

Lunch lecture TU Delft Power Web

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- MSc in High Voltage and Power Engineering
- Legacy KEMA (many different positions since 1985)
 - Transient (field) measurements in HV-grid
 - Development of Digital Lighting Impulse Test System
 - Power transformer modelling and diagnostics
 - Manager HV installations department
 - Innovations, FPGLab and Watt Connects
 - Consultant HVDC and Smart Grids
- Present
 - Segment Director Future Transmission Grids







Six Power System Challenges



CAVE-thinking



RES integration







Security threats

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The power system is transforming (fast) due to the impact of changing requirements and disruptive technologies



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Two developments: interconnectivity and "hybridisation"

 ENTSO-E estimates the total investment costs (for the next 15 years) for projects of pan-European significance at approximately €150 billion, of which €25 billion will be for subsea cables.



A trend is (transmission) undergrounding



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Digitalisation and increased complexity





From an analogue physical system to an interrelated non-linear digital control system



Power system grid architecture changes due to DC

Key HVDC LCC components for bulk power transmission



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Wind: larger and smarter



Distance to shore and average water depth of a representative selection of European wind farms. The size of the bubbles are indicative of the capacity of the wind farms.



The size of the bubbles are indicative of the capacity of the wind farms.

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Electricity storage for three discharge durations



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Hybrid grids



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Combination of ultra-high voltage DC and AC systems

HVDC lowest cost solution for transmission of high power electricity over long distances

- Today: More than ~600 km
- 2025: More than ~400 km

Onshore development driven by new converter technology and HVDC protection systems



Blogs: http://blogs.dnvgl.com/energy/what-are-hybrid-grids-a-brief-primer

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Adoption of new technologies New power reality Hybrid elf-thinking ower grids producing buildings Bi-direct in DRM Electricity rag

10 Technology trends creating a new power reality

https://www.dnvgl.com/energy/publications/download/technology-outlook-2025-energy.html

2025

2016

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Future Transmission grids focus areas

- T&D system resilience, opportunity and risk scenario model, new technology qualification
- Complex hybrid systems: embedded DC and increasing complexity of systems operation, grid stability
- Cyber physical system testing (closed loop testing)
- Data analytic services for grids, cyber security and reliability
- Verification of power systems, different quality levels and testing processes
- High-Voltage DC circuit breaker testing, develop requirements and test methods for future meshed HVDC grids.



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Thank you for your attention.

Peter Vaessen segment director Future Transmission Grids peter.vaessen@dnvgl.com +31 (0) 26 356 3584

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