

Digital Twins for Power Electronics-Driven Industrial Grids

Managing harmonics, stability and grid compliance in modern
installations

28-5-2026



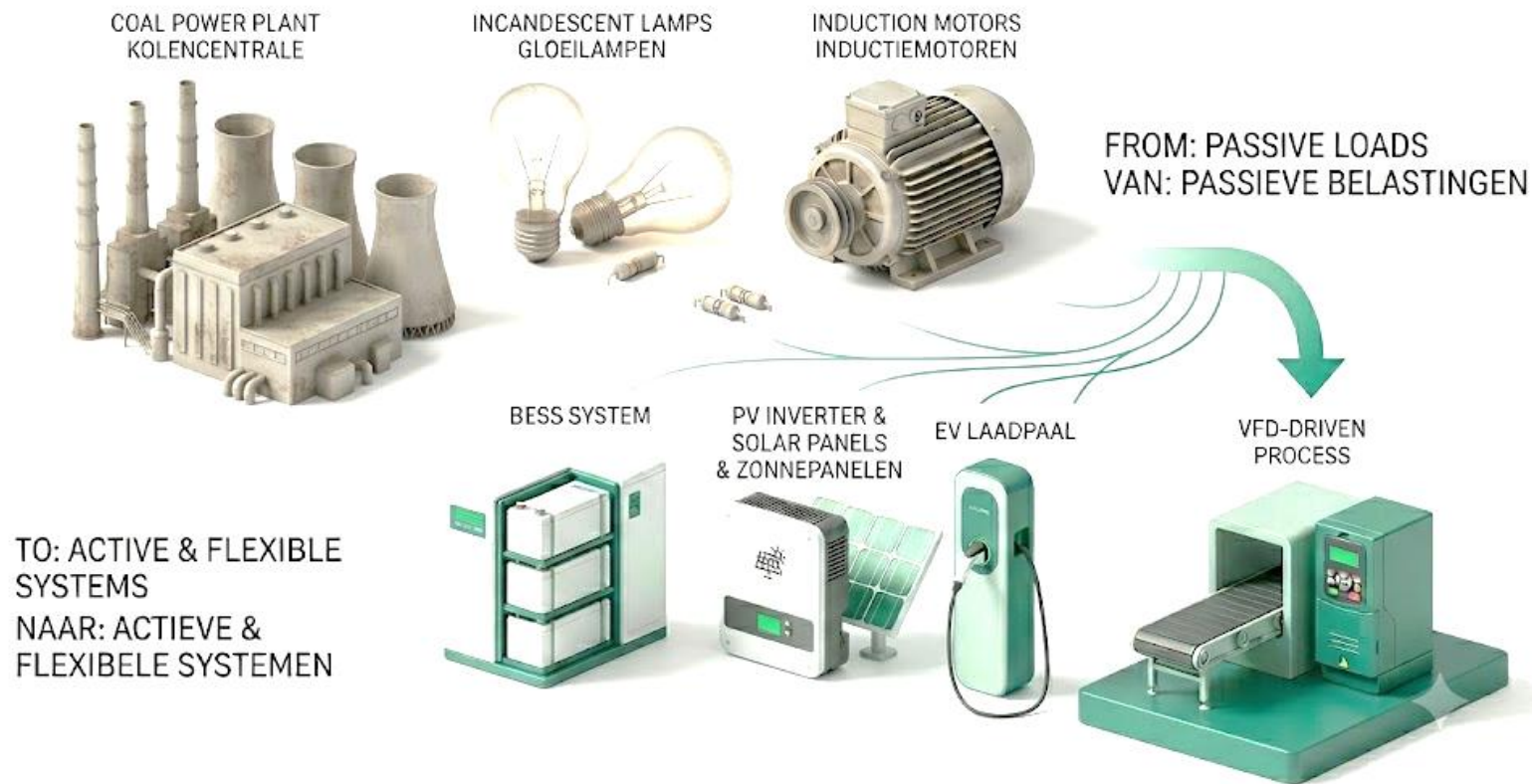
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The changing industrial power system

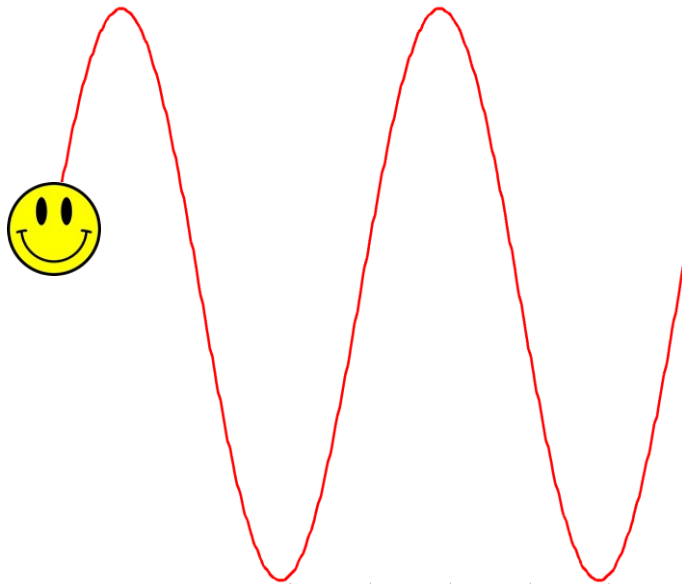
From rotating momentum to a converter-based dominated system



Why this matters

Power quality is no longer a fixed property of the system

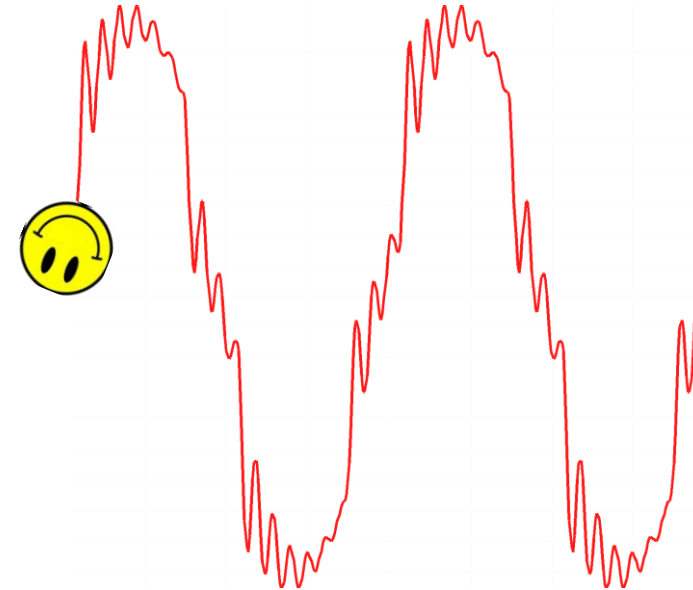
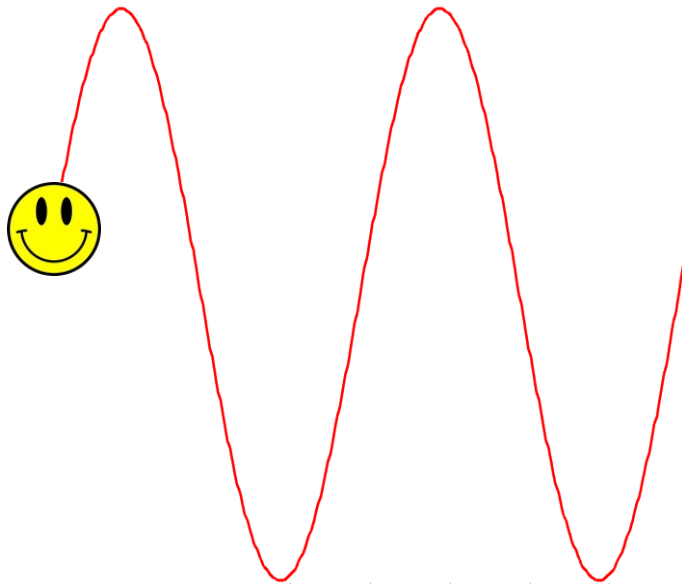
- Harmonic distortion



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

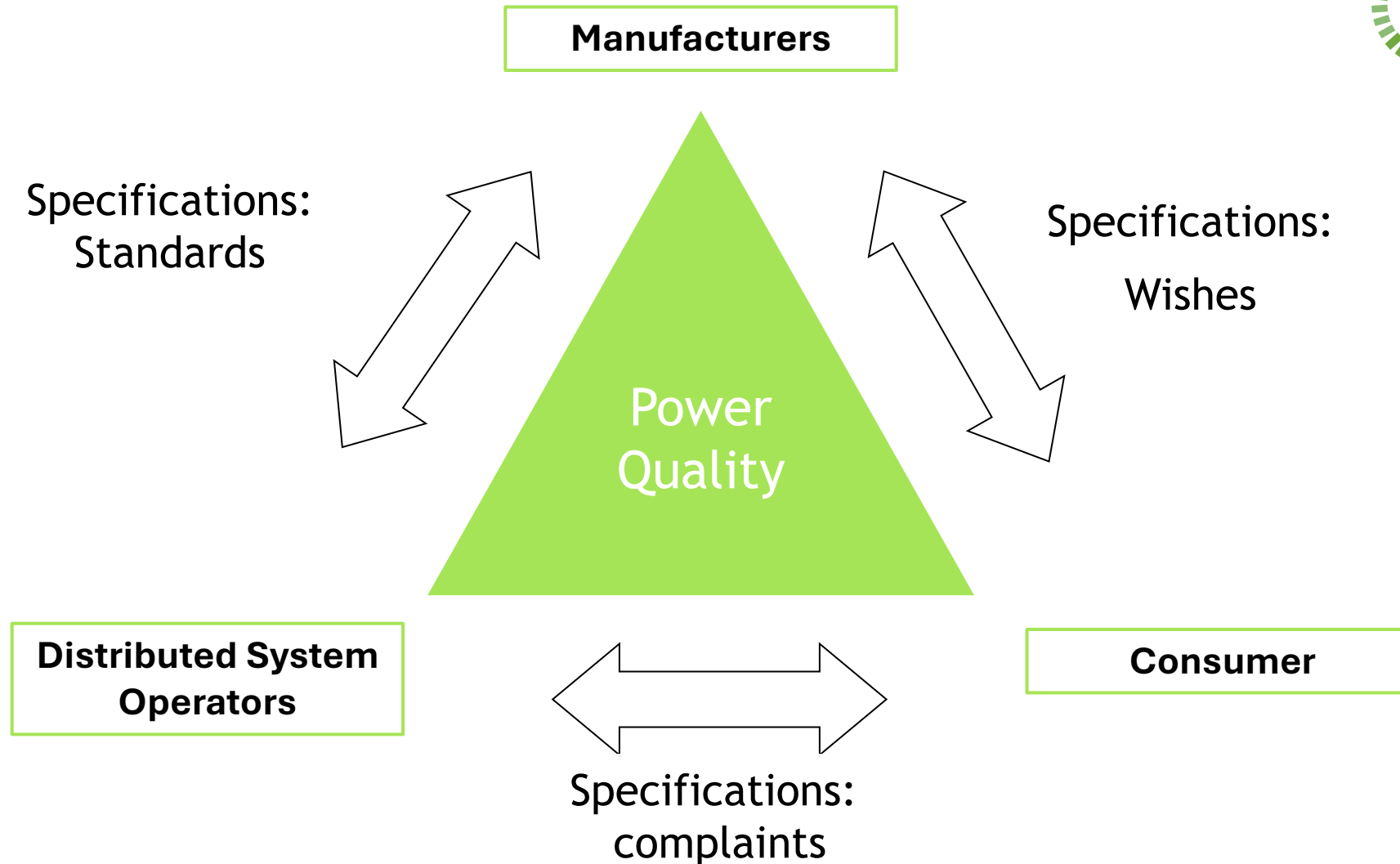
- **Harmonic distortion**
- **Resonance phenomena**
- **Small-signal instability**, arising from interaction between converter control loops
- **Phase-Locked Loop (PLL) interactions**, where weak or distorted grid voltage leads to inaccurate phase tracking and potential control oscillations
- **Weak 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

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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 System Modelling



HV/K

Synchronous generator

Contract	Reliability	Specifics	Note	Presentation	Selection	Variations
General	Generator	Connection	PQ diagram	Dynamics	Harmonics	

NSA 02
0,4 kV

Type:
Unom: 0,4 kV
Snom: 1000 kVA

Name: MOB NSA 02 X"d 0.14

Generator setting:

Pref: 1000 kW

Profile: Default

f/P droop: 3 %

Isochronous control: ☐

☐ cos(φ)- or reactive power control

Mode: cos(φ)-control

cos(φ): 0,95

Q: supply

Control measuref:

☒ Voltage control

Uref: 0,7 pu

U/Q droop: 1 %

Qlimit: default

Other control node:

dU = 0,004 kV

0 Q

OK Cancel



Power flow



Short circuit



Protection Coordination



Arc Flash Analysis



Harmonic Analysis



Resonance



EMT
Dynamic Analysis

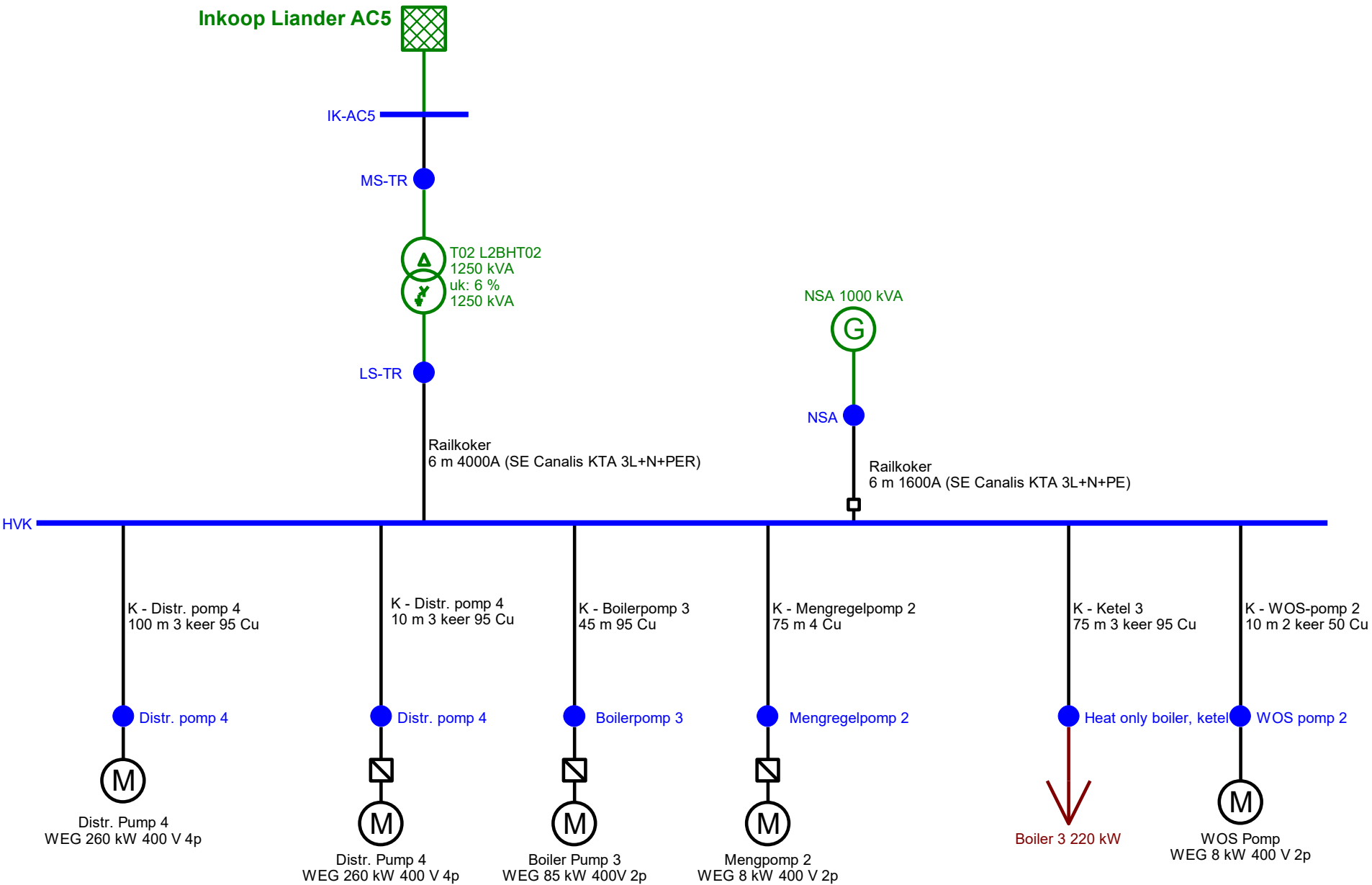


Compliance studies

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

Short circuit

Protection Coordination

Arc Flash Analysis

Harmonic Analysis

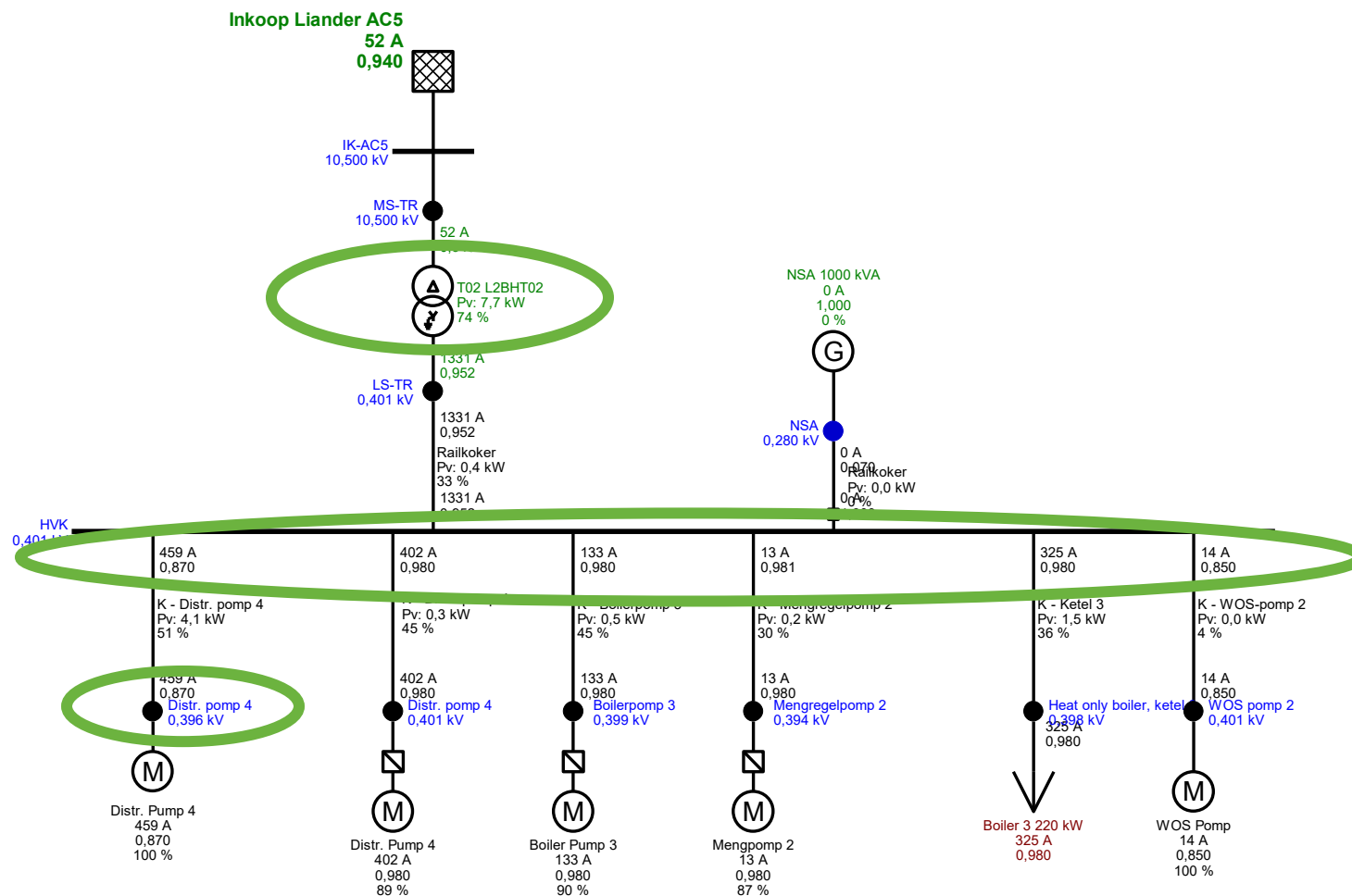
Resonance

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

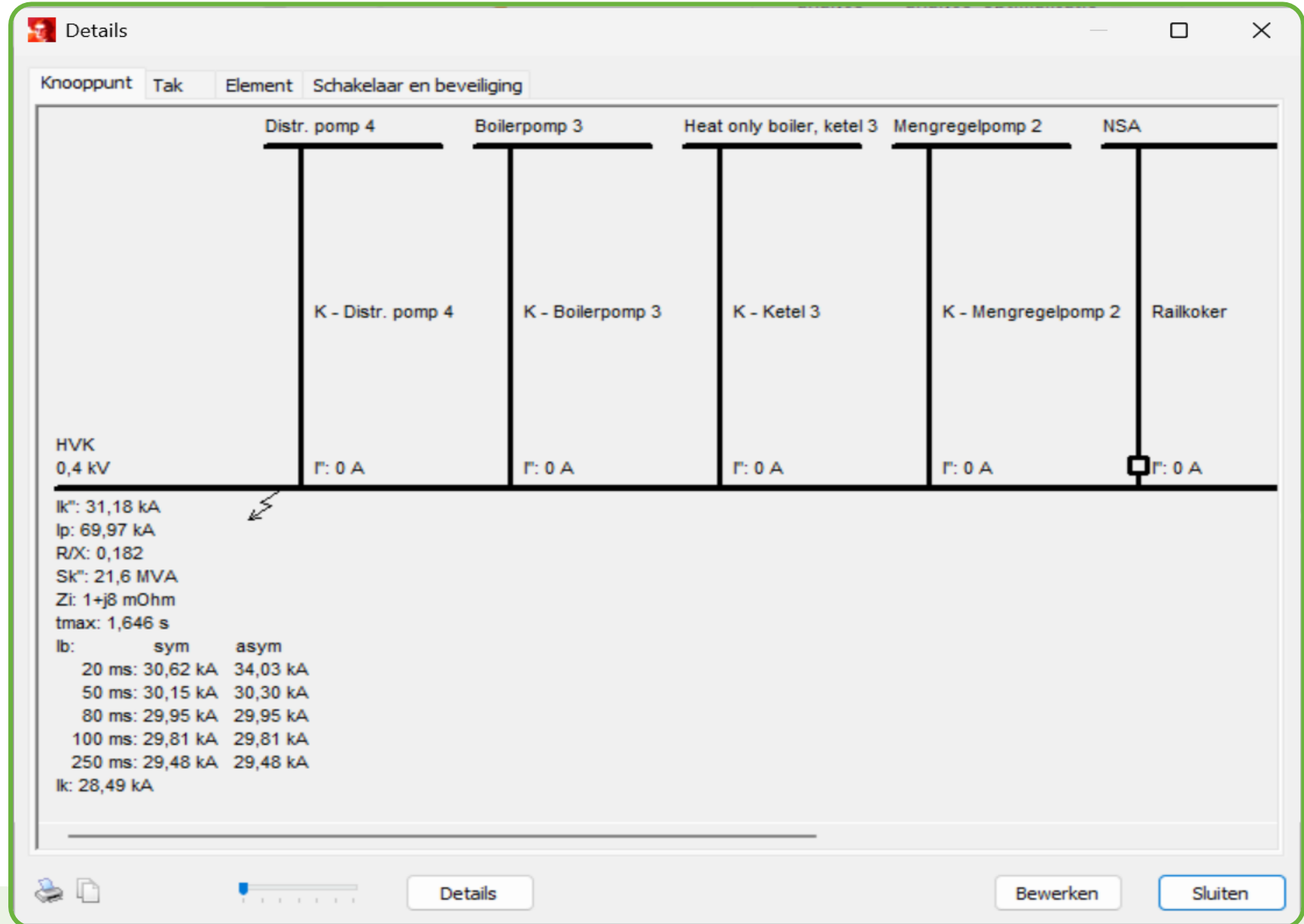
Harmonic Analysis

Resonance

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Compliance studies

Short Circuit



Power flow

Short circuit

Protection Coordination

Arc Flash Analysis

Harmonic Analysis

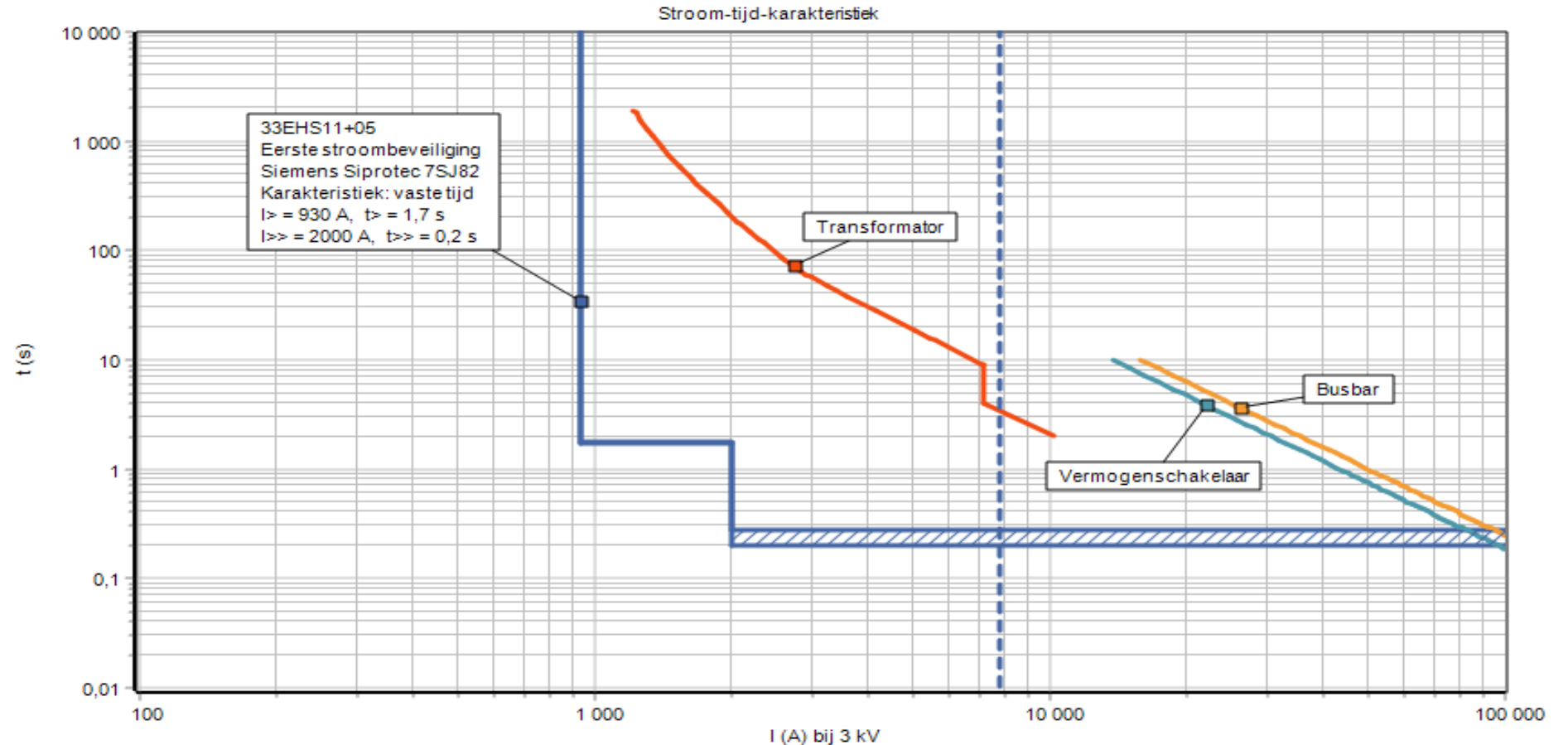
Resonance

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Compliance studies

Protection Coordination

Ensuring continuity



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

Power flow

Short circuit

Protection Coordination

Arc Flash Analysis

Harmonic Analysis

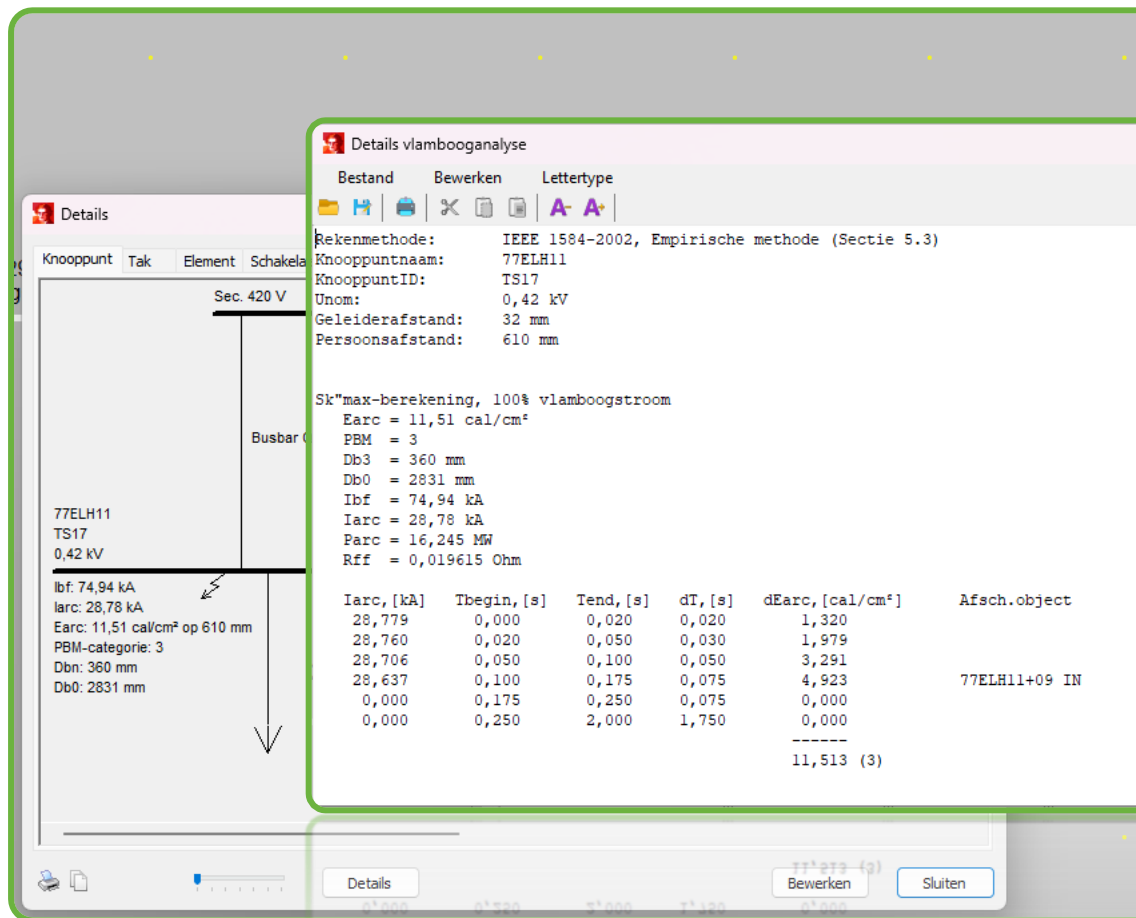
Resonance

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Arc Flash Analysis

Safety under energized conditions



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

**WAARSCHUWING**
Vlamboog Gevaar

Verdeler HVK

**Vlamboog**
Spanning: 400 V
Vrijkomende energie: 80 kJ
Boogstroom: 5.25 kA
Op werkafstand van: 300 mm

Vlamboog berekenings methode
DGUV 203-077:2021

Vlamboogtest
IEC 61482-1-2

APC klasse vereist
1

Klant Logo



Datum: mm-jjjj

ISO Nr.: AFLXXXXXXXX

Waarschuwing: Veranderingen in de systeemconfiguratie en/of de instellingen van de apparatuur zullen de resultaten en aanbevolen persoonlijke beschermingsmiddelen (PBM) voor dit vlamboogonderzoek ongeldig maken.
Dit label is onlosmakelijk verbonden met het rapport van dit onderzoek.

Power flow

Short circuit

Protection Coordination

Arc Flash Analysis

Harmonic Analysis

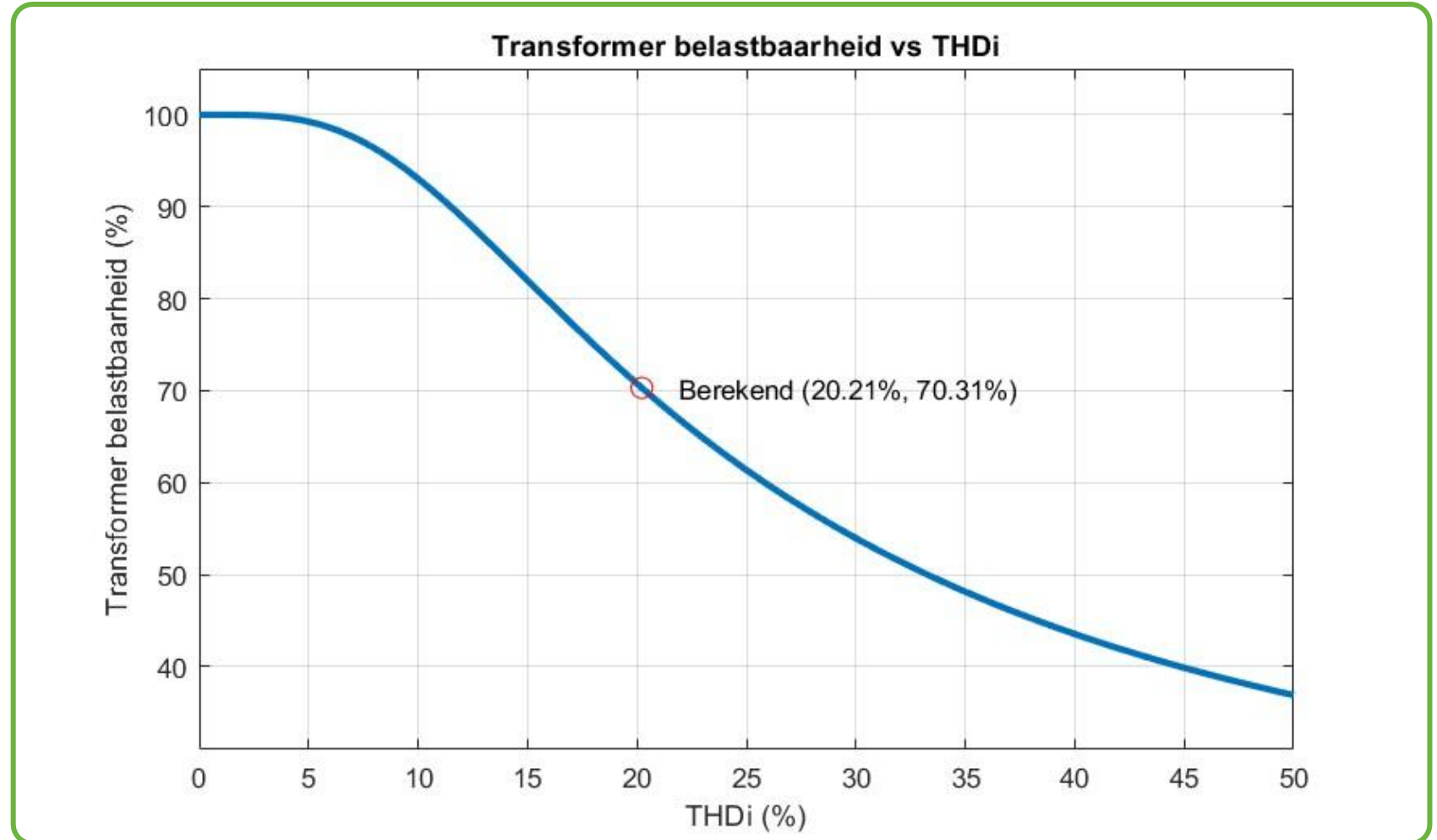
Resonance

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Harmonic Analysis

The invisible distortion



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

Power flow

Short circuit

Protection Coordination

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Harmonic Analysis

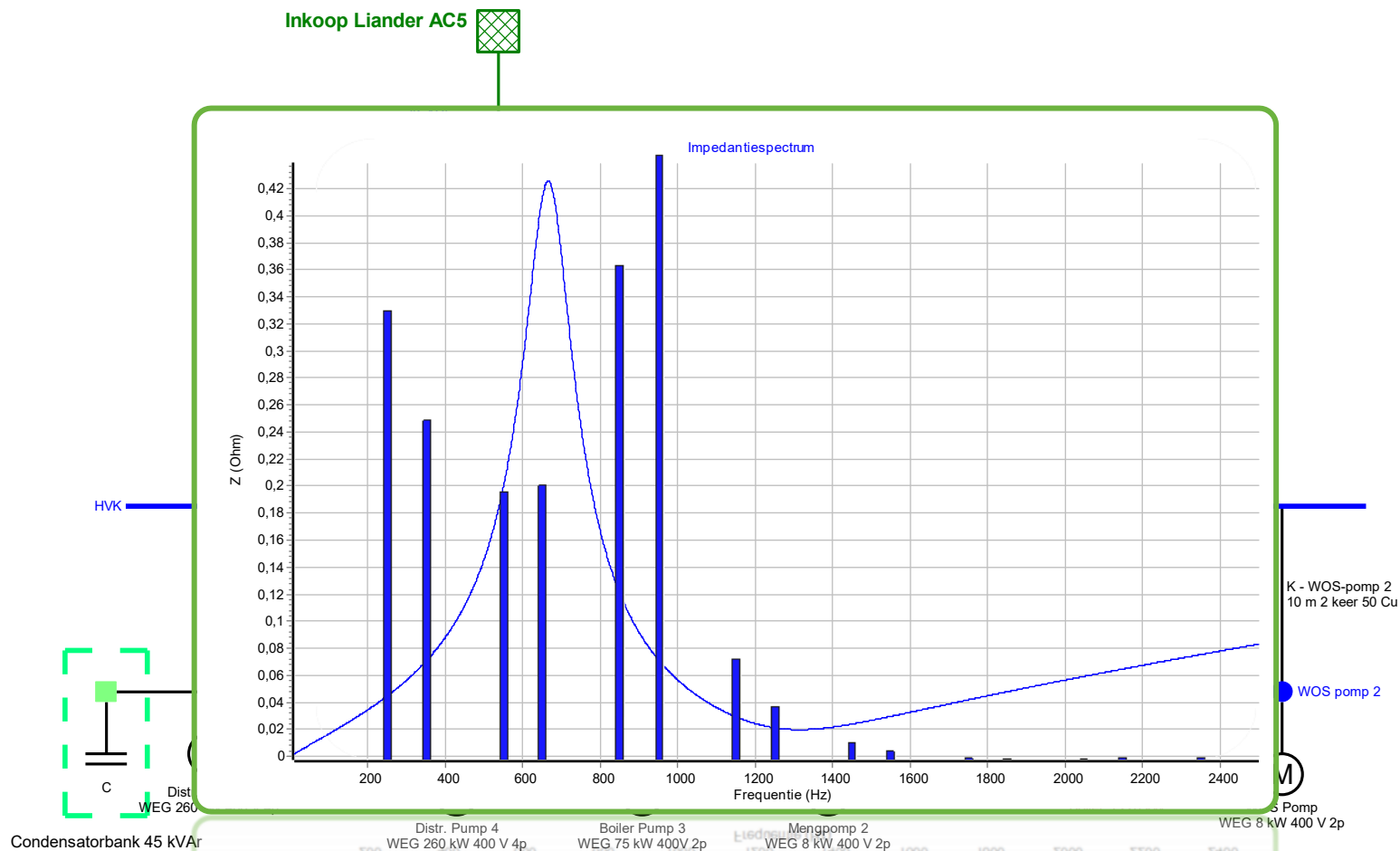
Resonance

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Impedance spectrum

The fingerprint of your network



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

Power flow

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Harmonic Analysis

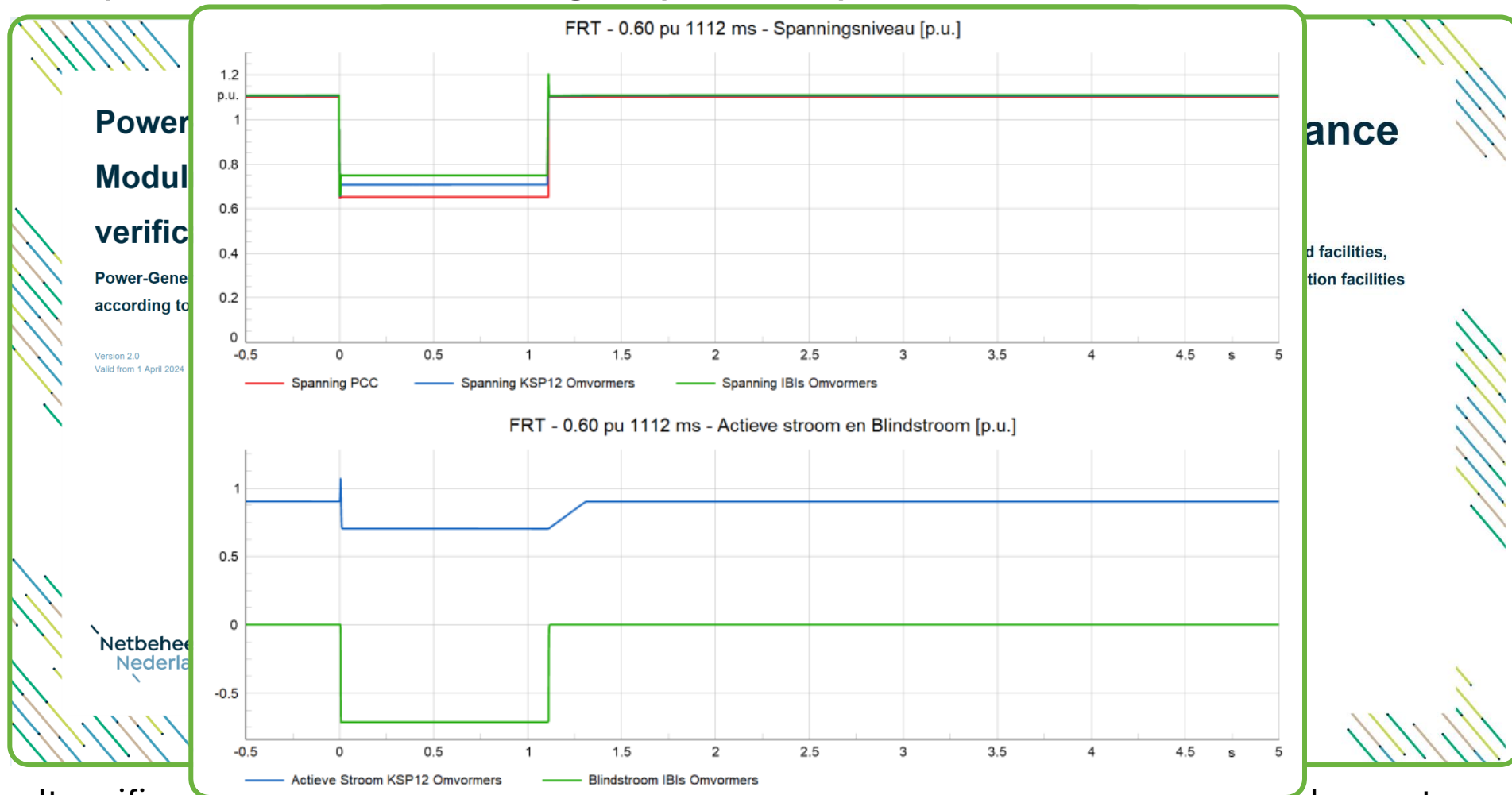
Resonance

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

Thank you

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