

Verandering zonder Compromissen

PAC als Fundament
van Betrouwbaarheid

8 april 2026

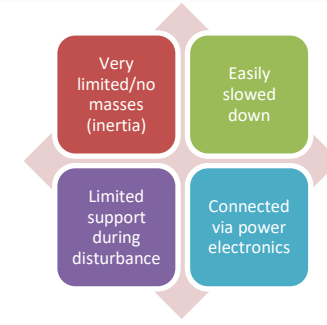
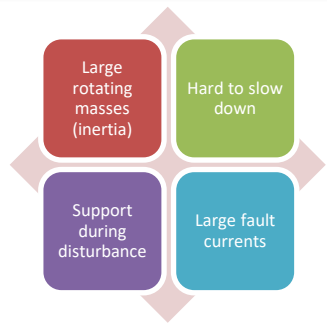
Roy Bosman – TenneT TSO – Asset Specialist PAC



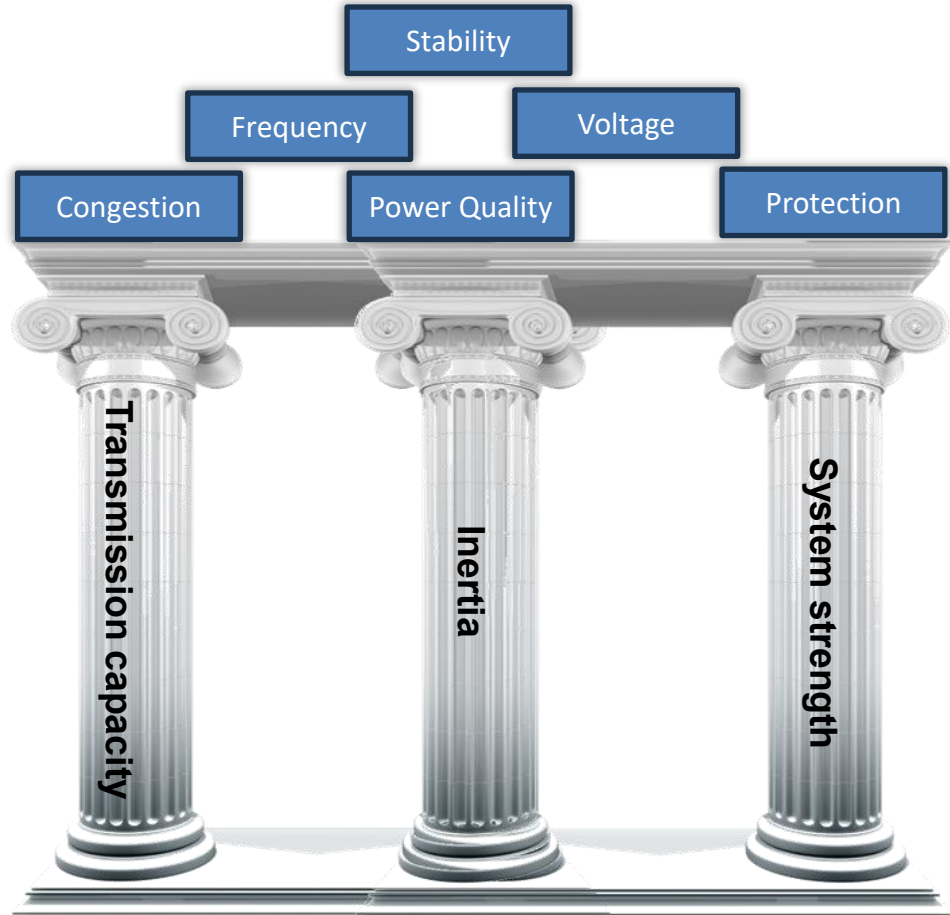
Agenda

- Introduction
- Changing system
- System strength / Inertia
- Use Cases
 1. Synchronous condenser
 2. Protection concept line-cable circuit

Changing system behaviour 'from container ship to sailboat'

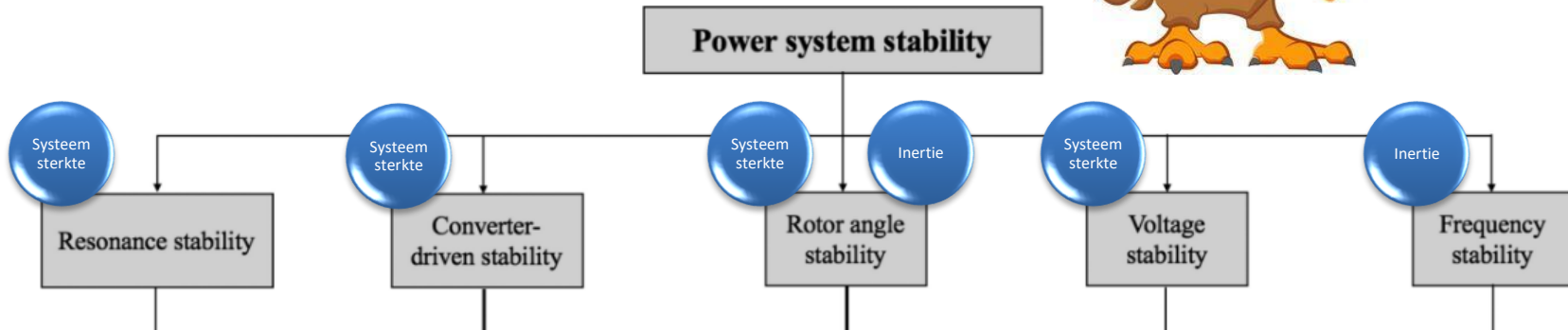


System challenges



Power system stability

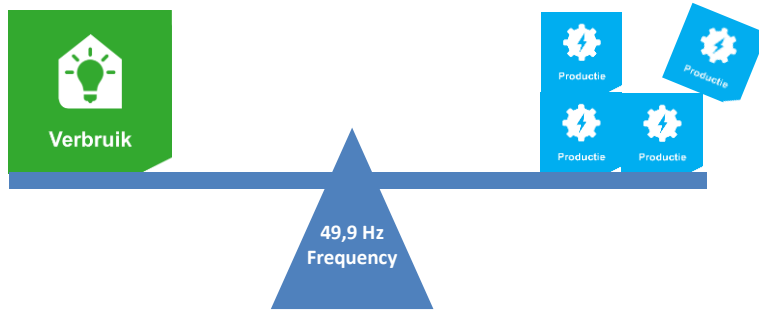
“Power system stability: The ability of a system to return to a stable operating point after a disturbance, for example a short circuit”



Bron: IEEE, Definition and Classification of Power System Stability – Revisited & Extended, Nikos Hatziaargyriou , F et al.

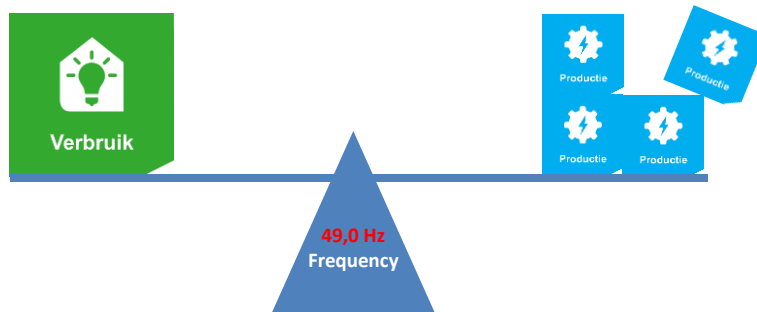
Inertia

Inertia: reserve energy available in the system to support system stability in case of an unbalance (MW)



Situation with many synchronous machines

- Stable behaviour
- Limited oscillation



Situations with many inverter-based resources

- Movements are faster
- Movements are larger (lower frequency nadir)
- Movements last longer

Large synchronous machines stabilise the system



Bron: A. Hally CIGRE
2020

Synchronous machines = **shepherds** (in current system)

Inverter based resources = **sheep**

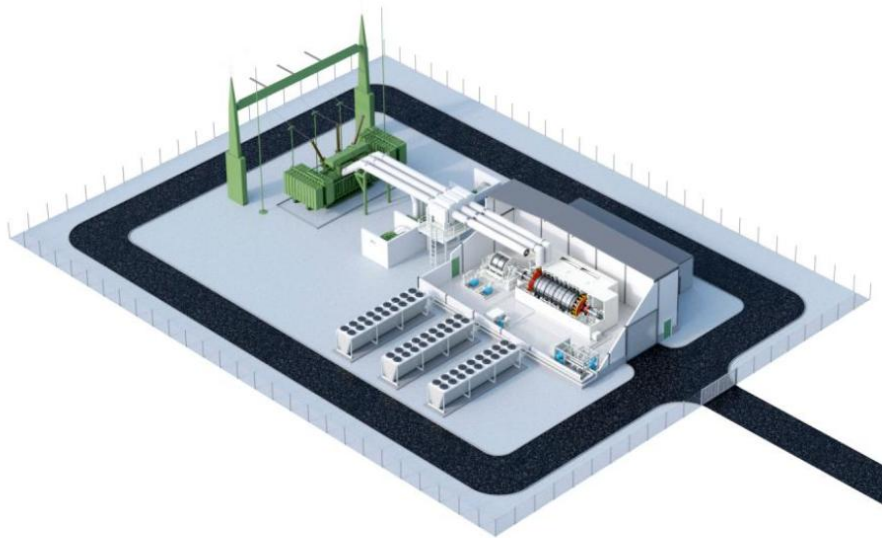
Sheep follow the **shepherds** and are dependent of them ('*grid following*')

Key questions TSOs are:

- How many shepherds are needed to look after an increasing number of sheep?
- How close do the shepherds need to be to effectively look after the sheep?
- Can we get sheep to look after themselves in the future? ('*grid forming*')

Use case 1: Synchrone condensators

- <https://www.tennet.eu/nl/inertie-essentieel-voor-een-stabiel-elektriciteitsnet>

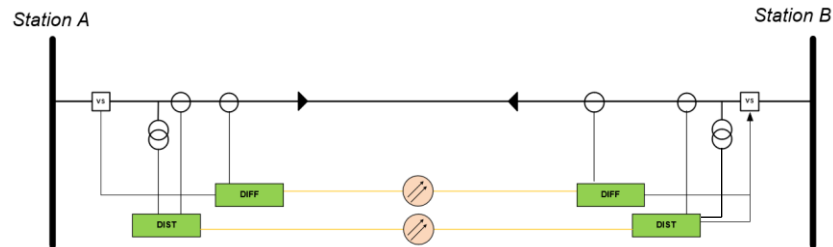


Bron: partner Siemens Energy

Use case 2: Protection concept line-cable circuit

Circuit protected by double protection IEDs

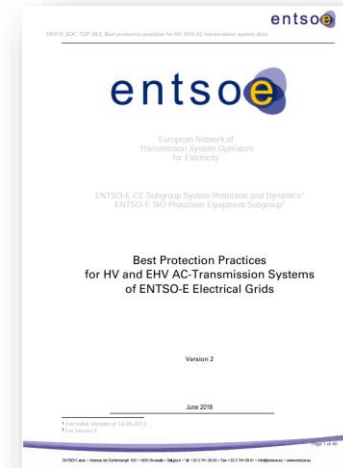
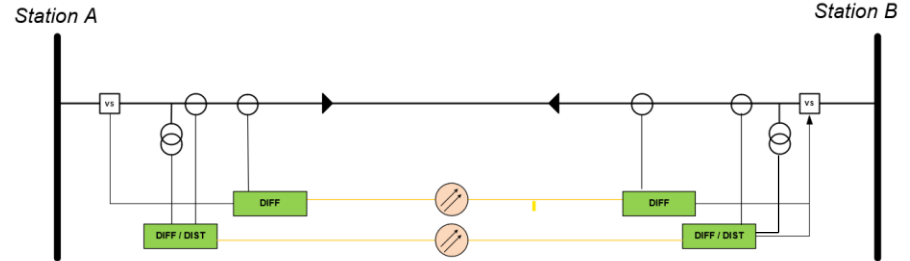
1. Differential protection
2. Distance protection



Use case 2: Protection concept line-cable circuit

Circuit protected by double protection IEDs

1. Differential protection
2. Differential protection with distance protection function



- Best Protection Practices for HV and EHV AC-Transmission Systems of ENTSO-E Electrical Grids
- Update planned

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cigre
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