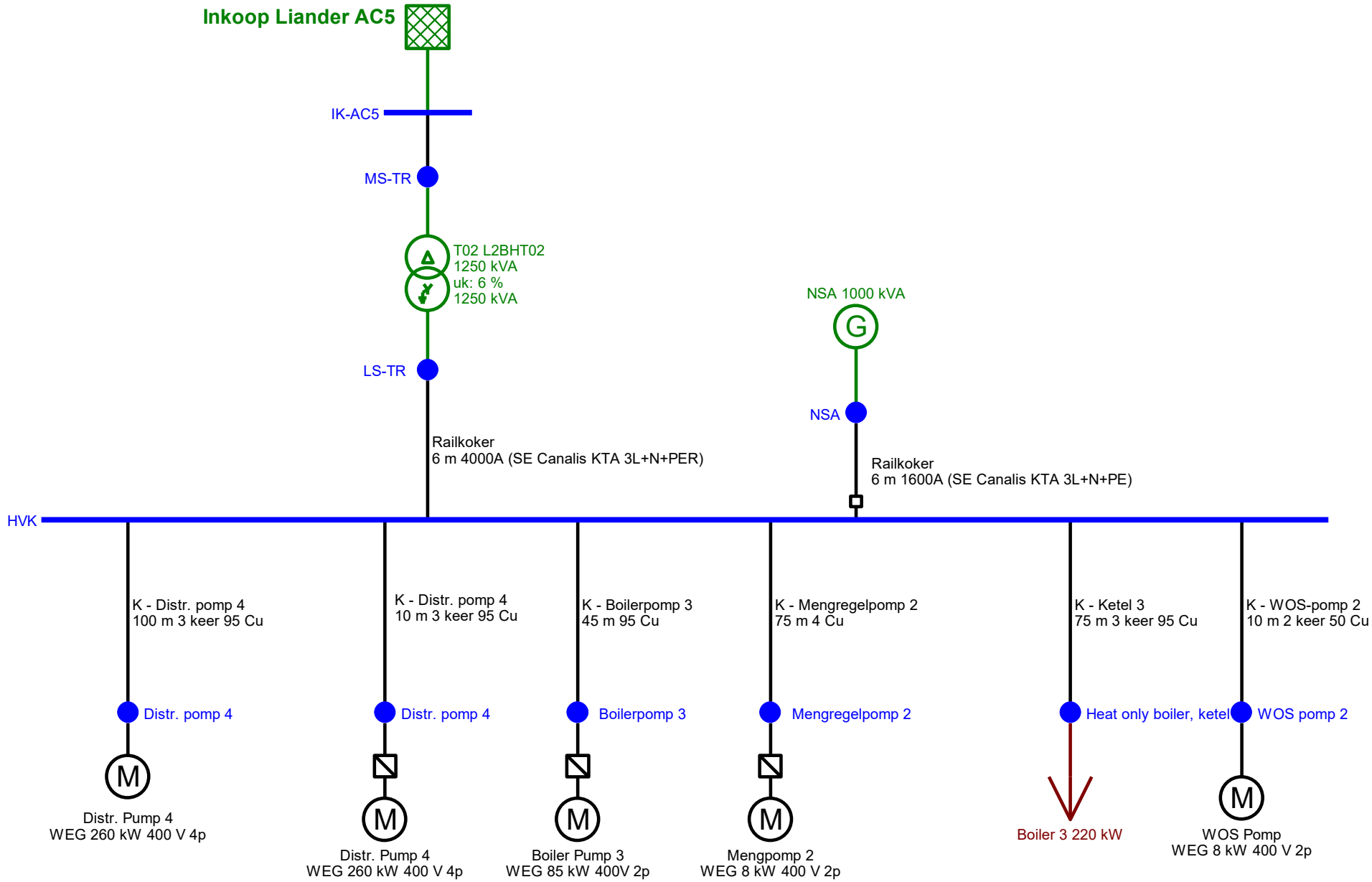


- Power flow
- Short circuit
- Protection Coordination
- Arc Flash Analysis
- Harmonic Analysis
- Resonance
- EMT
  Dynamic Analysis
- Compliance studies

Simulations for Industry

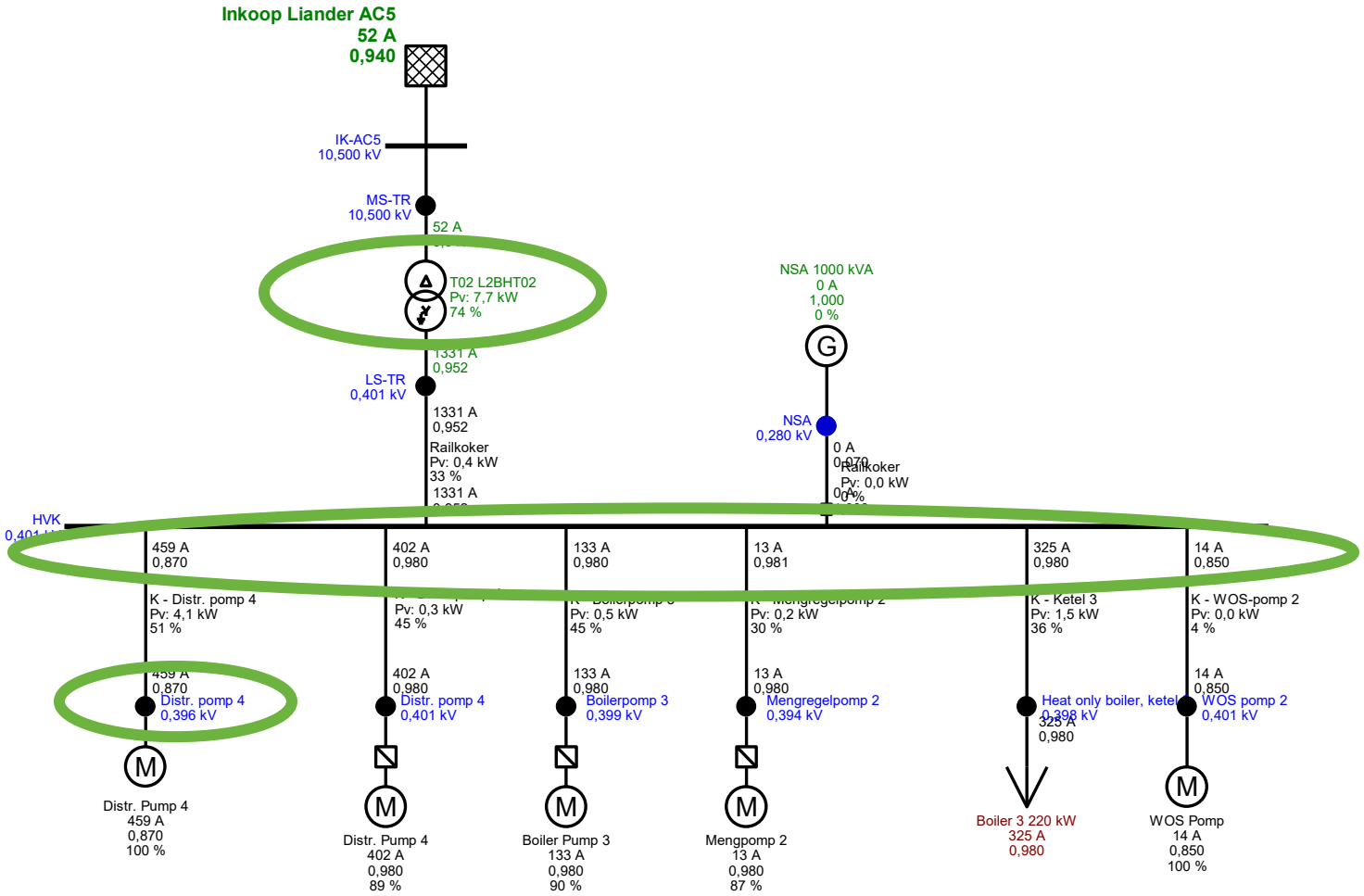
A small selection of the many possibilities

- Power flow
- Short circuit
- Protection Coordination
- Arc Flash Analysis
- Harmonic Analysis
- Resonance
- EMT
  Dynamic Analysis
- Compliance studies



Power flow

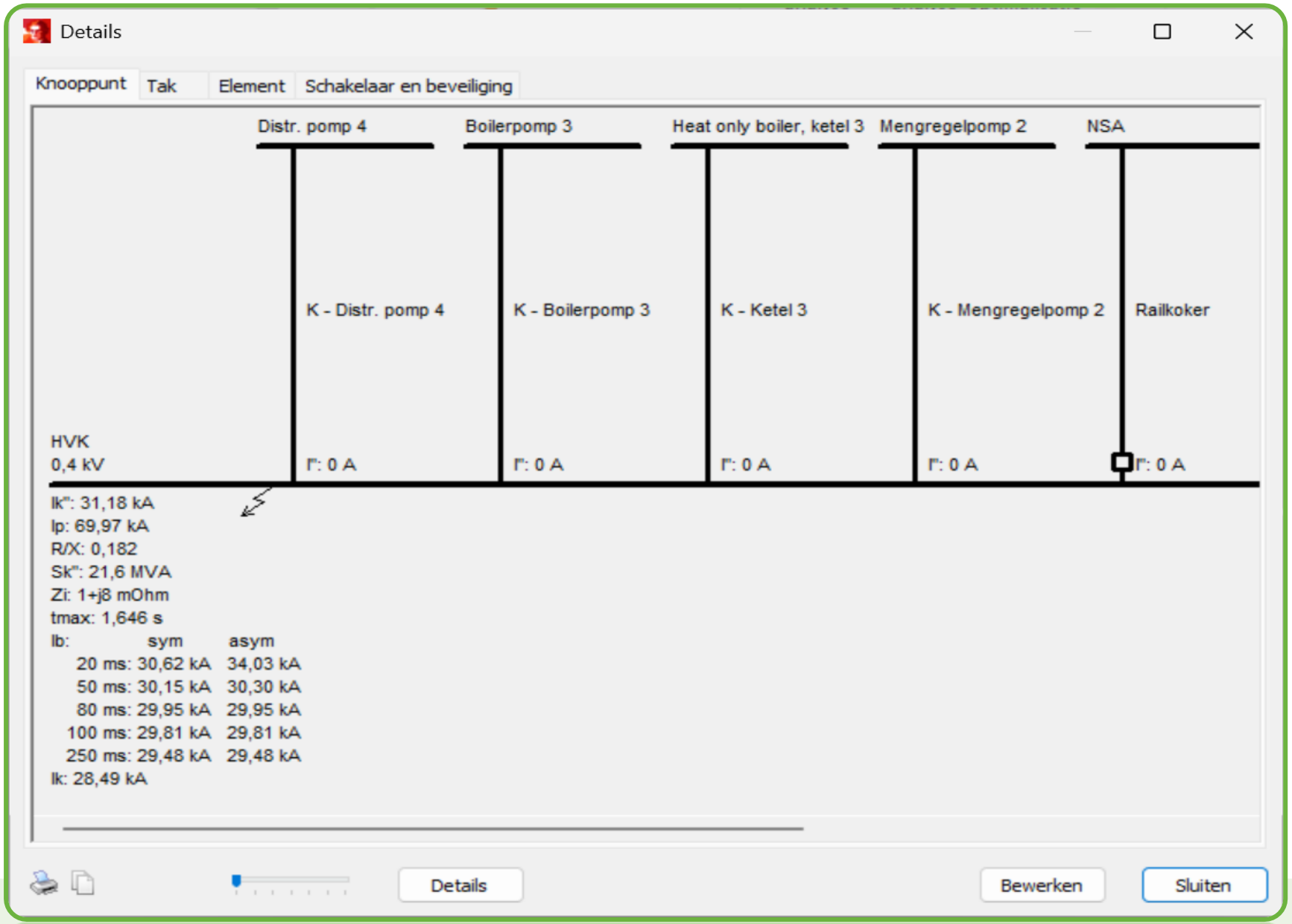
Insight into power flows, voltage stability and system efficiency



The power flow analysis shows how voltage and current are distributed throughout the network and helps identify overloads, voltage drops and system losses at an early stage.

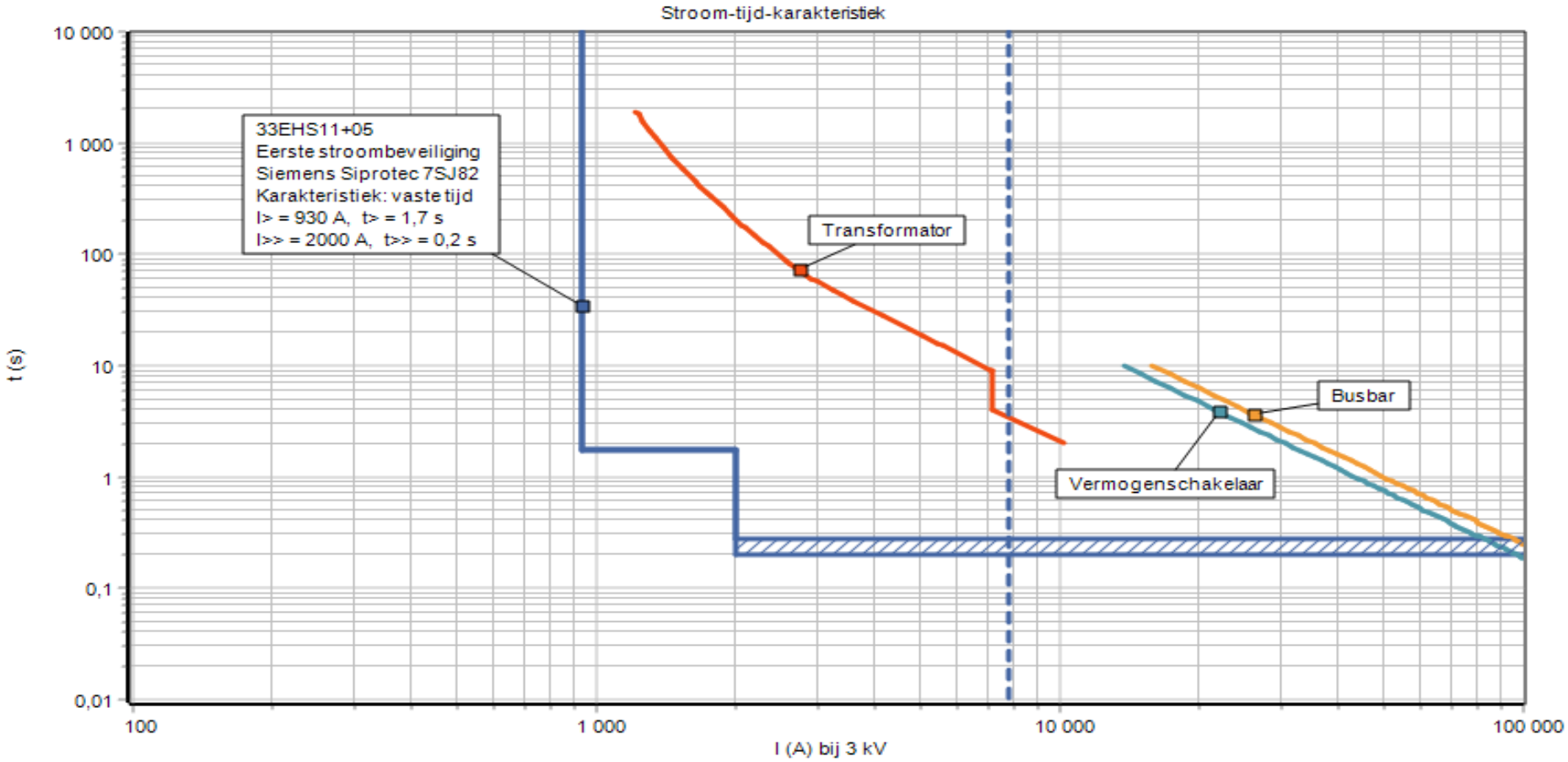
- Power flow
- Short circuit
- Protection Coordination
- Arc Flash Analysis
- Harmonic Analysis
- Resonance
- EMT
  Dynamic Analysis
- Compliance studies

Short Circuit



Protection Coordination

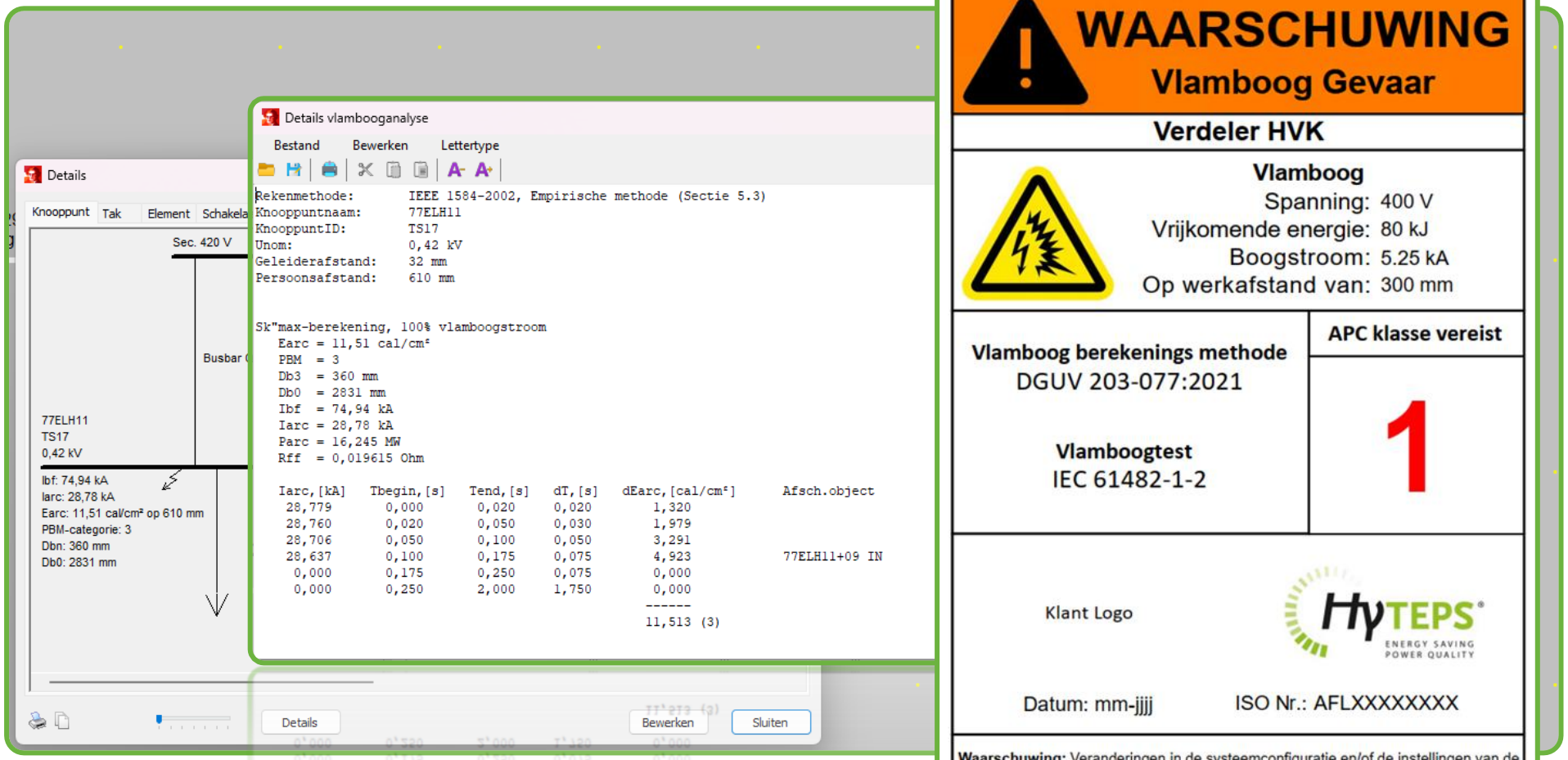
Ensuring continuity



A protection coordination study ensures that only the faulty section is disconnected, allowing production and critical processes to remain operational.

Arc Flash Analysis

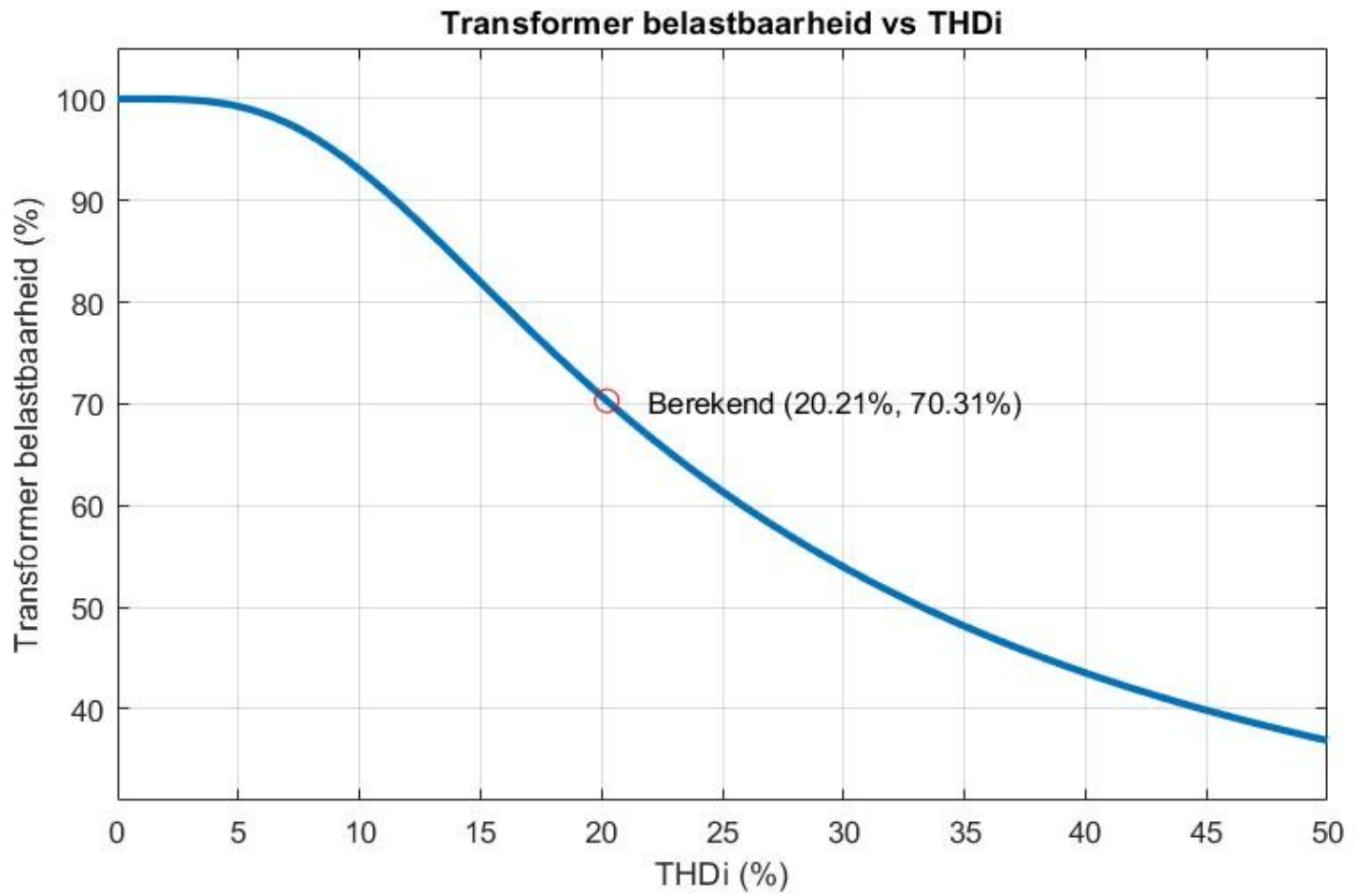
Safety under energized conditions



The arc flash analysis calculates the energy released d
determines the required safety measures.

Harmonic Analysis

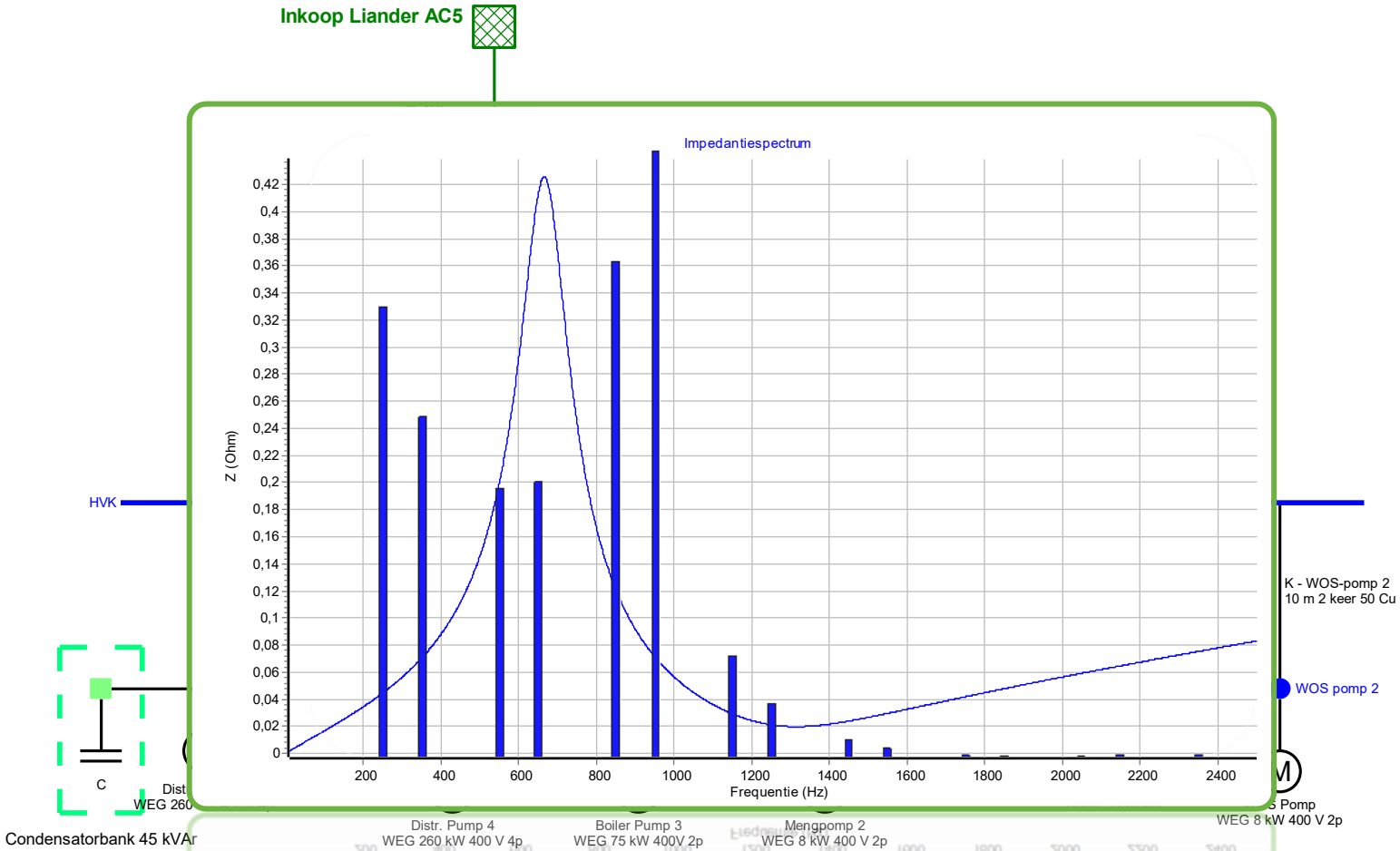
The invisible distortion



Provides insight into harmonic distortion to prevent malfunctions, overheating and accelerated equipment ageing.

Impedance spectrum

The fingerprint of your network

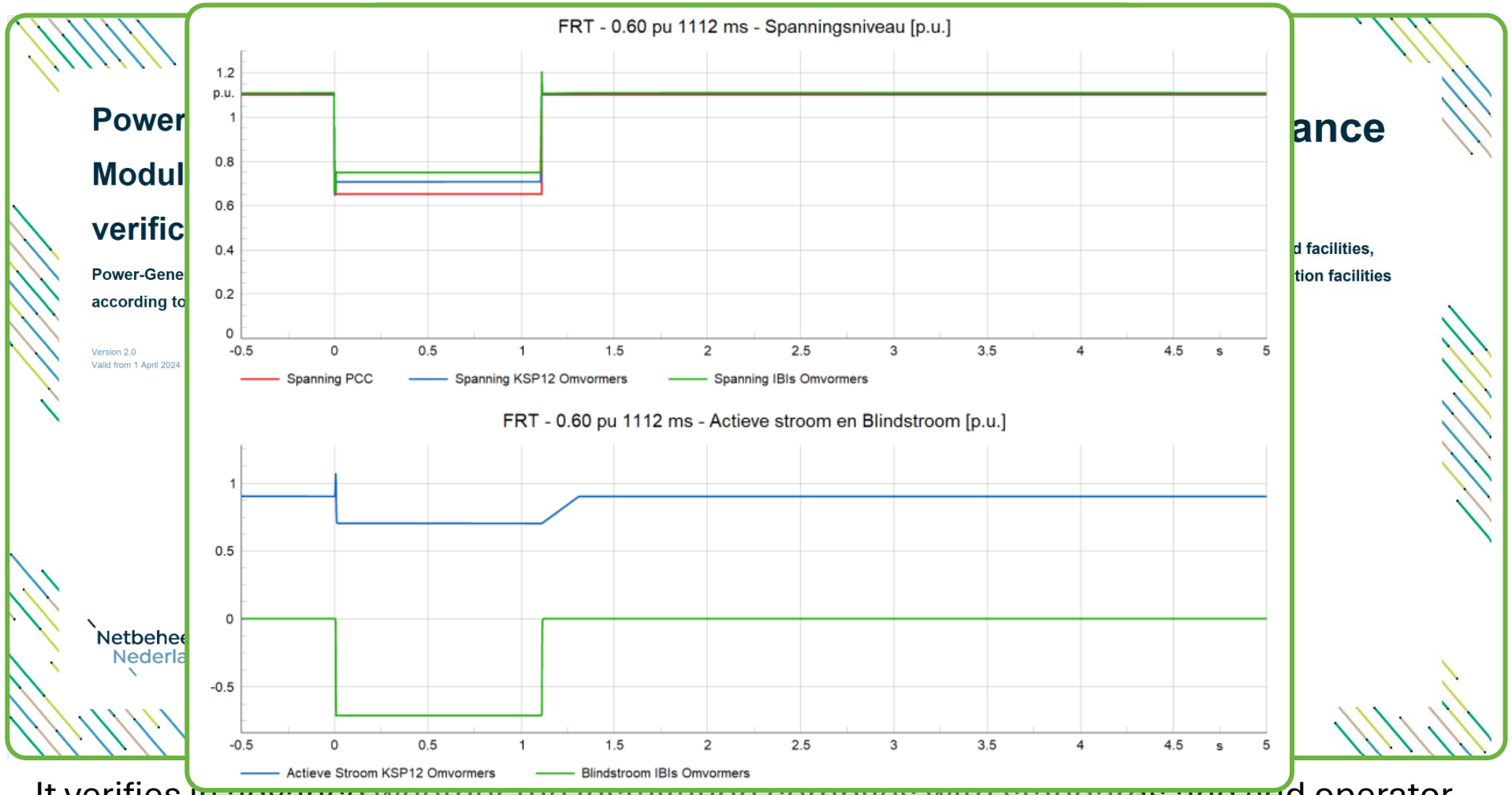


The impedance spectrum identifies resonance phenomena and forms the basis for effective filter design.

- Power flow
- Short circuit
- Protection Coordination
- Arc Flash Analysis
- Harmonic Analysis
- Resonance
- EMT
  Dynamic Analysis
- Compliance studies

Compliance studies

Compliance with standards and grid operator requirements



It verifies in advance whether the installation complies with standards and grid operator requirements, which is essential for reliability and grid connection.

Key Takeaway

To conclude: industrial power systems are changing from static distribution networks into dynamic, interaction-driven systems.

- Power systems are now interaction-driven
- Key risks are frequency-related
- Static design methods are no longer sufficient
- Digital Twin enables predictive engineering

Federatie van technologiebranches

HyTEPS®
ENERGY SAVING
POWER QUALITY

Thank you

Contact details

HyTEPS

Beemdstraat 3

5653 MA, Eindhoven

+31 (0)492 37 12 12

Colin Willemsen

c.willemsen@hyteps.nl