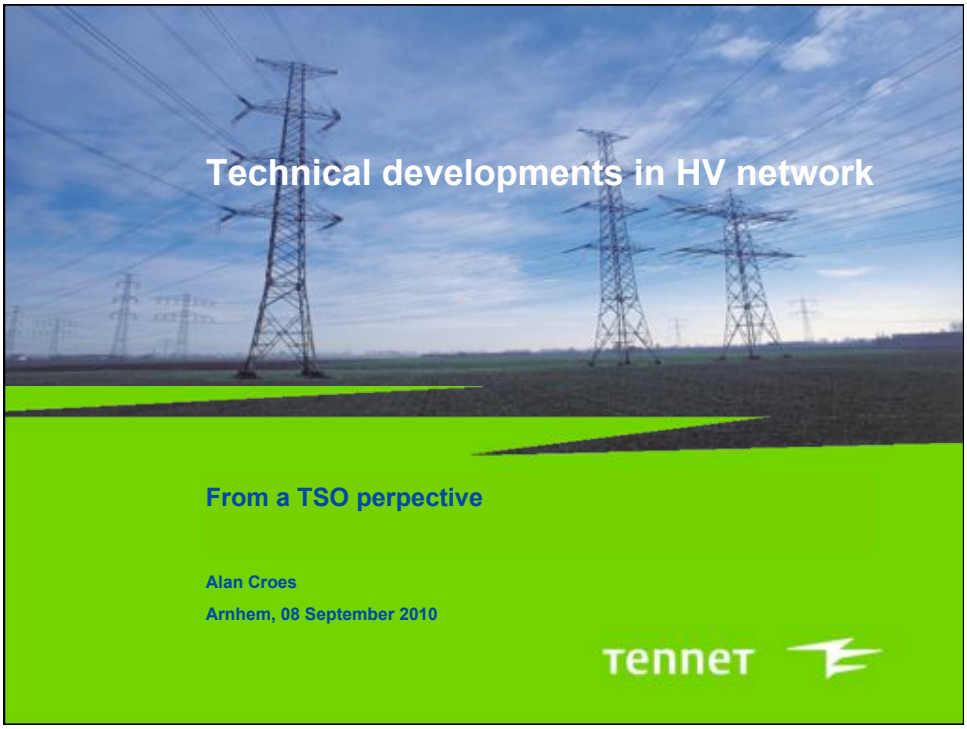


Content

- A TSO perspective
- Change of requirements
- Available technologies
- Issues
- Outlook

2

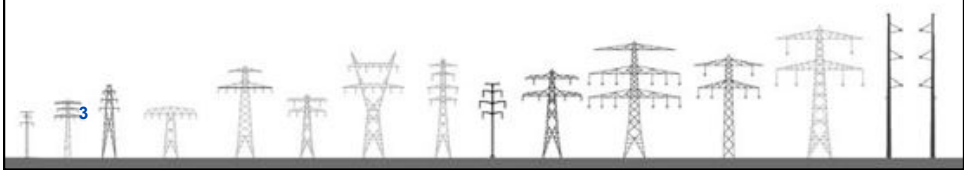
A TSO perspective (hardware)

Build, maintain a robust and reliable network. With this network supply power, balance the system and facilitate the market.

We have been "spoiled" with rather simple straight forward technologies realizing a high standard of reliability:

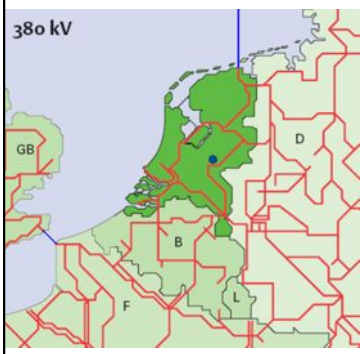
- **No active control**
- **No additional components needed for compensation**
- **Rather straight forward and fast repair options**

Downside is a visible overhead line with a footprint.



3

A TSO perspective (operation)

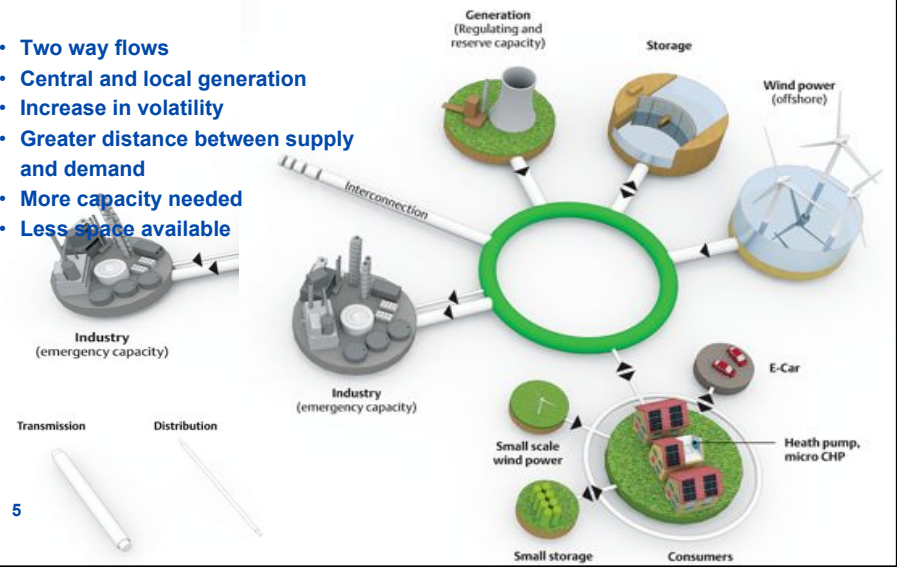


- **European meshed network**
- **Back-bone functionality:**
  - **380 kV ≈ 1000 – 2640 MVA**
  - **150 kV ≈ 100 – 300 MVA**
- **N-1 (even with maintenance) grid code**
  - **one fault acceptable without cascading effects**
  - **transport redispatched within millisecond timeframe**
- **Voltage requirements ± 10%**
  - **guaranteed stability with N-1**

4

Change of requirements

- Two way flows
- Central and local generation
- Increase in volatility
- Greater distance between supply and demand
- More capacity needed
- Less space available



5

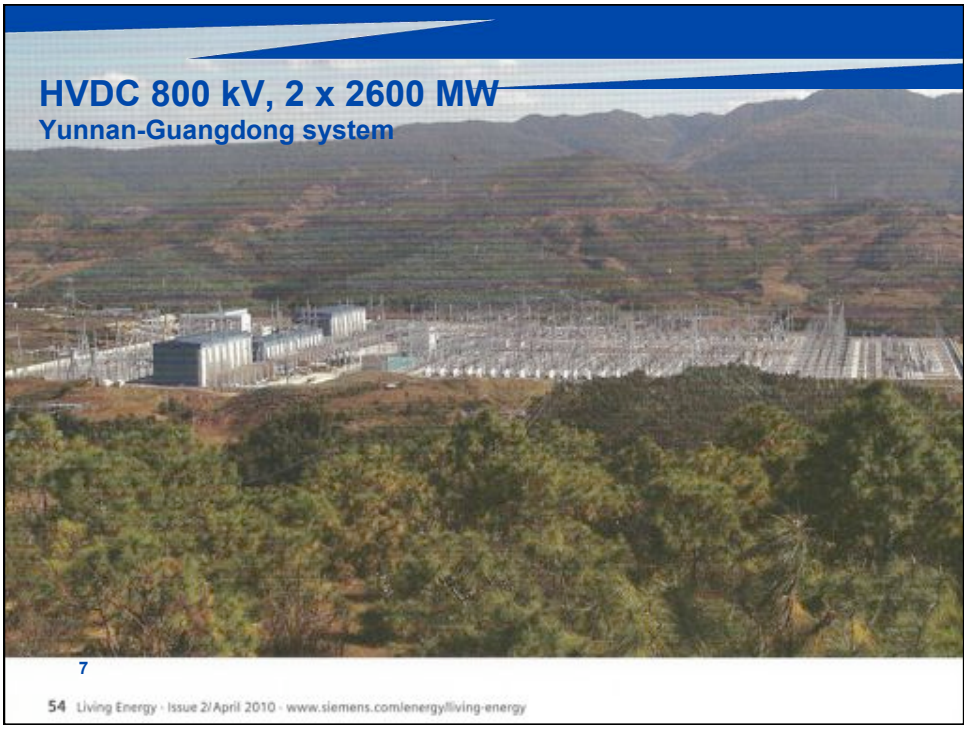
Available technologies

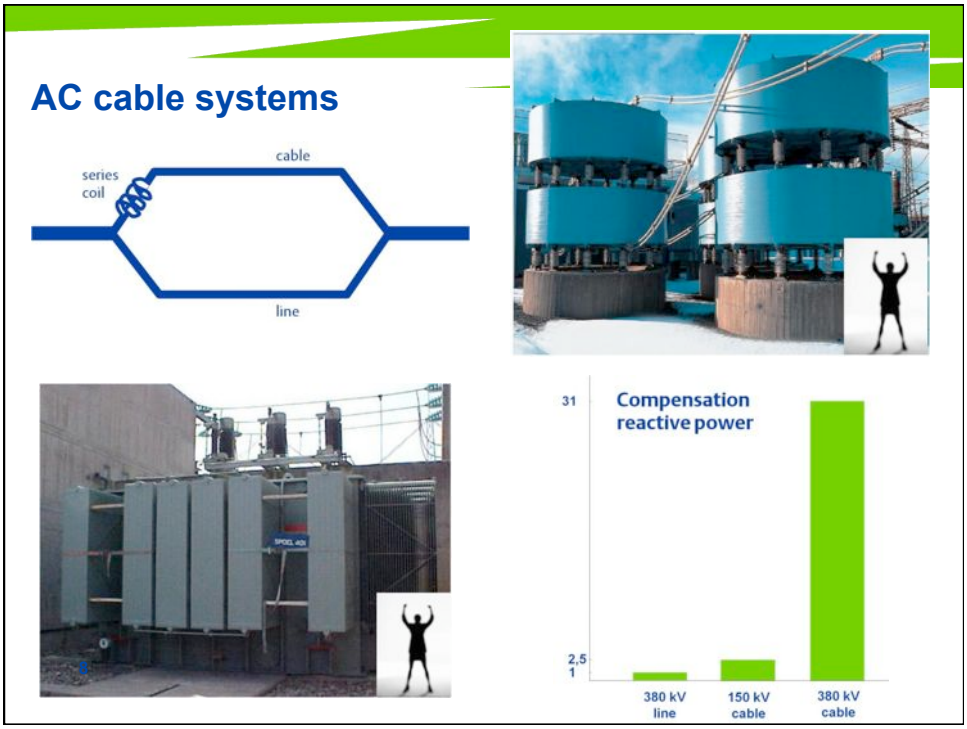
HVDC (max 3000 MW LCC / 800 MW SVC)
- active converter stations needed
- no DC-switch gear available
- OHL / cable possible

AC Cables
- compensation needed
- joints / terminations critical equipment
- repair time

GIL
- SF6 / greenhouse gas
- not a lot of experience with directly buried GIL
- dilatation management needed, 3.5m movement for each 5km

6


HVDC 800 kV, 2 x 2600 MW
Yunnan-Guangdong system
7
54 Living Energy · Issue 2/April 2010 · www.siemens.com/energy/living-energy


AC cable systems
cable
series coil
line
31
Compensation reactive power
2,5
1
380 kV line
150 kV cable
380 kV cable

Outlook

Each technology has useful advantages:
- HVDC, controllability, no synchronous area needed
- Cables, buried infrastructure applicable for AC and DC systems
- GIS, no (major) compensation needed and high capacity

TenneT investigates the use of “new” technologies within the framework of a robust and reliable network.

If profitable and secure this technology is used to immediately gain the advantages and expand the worldwide knowledge.

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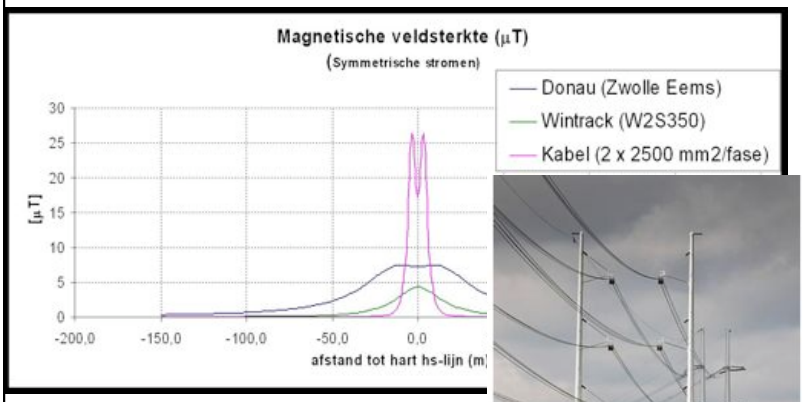
Wintrack



Wiring of Wintrack
Bleiswijk August 2010

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Thank you for your attention.

TenneT