Cigre SC C4:Power System Technical Performance

Changing Landscape

cigre
For power system expertise

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Outline

Aim presentation: provide an overview of the changes and challenges Cigre C4: Power System Technical Performance

1. Scope of Cigre C4
2. What is changing the landscape?
3. Examples on how do these changes influence Power System Technical performance

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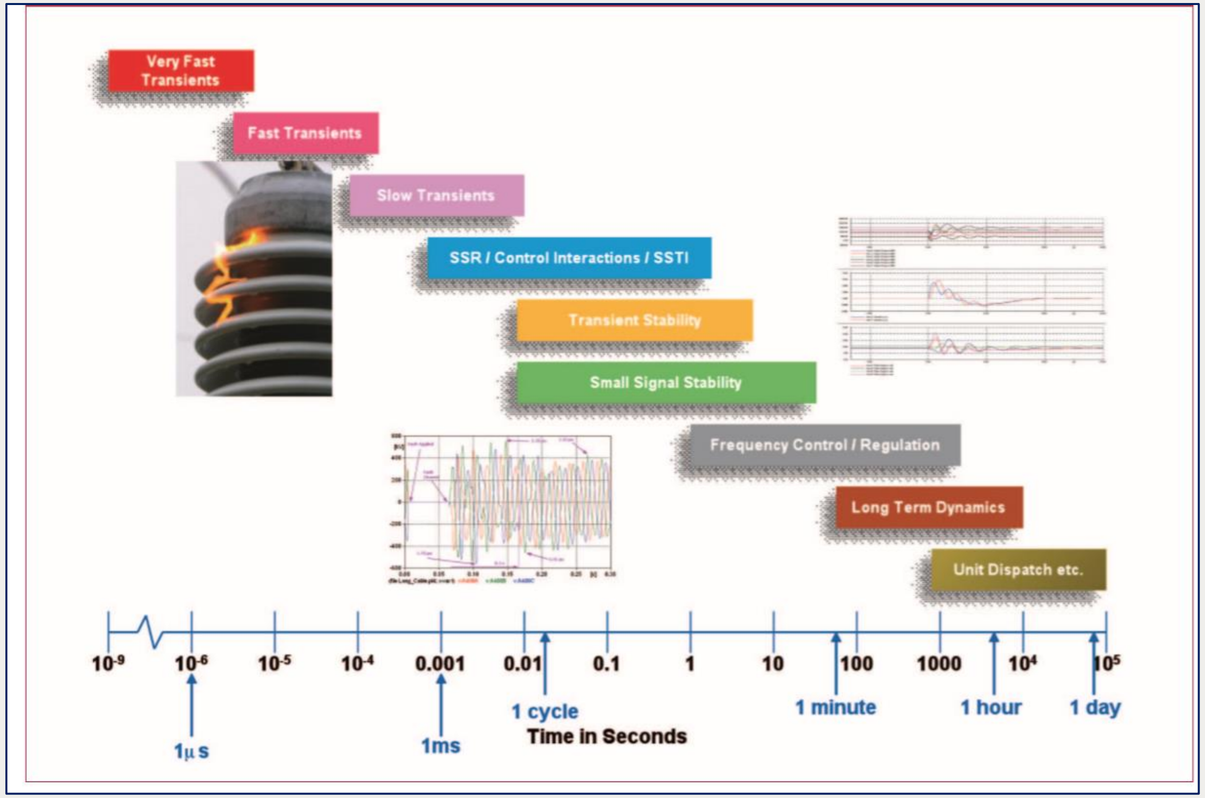
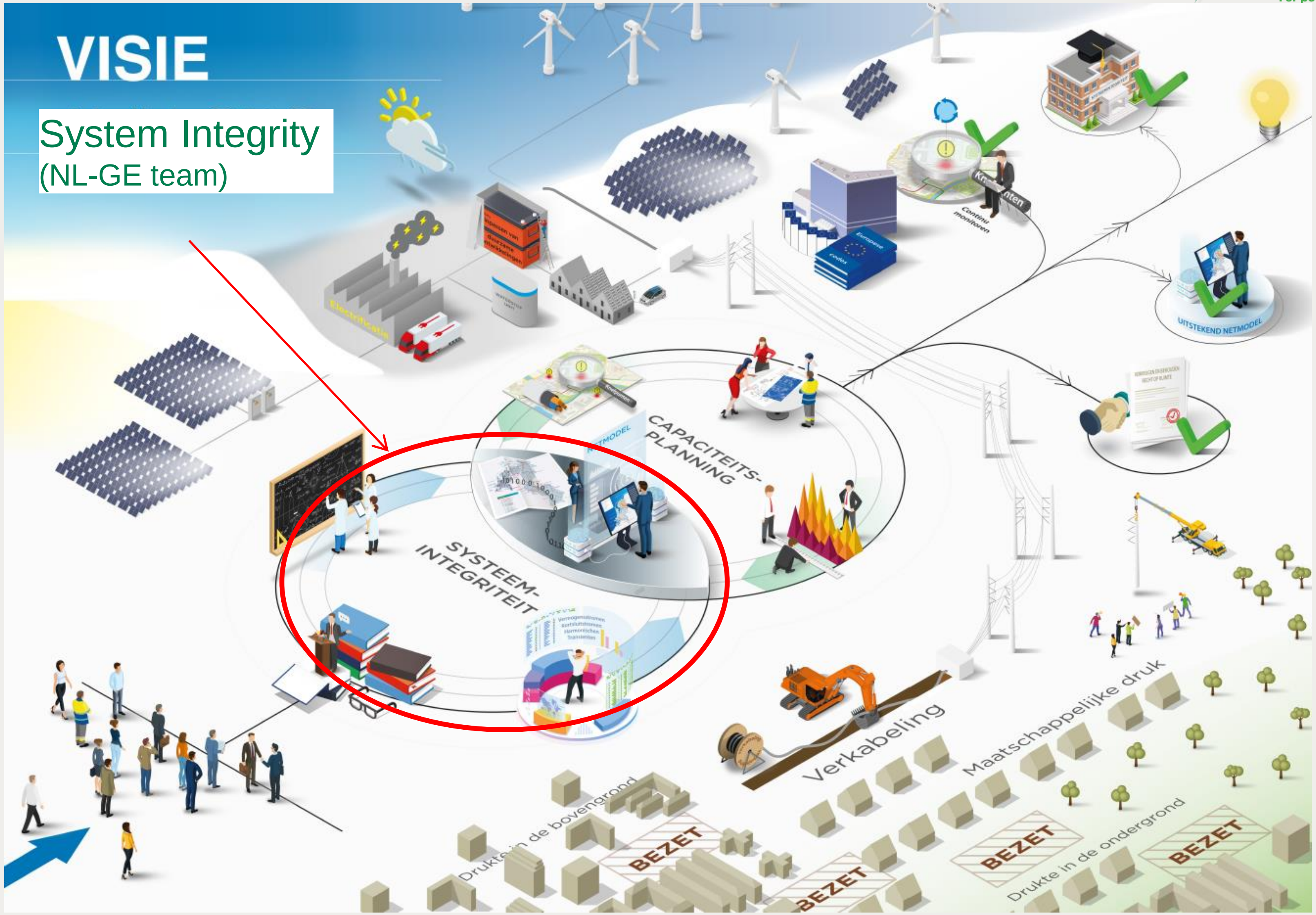
C4:Power System Technical Performance

Keywords

- Interaction Power System ↔ subsystems ↔ apparatus
- Dynamic &Transient phenomema
- Methods and tools for analysis



The landscape

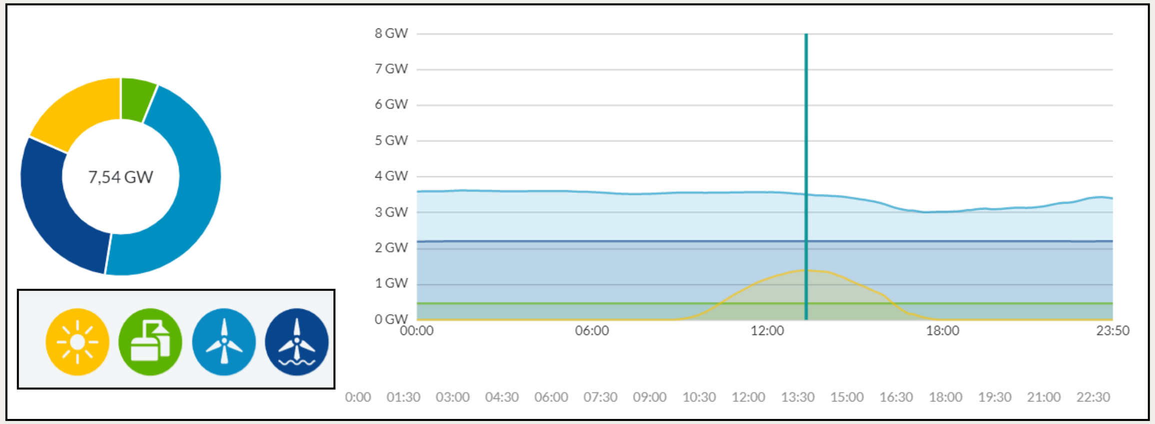


Changing landscape: Generation shift

- From synchronous machines to inverter based generators
- Locations shift to different nodes in the grid

  (where the system is weak…)
- Example January 20th 2021

  (https://energieopwek.nl/)



Changing landscape: Cables

- Due to replacement overhead lines by cables
- Connection new Windfarms

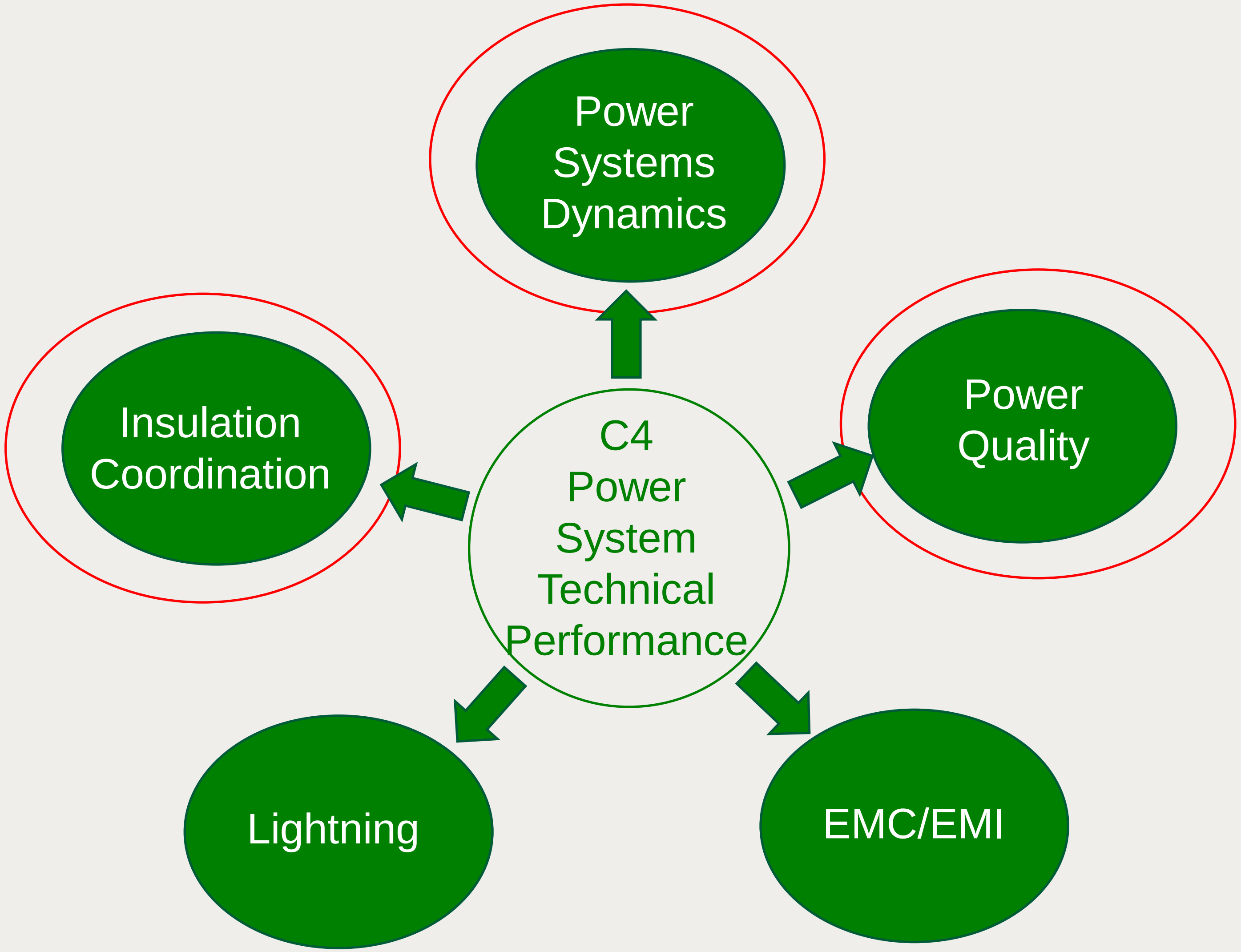
Impact

- Cables add capacitance, reactive power
- Shift resonance frequencies to lower values

Changing landscape: Power Electronics

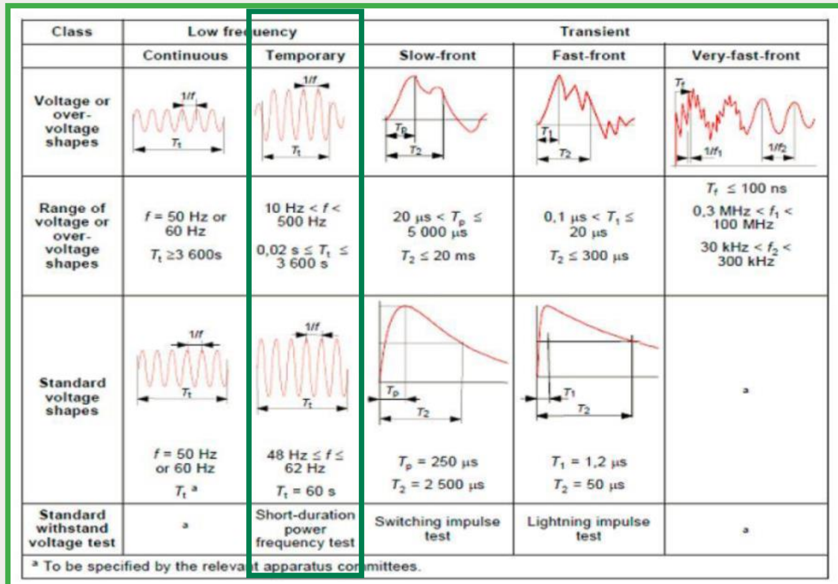
- Increased usage of power electronics
  - Emission?
  - Immunity?
  - Quantify risks interactions?

Impact changes on Power System Technical Performance



Impact on Insulation Coordination (Kostas Velitsikakis)

- Aim is to prevent damage to equipment due to transient overvoltages
- More cables and lower system strength result in a different type of overvoltages:
  - Longer duration
  - Higher Amplitudes
- Detailled studies required
- New assessment criteria developed



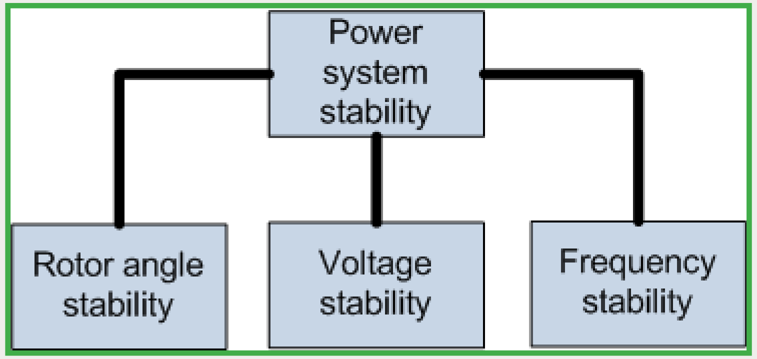
Class	Low frequency		Transient		
	Continuous	Temporary	Slow-front	Fast-front	Very-fast-front
Voltage or over-voltage shapes					
Range of voltage or over-voltage shapes	f = 50 Hz or 60 Hz T_t ≥3 600s	10 Hz < f < 500 Hz 0,02 s ≤ T_t ≤ 3 600 s	20 µs < T_p ≤ 5 000 µs T_2 ≤ 20 ms	0,1 µs < T_1 ≤ 20 µs T_2 ≤ 300 µs	T_f ≤ 100 ns 0,3 MHz < f_1 < 100 MHz 30 kHz < f_2 < 300 kHz
Standard voltage shapes	f = 50 Hz or 60 Hz T_t [a]	48 Hz ≤ f ≤ 62 Hz T_t = 60 s	T_p = 250 µs T_2 = 2 500 µs	T_1 = 1,2 µs T_2 = 50 µs	[a]
Standard withstand voltage test	[a]	Short-duration power frequency test	Switching impulse test	Lightning impulse test	[a]

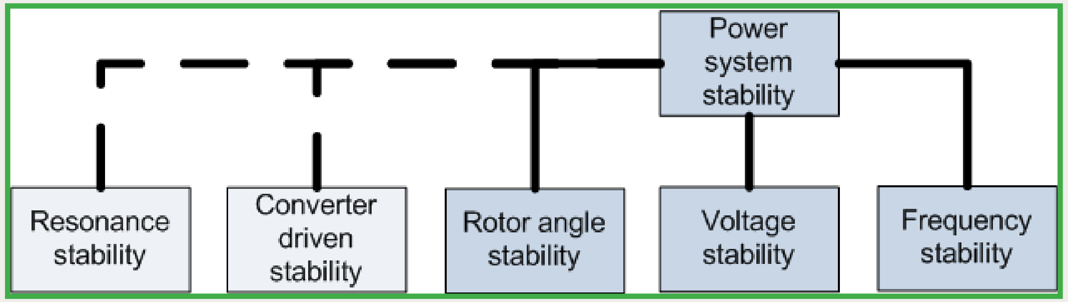
[a] To be specified by the relevant apparatus committees.

Figure 3: Classes and shapes of overvoltages (IEC 60071 and Table 2.1.4 CIGRE TB 542).

Impact on power system stability (Jorrit Bos)

- Classical definition:
- Phenomena in ms-sec-min range





- New definition (IEEE PES-TR77)
- New' phenomena in µs-ms range:
  - mainly related to converter controls
  - Quite limited in current studies, however becoming increasingly important
- Also requirements for generators (RfG), explained by Peter

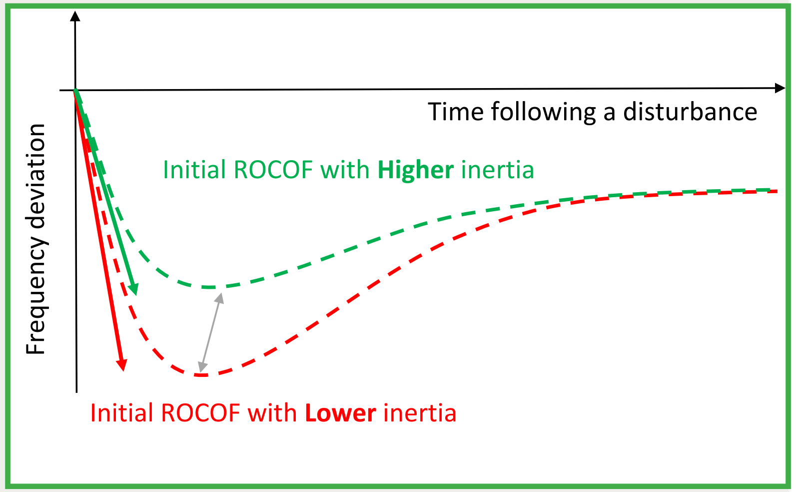
Classical power system stability aspects (1): Frequency stability

- Reduction of inertia affects RoCoF and nadir (min freq.)

  Note: @49Hz load disconnected, 49.2 “Plannniveau”

- Initial RoCoF and dip size (nadir) depends on **inertia** and **generation demand imbalance**

- Subsequent frequency recovery depends on size and activation time of **Frequency Containment Reserves (FCR)**



Challenges:

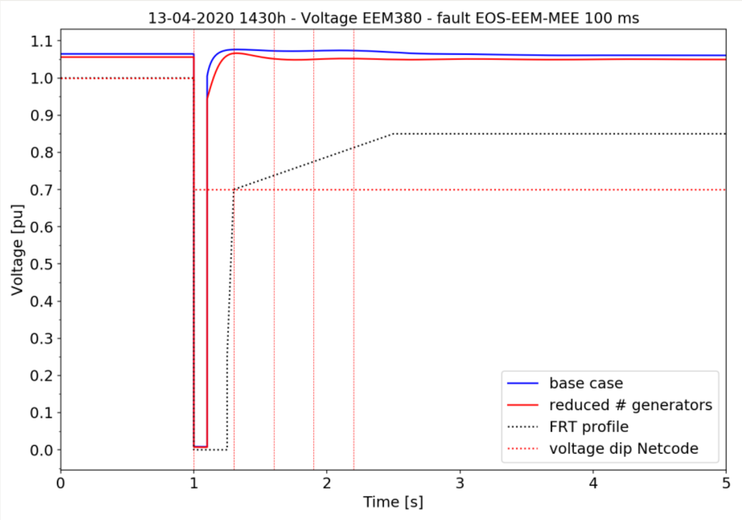
- Keep RoCoF within limits of equipment (machines, loads, protection)
- Keep nadir above limit for load frequency demand disconnection (LFDD)

Classical power system stability aspects (2): Voltage stability / transient stability

Mainly affected by reduction of **system strength**

Voltage stability

- Less dynamic **reactive power** support leads to slower voltage recovery
- See presentation Peter

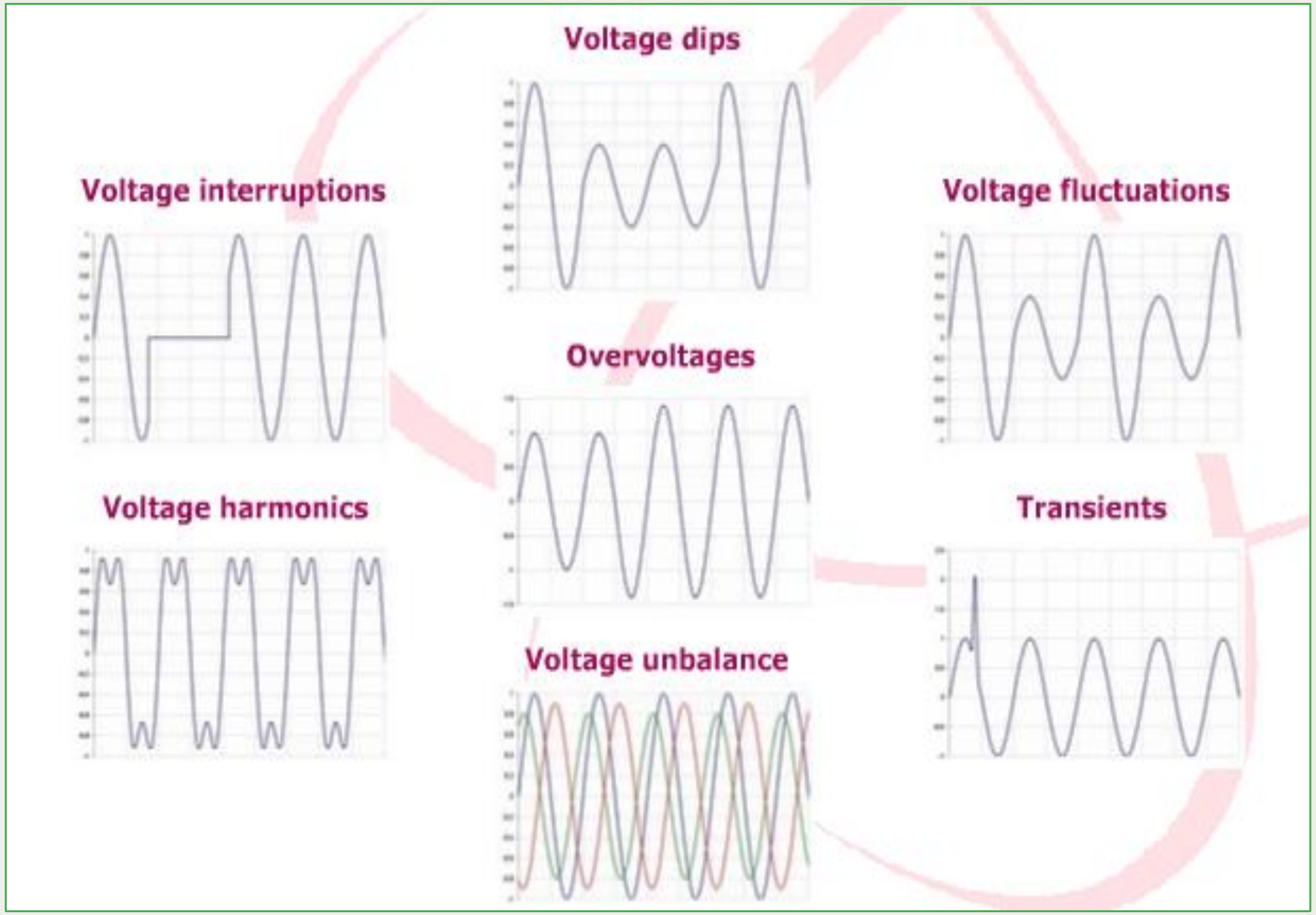


Transient stability

- Reduction of short circuit-power resulting in reduced critical fault clearing time of synchronous generators

(Dip duration ↑, risk disconnection ↑)

Power Quality (Frans van Erp, Jeroen van Waes)



Power Quality: Example voltage dips

- Can have huge impact on performance connectees
- Caused by short circuits
- Fault clearance time important
- Legislation voltage dips since 2020

RETAINED VOLTAGE (*p.u.*)	DURATION (*ms*) 10 to 200	200 to 500	500 to 1000	1000 to 5000
0.8 = U <0.9	Class A	Class A	Class A	Class A
0.7 = U <0.8	Class A	Class A	Class C	Class C
0.4 = U <0.7	Class A	Class B2	Class C	Class C
0.05 = U <0.4	Class B1	Class B2	Class C	Class C
0.01 = U <0.05	Class B1	Class B2	Class C	Class C

Oorzaak stroomstoring Schiphol bekend

De grote stroomstoring op Schiphol eind april is onder meer veroorzaakt door een verkeerd ingesteld noodstroomaggregaat.

ANP 28 september 2018, 11:41

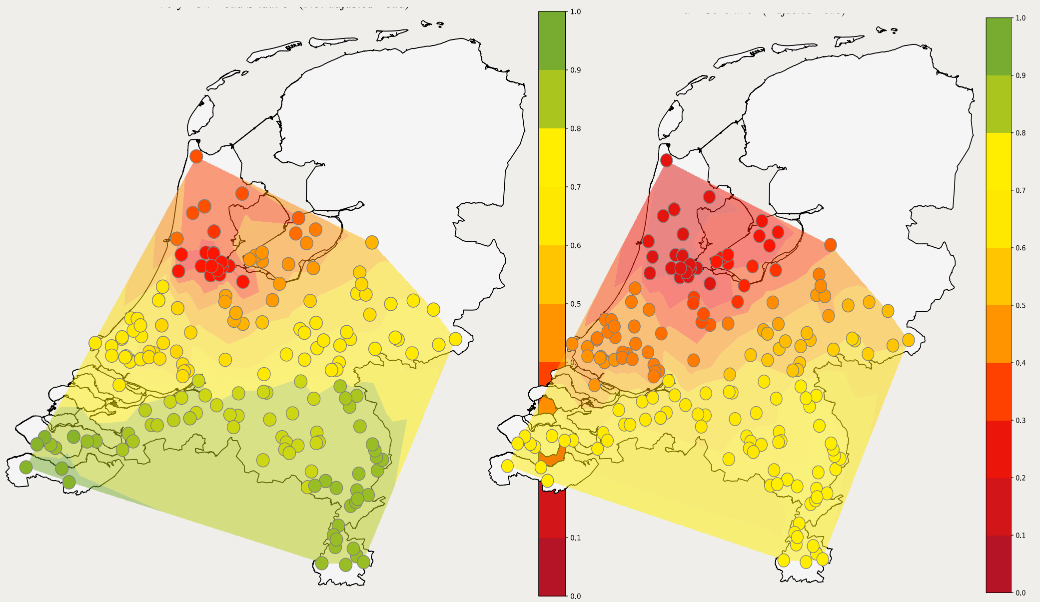
BEELD ANP

Dat blijkt uit onderzoek van onderzoeksorganisatie TNO, die spreekt van een samenloop van omstandigheden. Schiphol heeft naar aanleiding hiervan besloten het toezicht op de infrastructuur te verbeteren.

TNO deed de afgelopen tijd onderzoek naar de problemen die op 29 april ontstonden na een spanningsdip in het hoogspanningsnet van Tennet. Door een stroomstoring vielen check-in-systemen en vluchten uit op Schiphol.

Power Quality: Example voltage dips

- PhD Study R. Torkzadeh
- Aim: what is the impact on voltage dips?
  - Includes propagation MV grids
- 2 stage approach:
  1) Model & Validation
  2) Analyse Energy transition scenarios



Example Voltage dip propagation EHV, HV and MV network.

Left: Base case.
Right: Base case but with significant RES.

Summary presentation

- Changes in landscape i.r.t. Cigre C4:
  - Generation shift;
  - Cables;
  - Power Elektronics
- Impact illustrated on:
  - Insulation coordination
  - Stability
  - Power Quality

Existing system in a changing or new landscape…

(Erik Schenkel/ Albert E.)

Poll

What change in the landscape has most impact on the system?

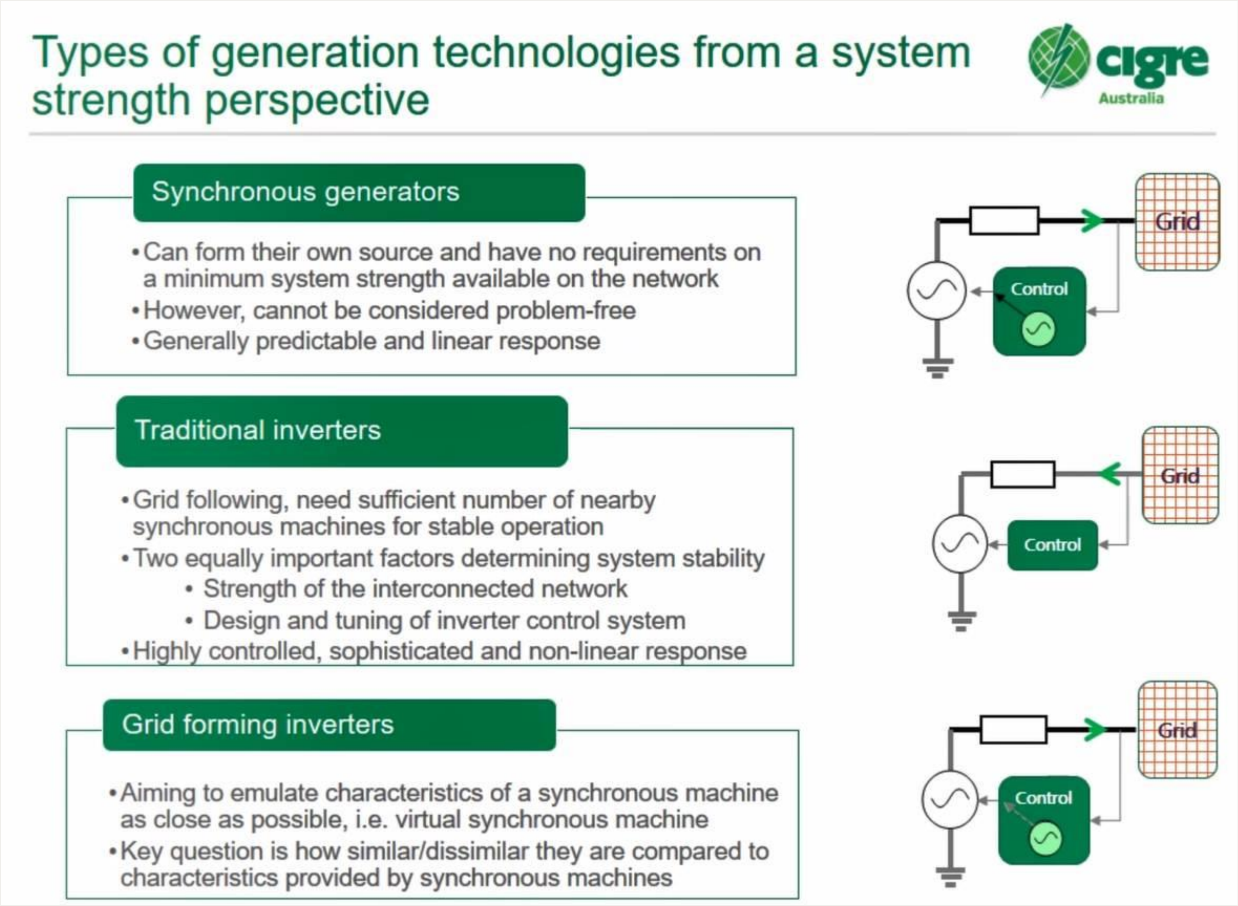
- ❑ Generation Shift
- ❑ Cables
- ❑ Power Electronics
- ❑ …

Solutions (Roald de Graaff, Jorrit Bos)

- Grid forming inverters
  - Stabile frequency
  - Suppliers are challenged
  - Statcoms with gridforming functionality (GE)
- Synchronous condensors
  - System strength

Related questions:

- When, where, how many?
- #scenario’s



Cigre WS System Strength, August 2020