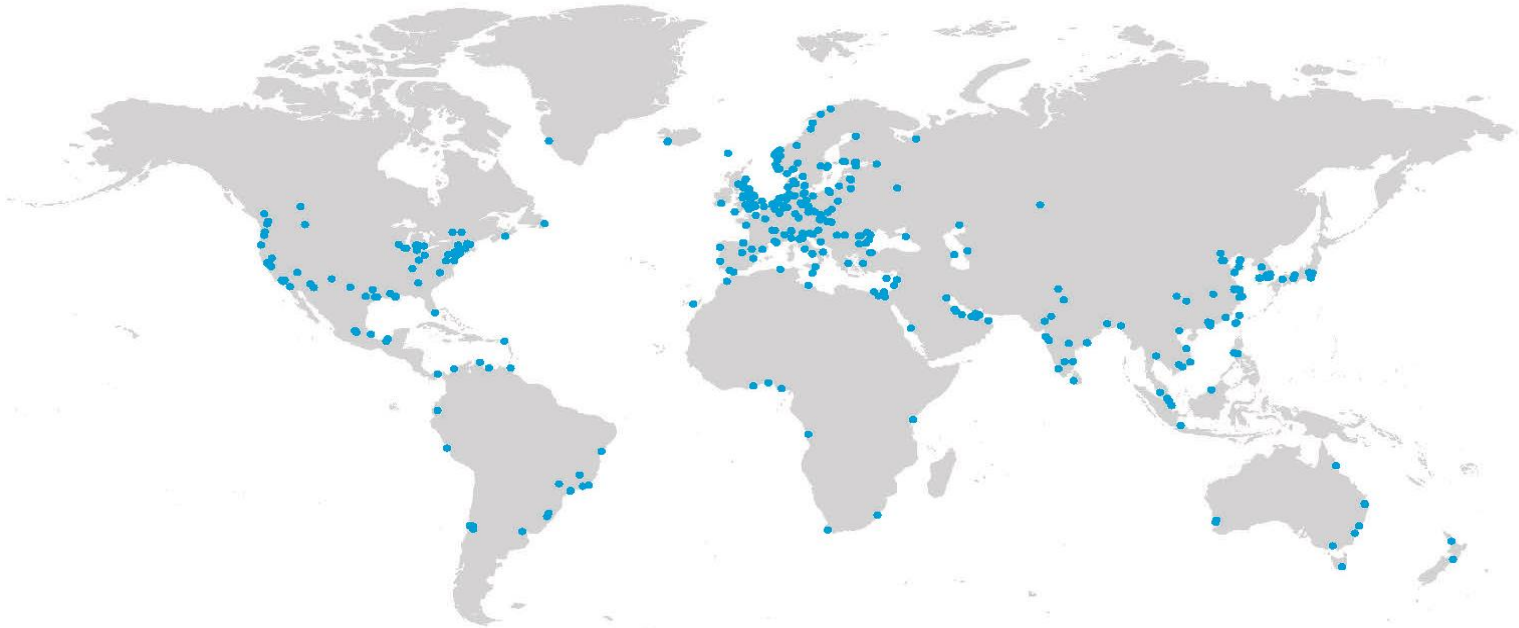
Welcome

PROMOTioN: Demonstration MMC Control hardware in the loop testing for performance and model validation

Theo Bosma

Arnhem, November 21, 2019

Our vision: global impact for a safe and sustainable future



MARITIME

OIL & GAS

ENERGY

BUSINESS ASSURANCE

DIGITAL SOLUTIONS

150+ years

100+ countries

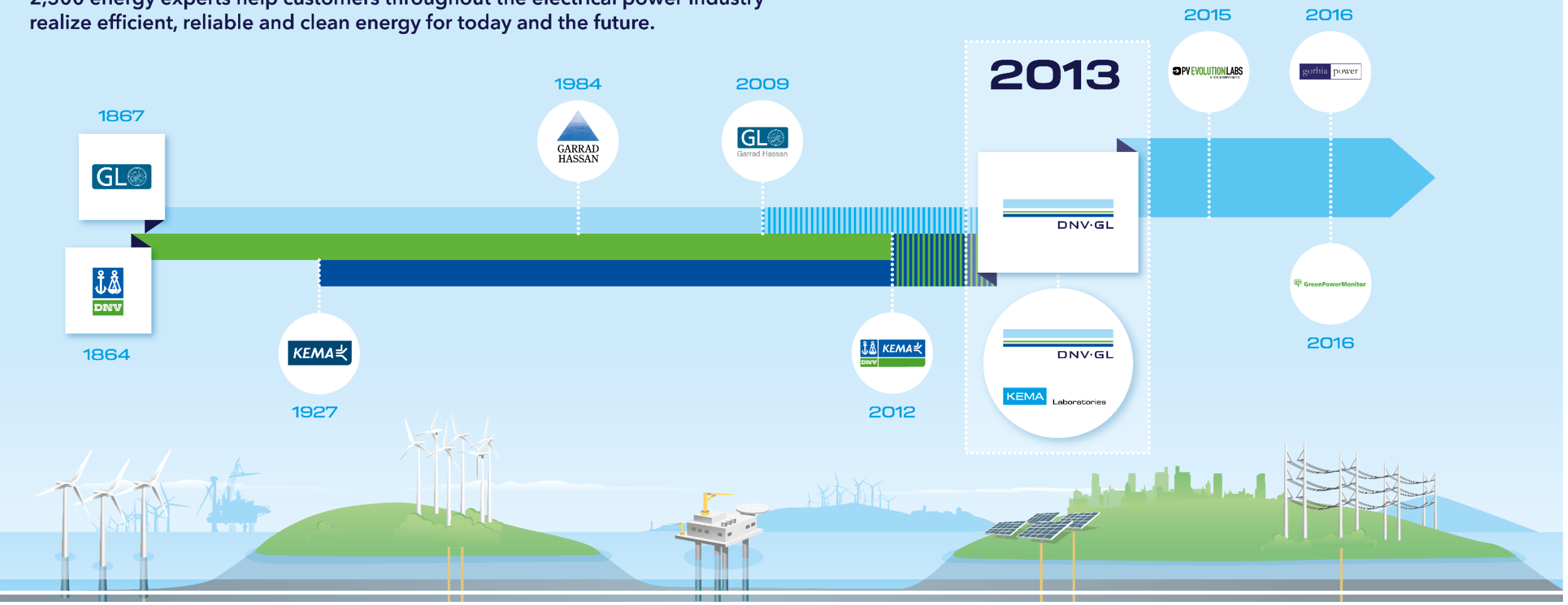
100,000 customers

12,500 employees

5% of revenue spent on R&D

Industry consolidation – strong brands

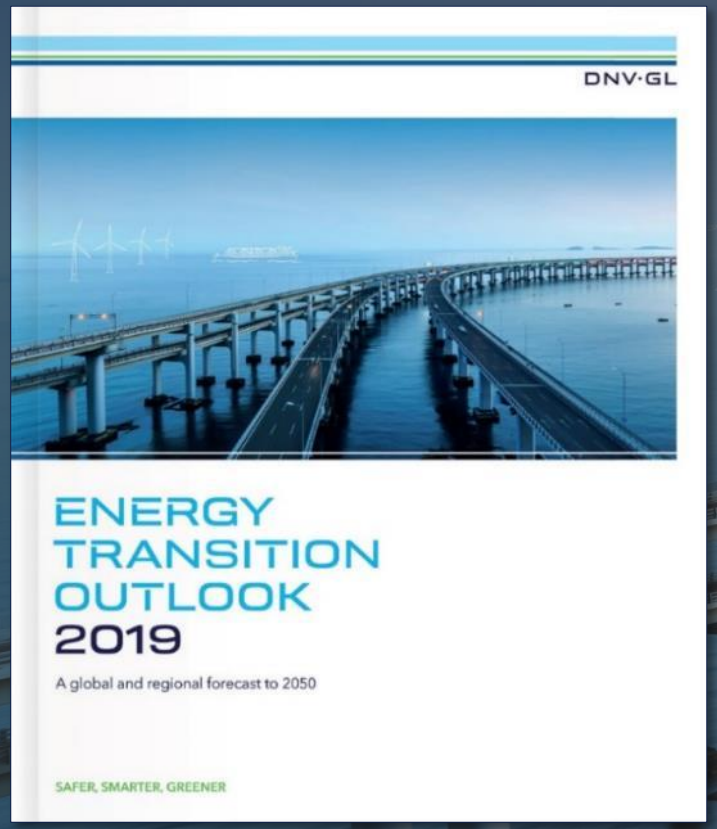
2,500 energy experts help customers throughout the electrical power industry realize efficient, reliable and clean energy for today and the future.

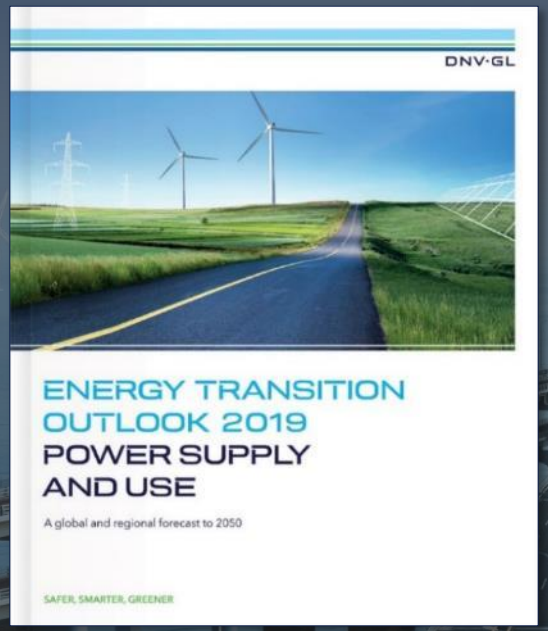


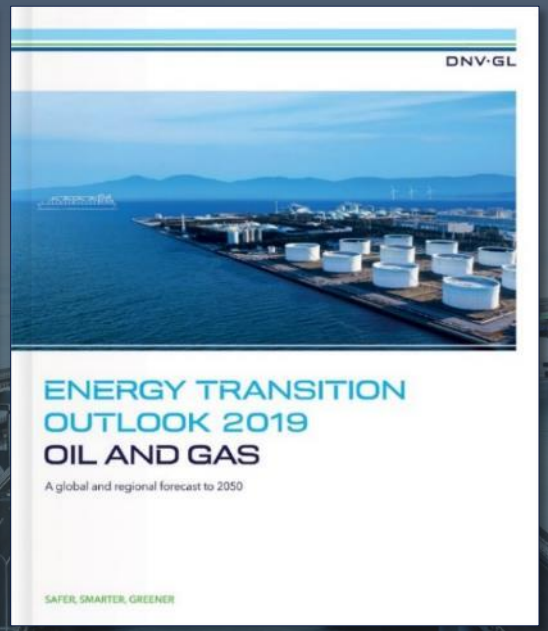
Importance of Energy & PROMOTioN project

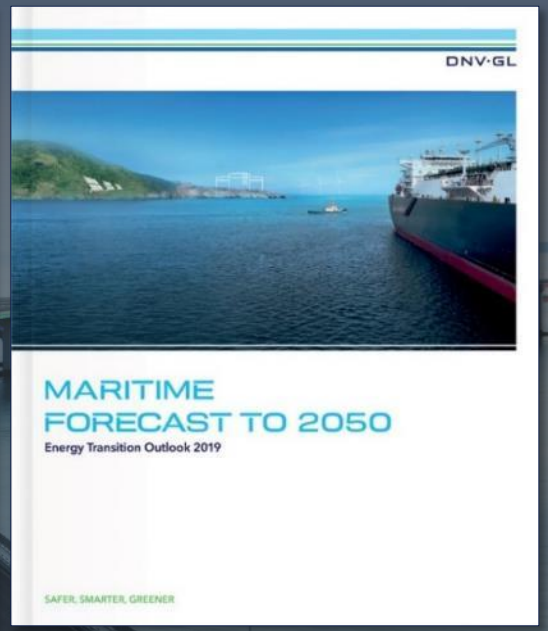
70% of our business is connected to energy

A SUITE OF REPORTS



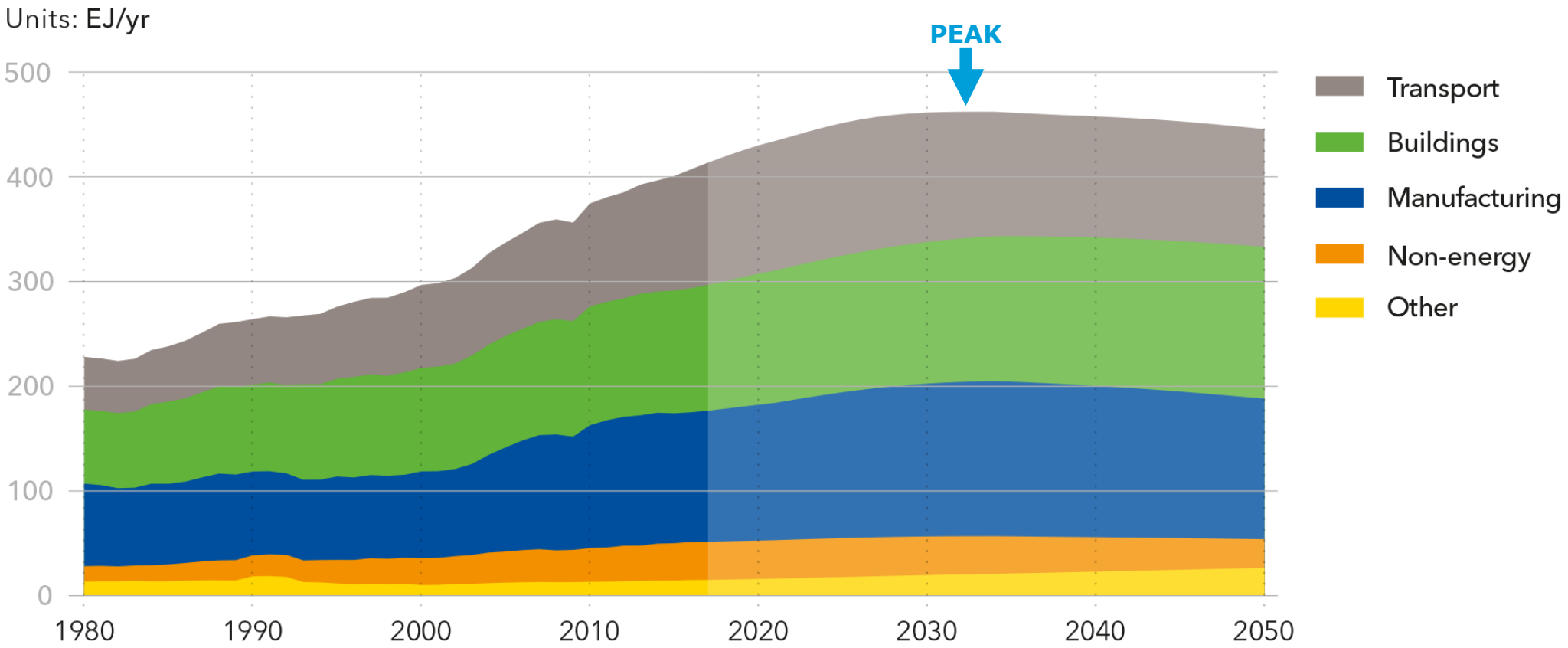






Final energy demand peaks in 2033

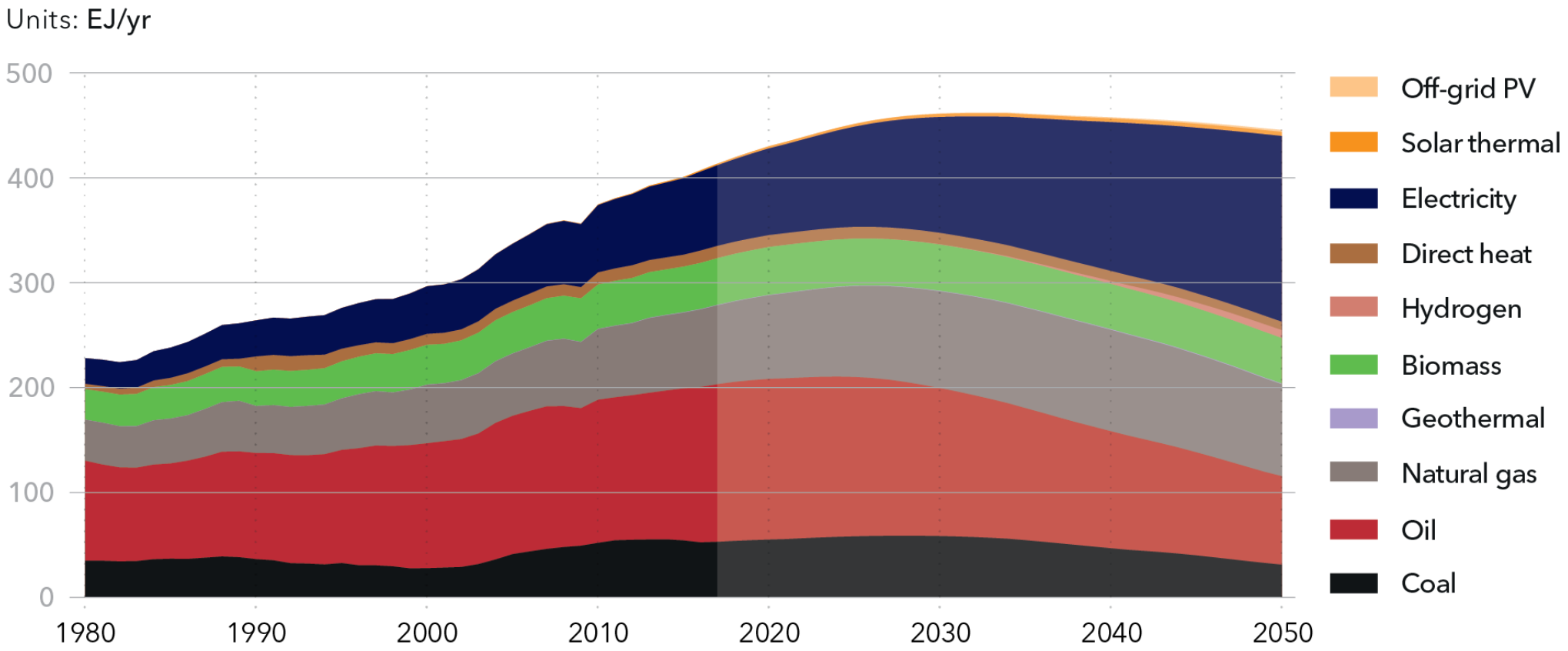
World final energy demand by sector



Historical data source: IEA WEB (2018)

The share of electricity in the final energy demand mix will more than double

World final energy demand by carrier



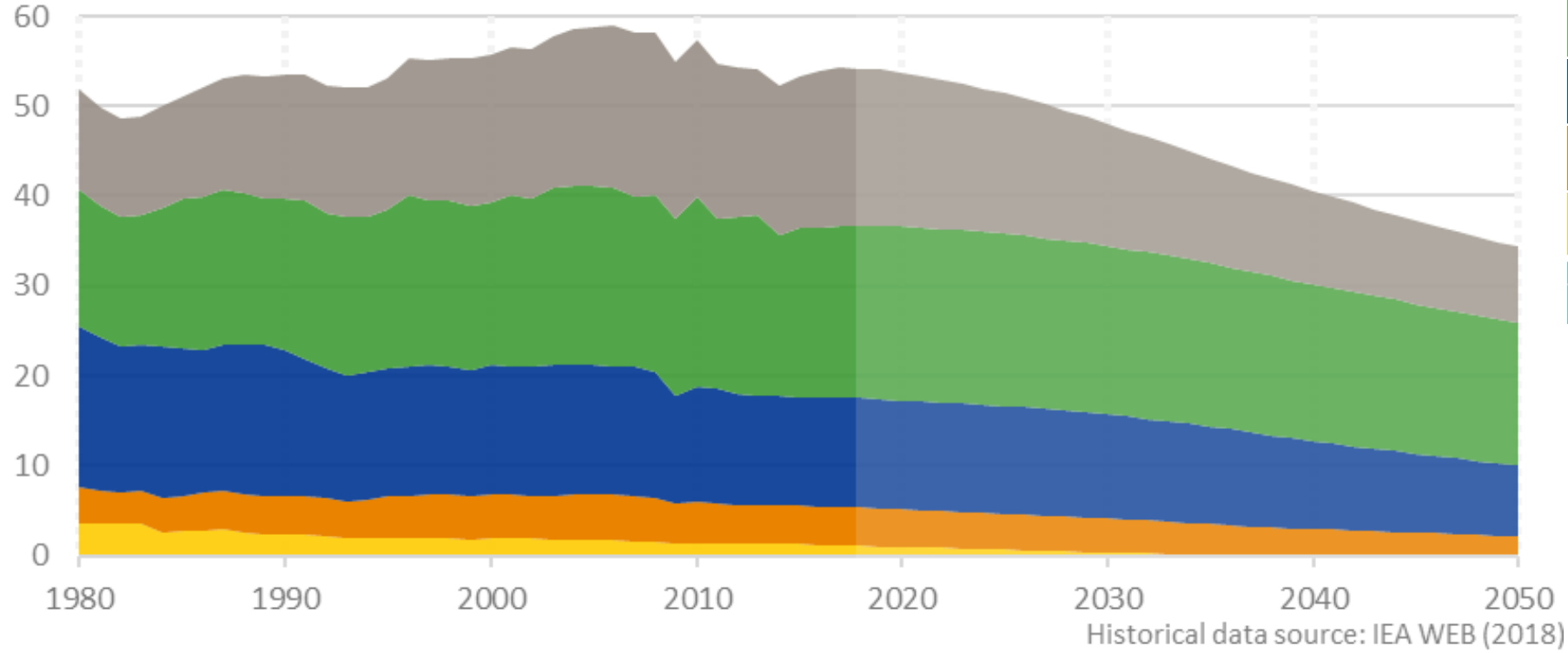
Historical data source: IEA WEB (2018)

Final energy demand

Europe

Final energy demand by sector

Units: EJ/yr



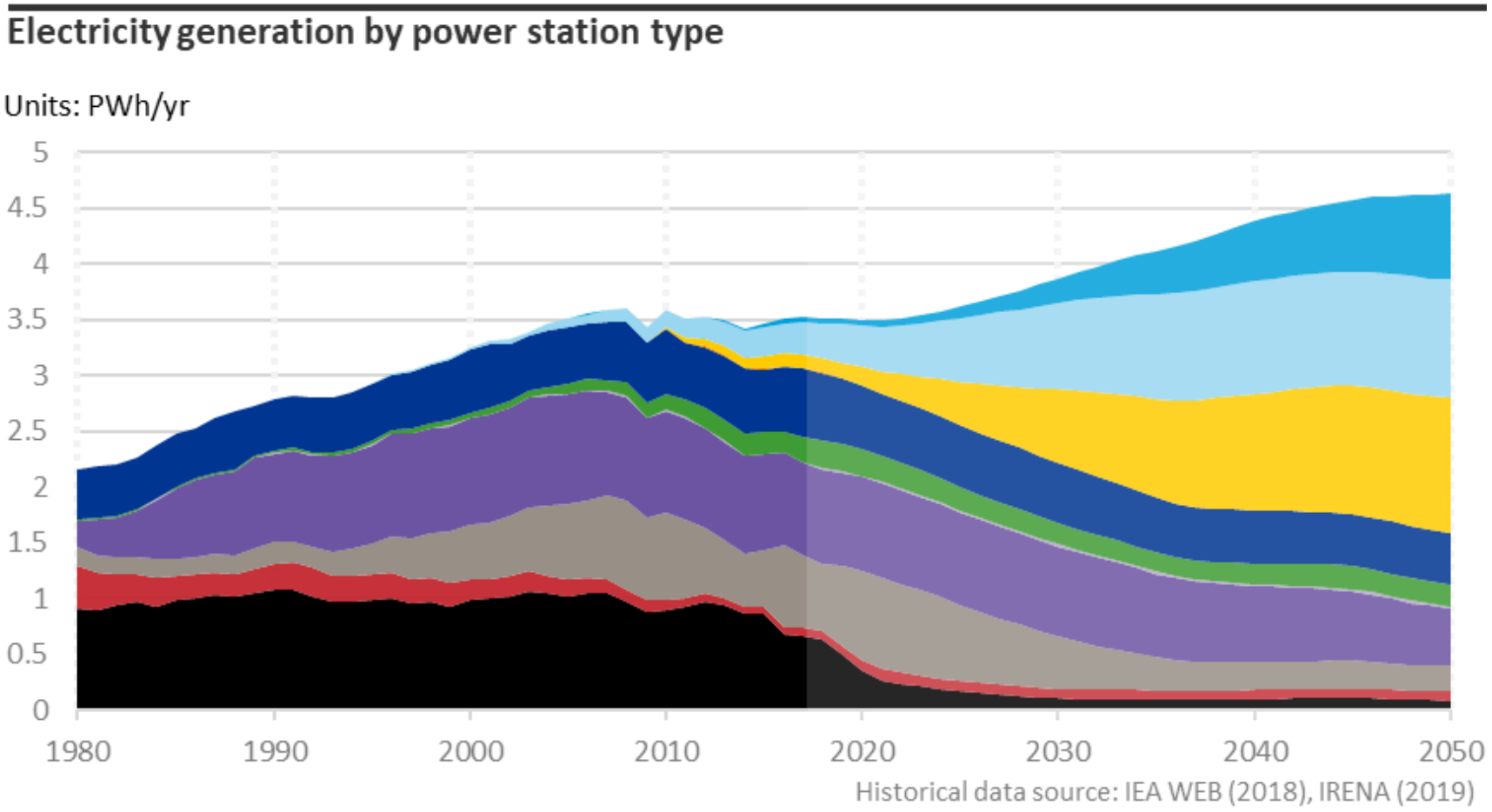
Historical data source: IEA WEB (2018)

Sector	2017	2030	2050
Transport	33%	28%	25%
Buildings	35%	39%	46%
Manufacturing	23%	24%	23%
Non-energy	8%	8%	6%
Other	2%	1%	0%
Total	100%	100%	100%

Table entries may not add up due to rounding.

Electricity generation mix

Europe

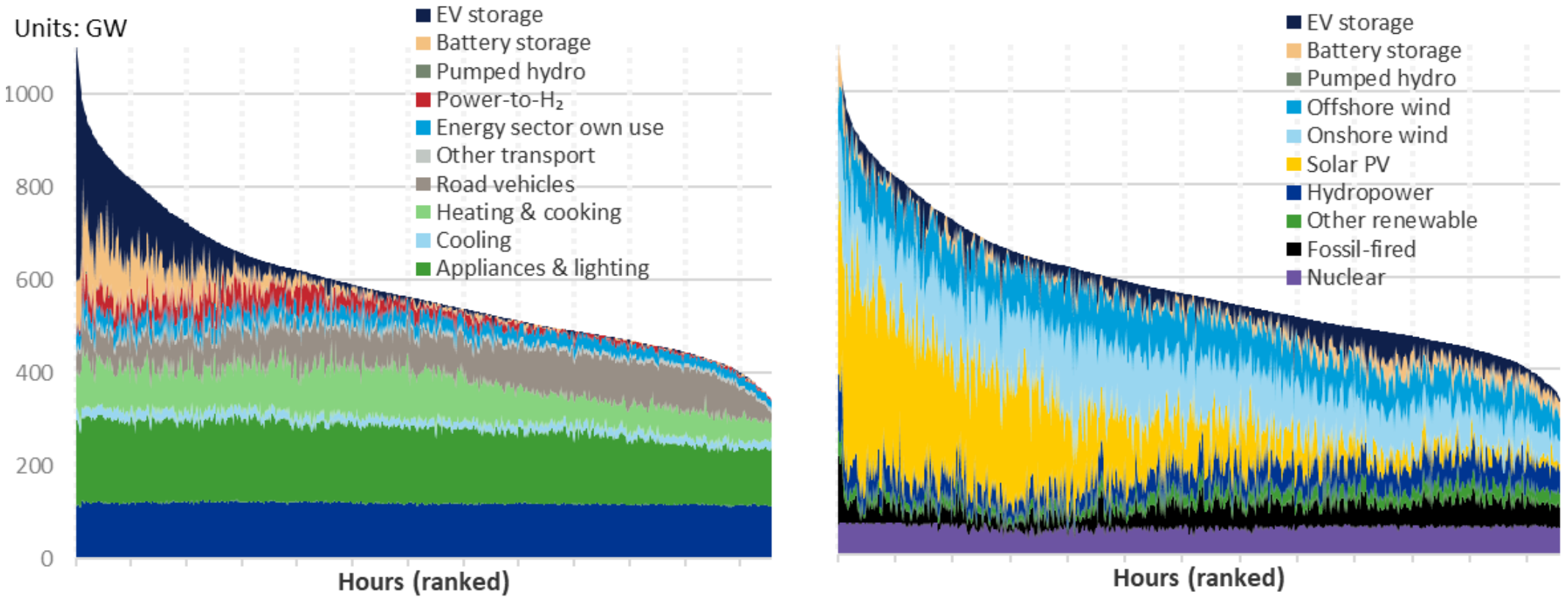


Power station type	2017	2030	2050
Non-Fossil	**61%**	**83%**	**91%**
Offshore wind	1 %	6 %	17 %
Onshore wind	8 %	20 %	23 %
Solar PV	3 %	17 %	26 %
Solar thermal	0 %	0 %	0 %
Hydropower	18 %	14 %	10 %
Biomass-fired	6 %	5 %	4 %
Geothermal	0 %	0 %	0 %
Nuclear	24 %	21 %	11 %
Fossil	**39%**	**17%**	**9%**
Gas-fired	18 %	12 %	5 %
Oil-fired	2 %	2 %	2 %
Coal-fired	19 %	3 %	2 %
Total	100%	100%	100%

Regional story – Towards a flexible power system

Europe

Electricity demand and supply over the year in 2050

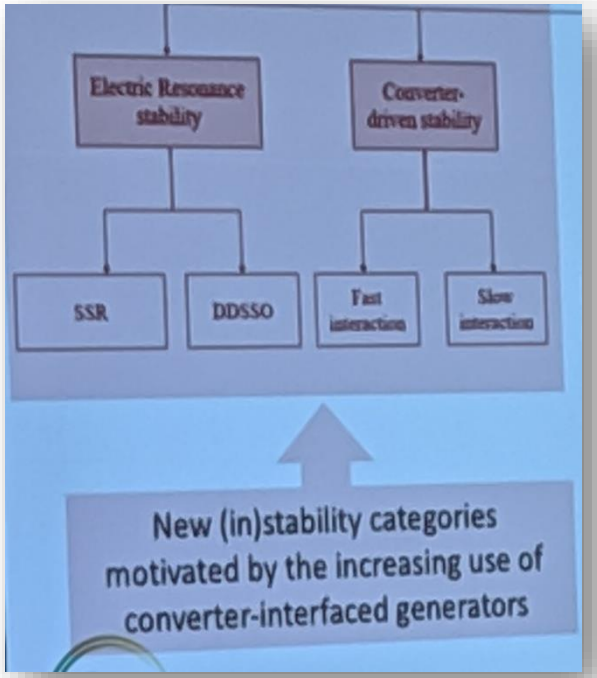


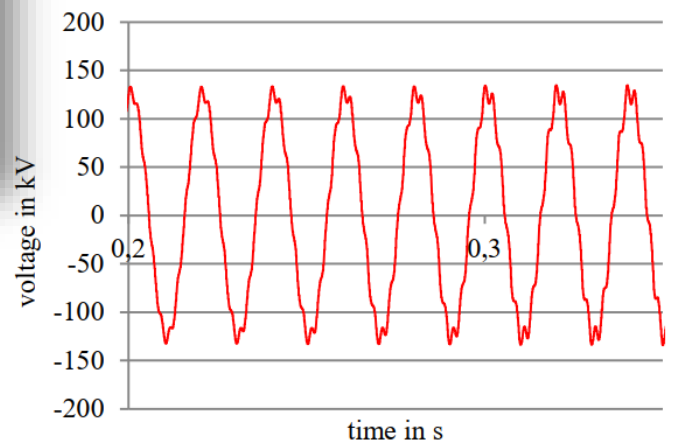
Offshore wind and network grow and concentrate; what about the harmonic stability

- Sustained oscillations have been observed in power systems with VSCs
  - VSC and AC grid
  - Offshore HVDC link and wind farm
  - Related to resonance interactions
    - Caused by interactions of a converter controllers with grid resonance
    - Not to be mistaken as steady state harmonics

➢Often referred to as harmonic instability

  - Converter driven stability

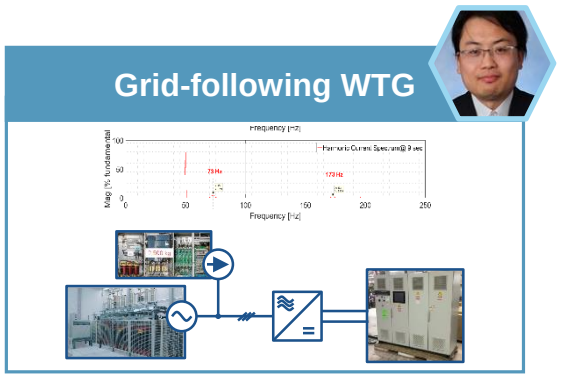




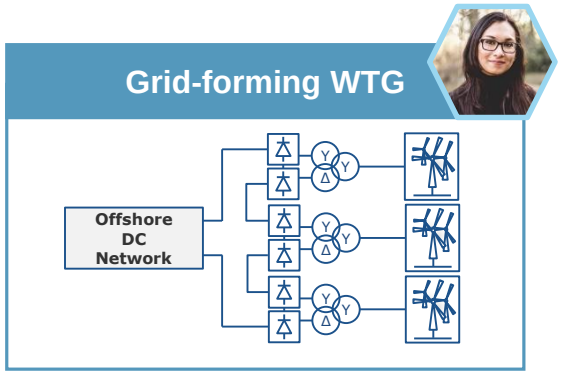
Source: TenneT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

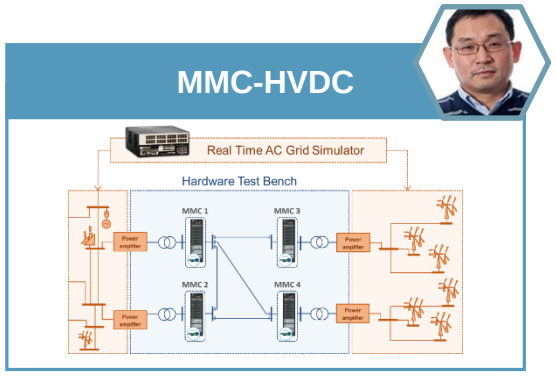
Objectives for working on cyber physical demos



CHiL PHiL



CHiL PHiL Cosimulation

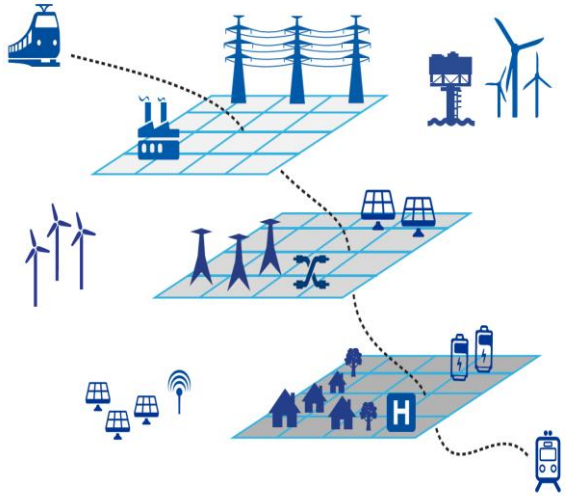


CHiL

- Help industry moving forward in understanding the impact of voltage source converters control on the power system
- Fundamental understanding followed by industrial solutions
- Model validation and fit for purpose testing through CHIL and PHIL
- Assess active component without opening the “blackbox” (manufacture IP)

Model validation through input admittance measurements

Physical Asset



Model Validation

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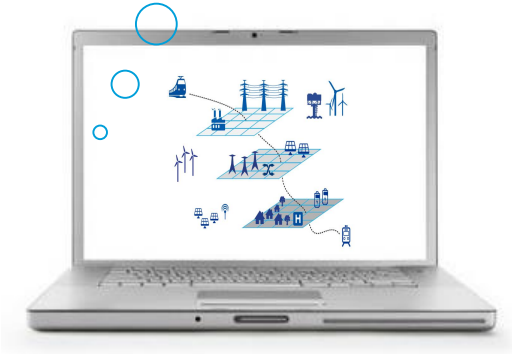
Selection of Tools



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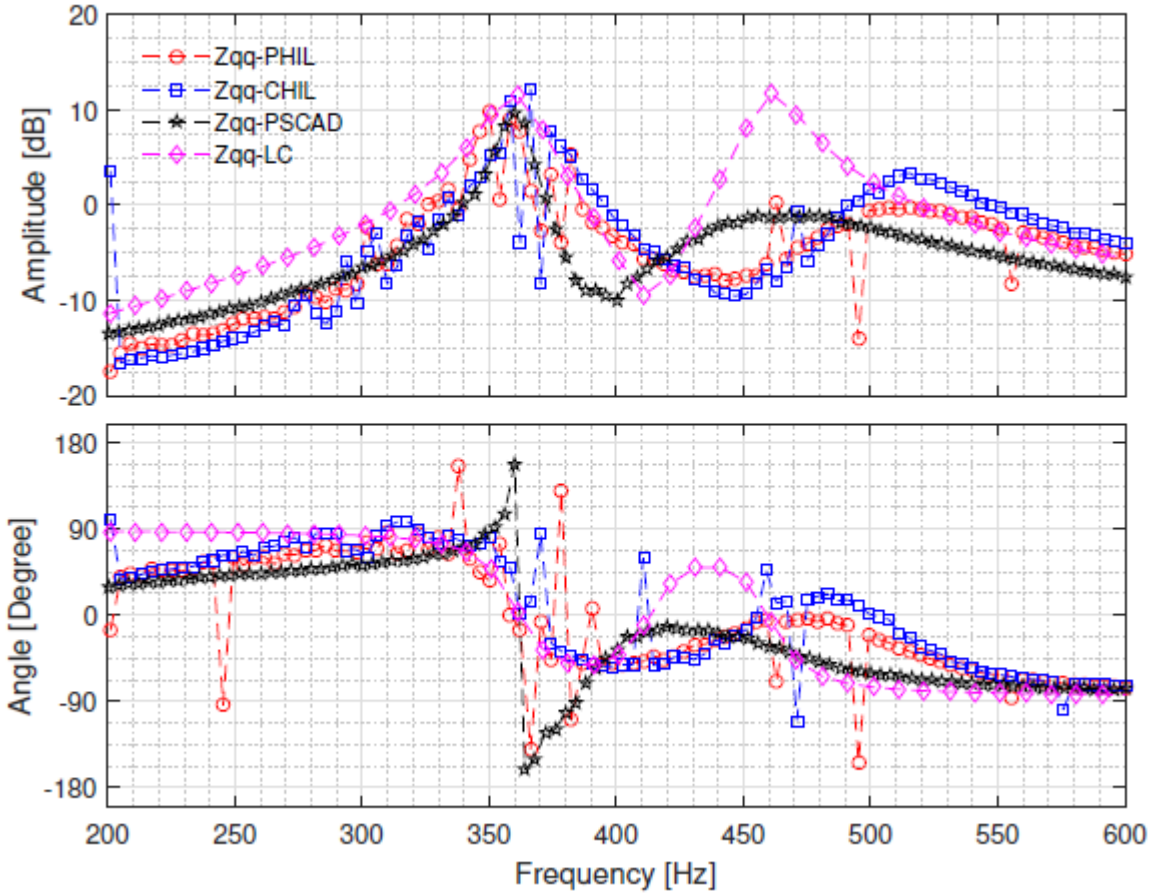
Model validation through input admittance measurements



- Impedance measurement results – Zqq med range 200 Hz to 600 Hz
- Using a small signal AC perturbation method
- Can be done with respect towards manufacturer IP
- Jury is still out be we think this approach can be an industry wide applicable method for model validation

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WELCOME!