

# Novel Switchgear for Future Multi-terminal HVDC Grids



**PROMOTioN**

PROGRESS ON MESHED HVDC  
OFFSHORE TRANSMISSION  
NETWORKS



DNV GL – Energy Advisory

Transmission & Distribution Technology Dept.

Coordinator – PROMOTioN Project

**Dr. Cornelis Plet**

# Overview

- An overview of the PROMOTioN project and meshed HVDC grid development

Cornelis Plet (DNV-GL)

- Development and performance demonstration of HVDC circuit breakers

Nadew Belda (DNV-GL/KEMA)

- Development and performance demonstration of HVDC gas insulated switchgears

Uwe Riechert (ABB)



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

# EU Energy Strategy 2030



**40%**

Cut in greenhouse  
gas emissions  
compared to 1990  
levels



**32%**

Share of  
renewable energy  
consumption



**27%**

Energy savings  
compared with  
the business-as-  
usual scenario



**15%**

Electricity  
interconnection  
target

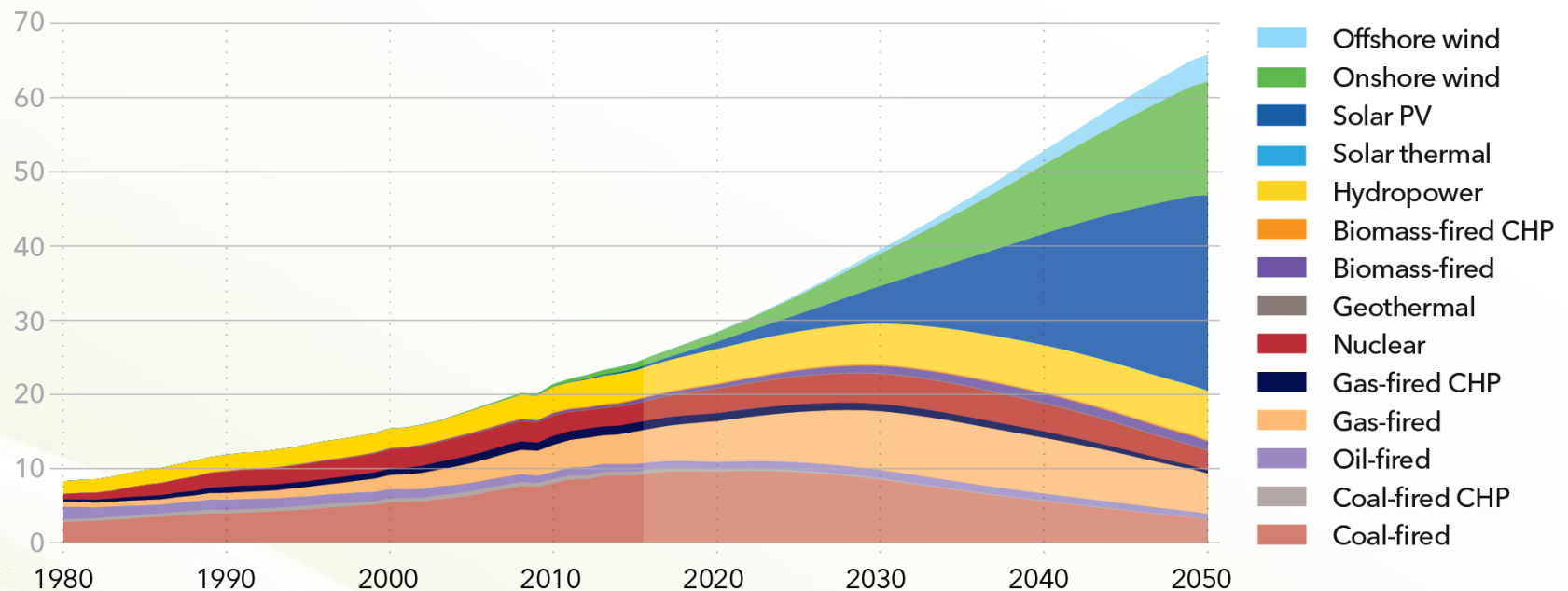


# The transition towards sustainable sources just started

World electricity generation by power station type

CHP = Combined heat and power

Units: PWh/yr



Source: DNV GL Energy Transition Outlook (<https://eto.dnvgl.com/2018>)



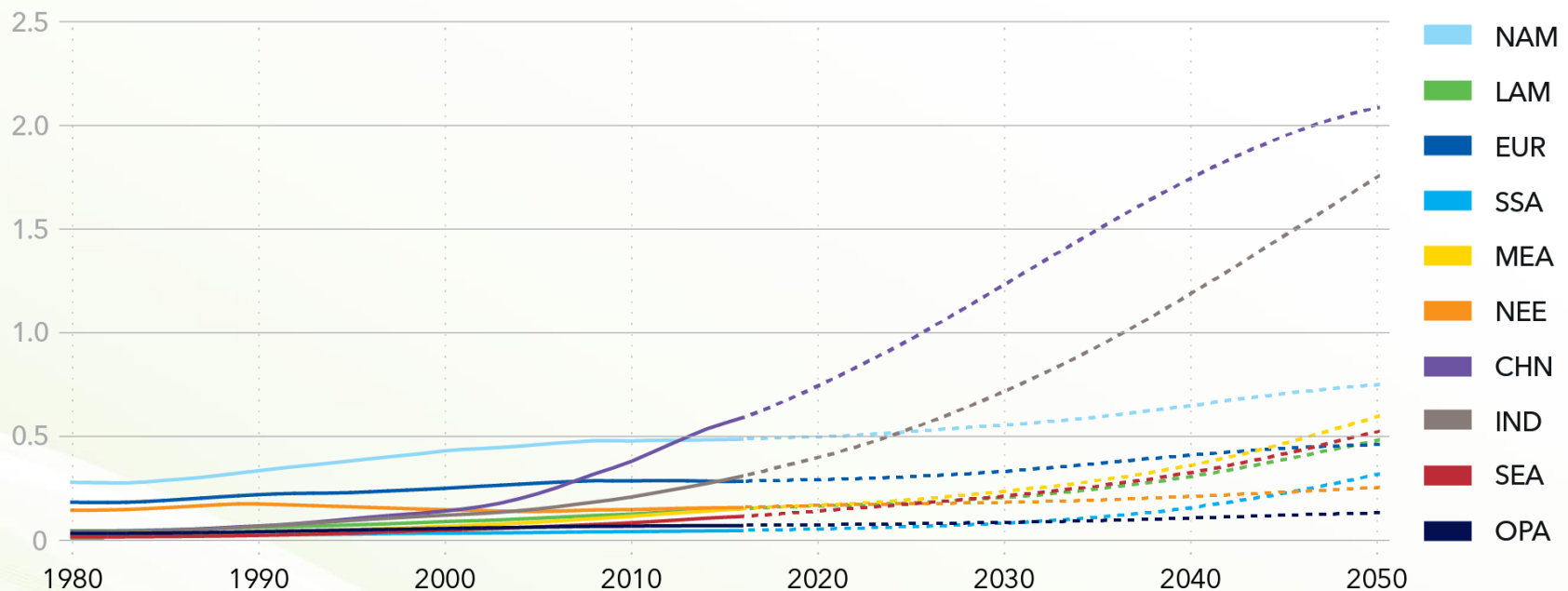
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# Growth of Power Lines Increases by a Factor of >3

## Power line capacity by region

Units: PW-km



Source: DNV GL Energy Transition Outlook (<https://eto.dnvgl.com/2018>)



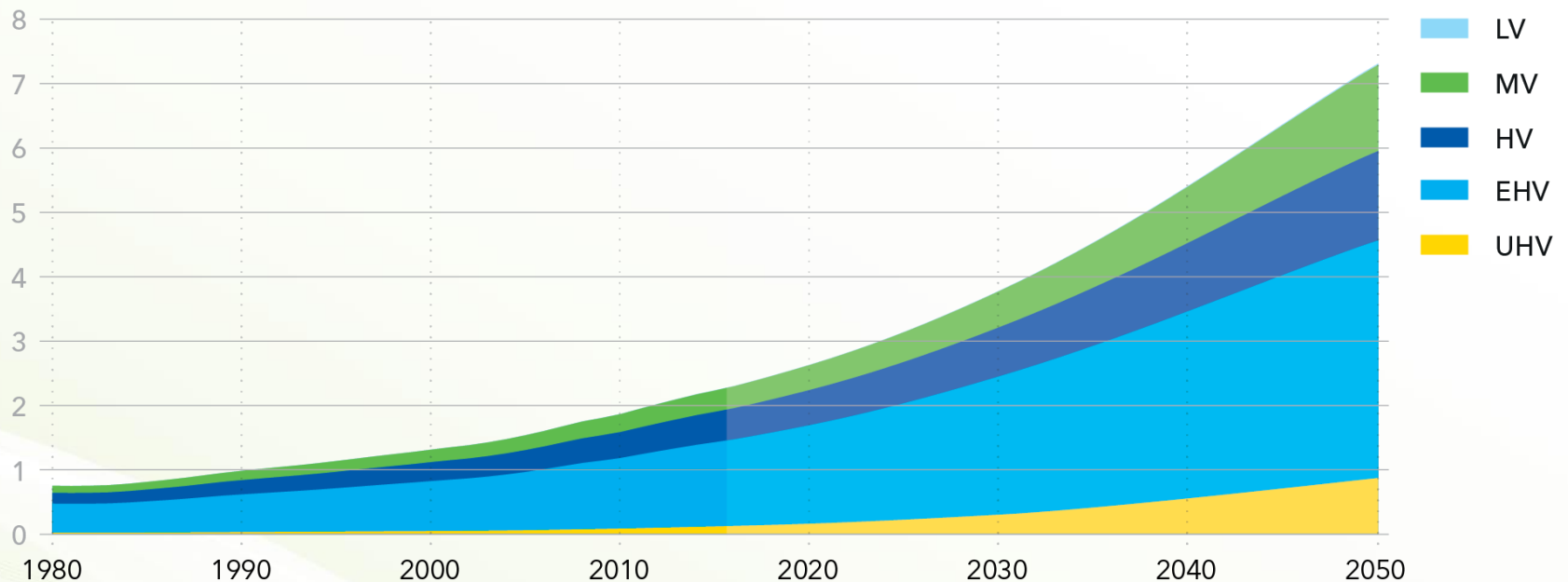
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# Most Growth Occurs at EHV Level!

World power line capacity by voltage

Units: PW-km



Source: DNV GL Energy Transition Outlook (<https://eto.dnvgl.com/2018>)



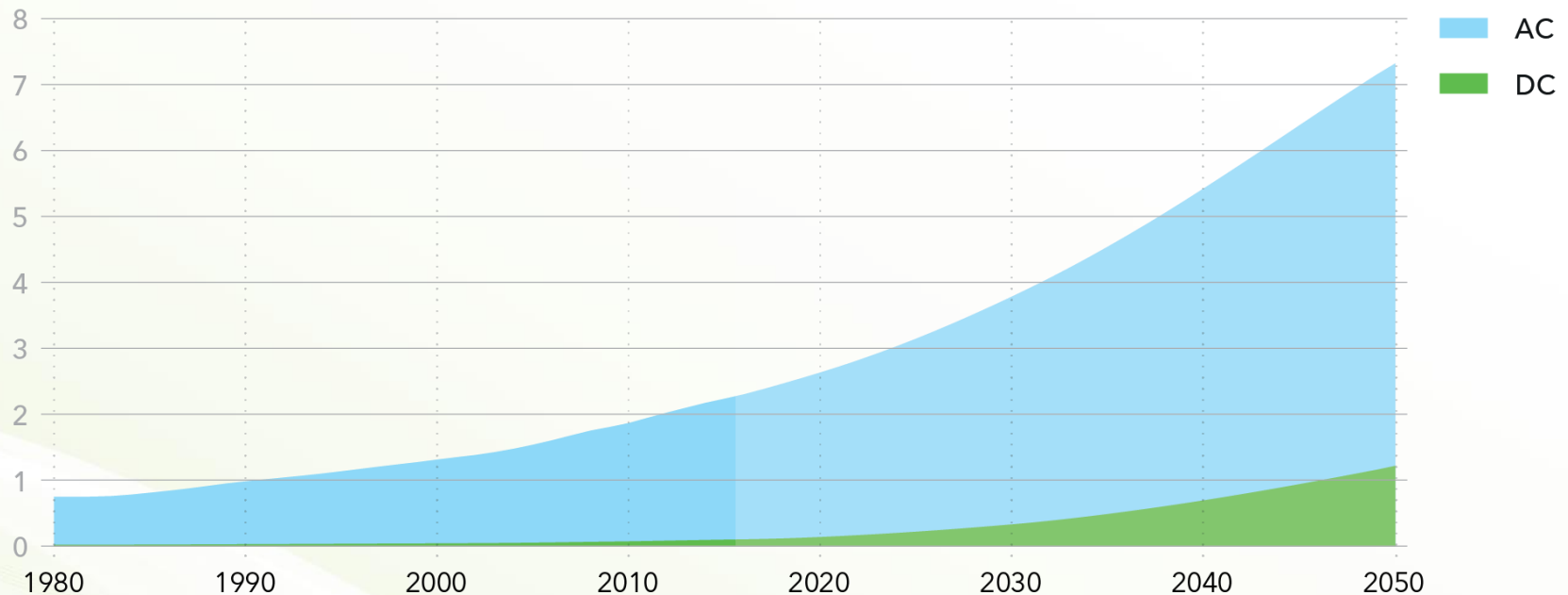
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# Significant Role for DC Transmission

## World power line capacity by technology

Units: PW-km



Source: DNV GL Energy Transition Outlook (<https://eto.dnvgl.com/2018>)

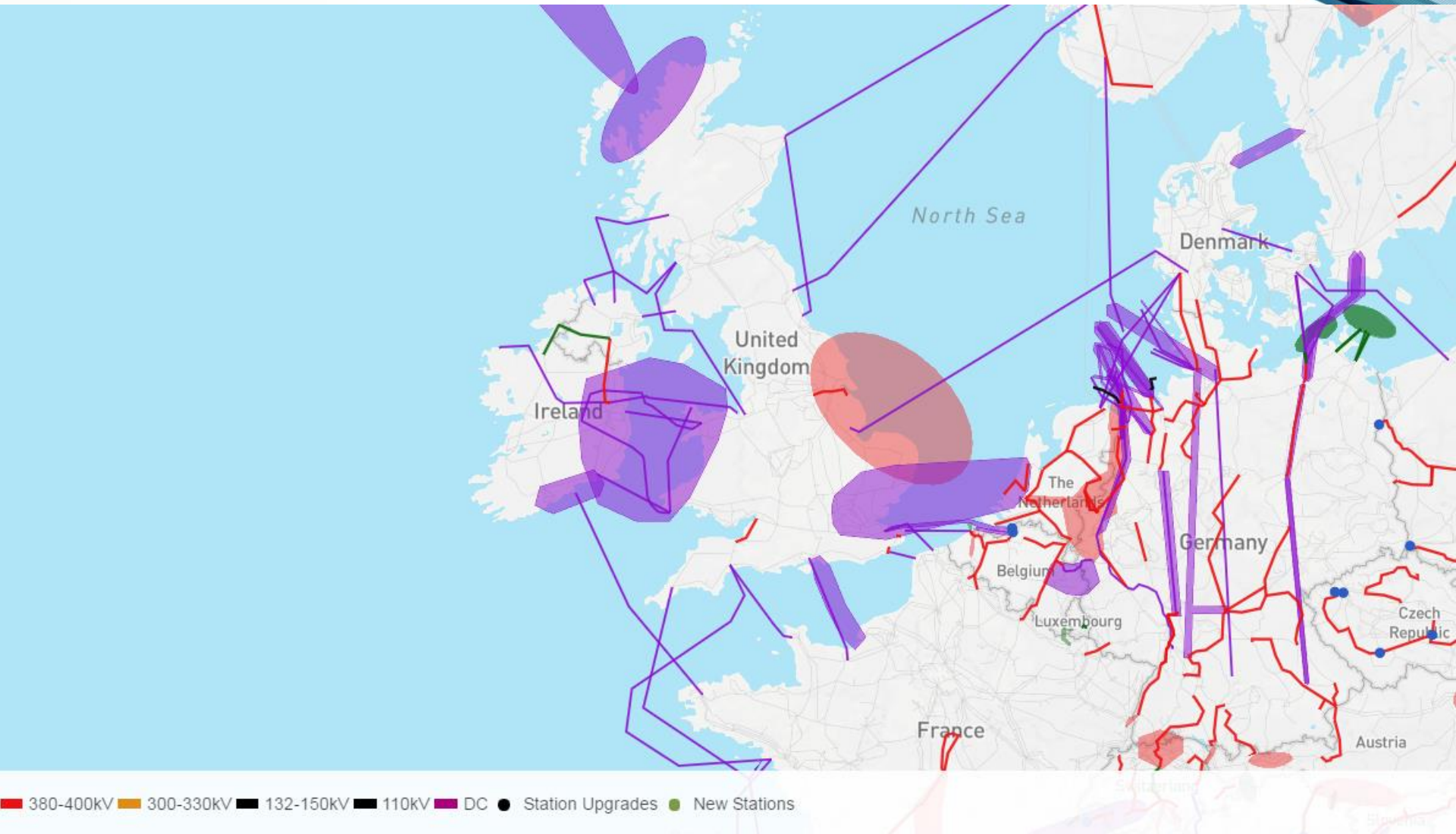


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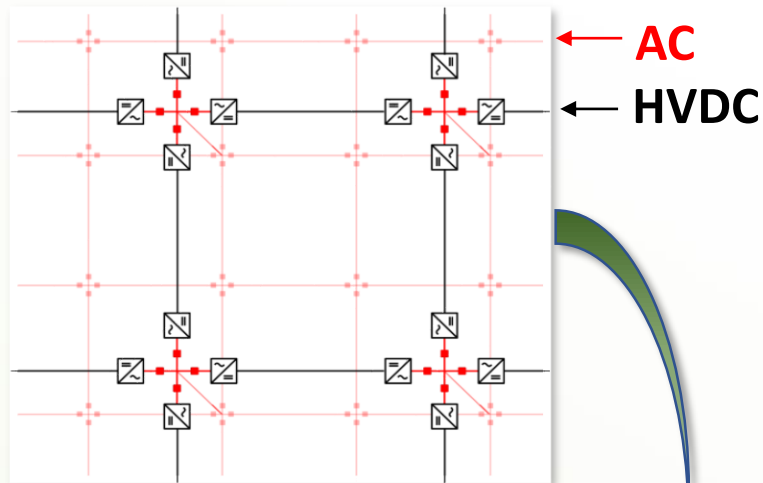


# Grid development in Europe

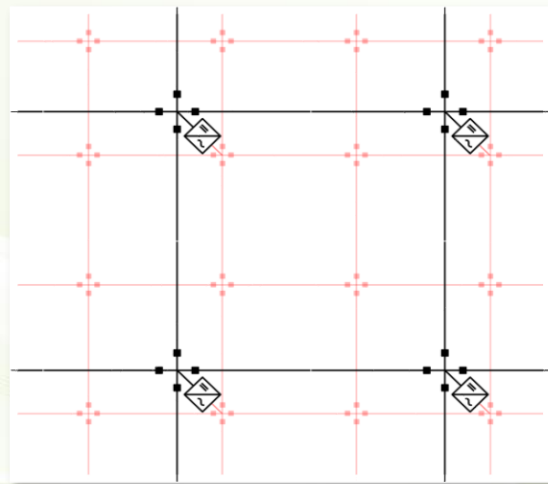




# Benefits of Meshing HVDC connections



Point-point



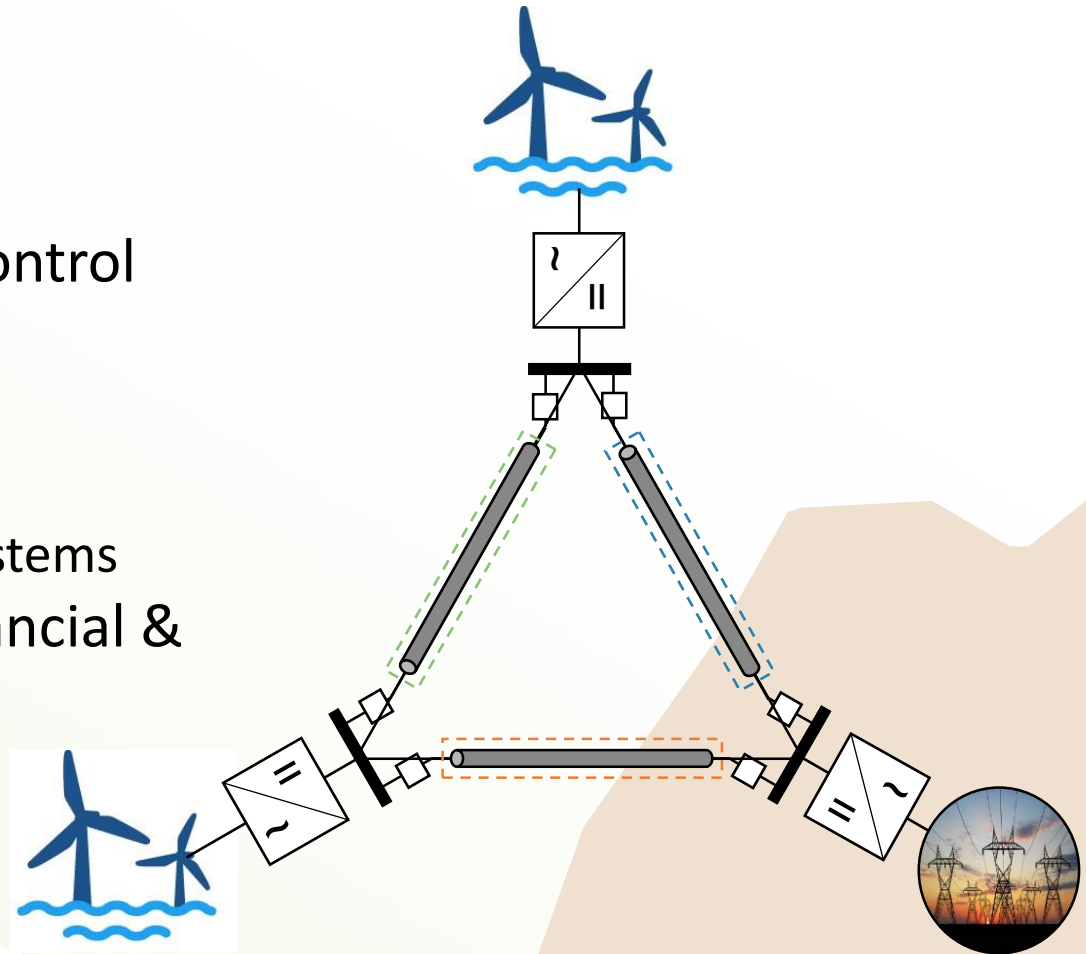
Meshed multi-terminal

- Better utilization
  - Offshore wind power export
  - Interconnection of countries
- Higher availability
  - Redundancy
  - Fewer converters
- Lower losses
  - Fewer converters
- Lower investment
  - Fewer converters



# Ingredients of a Meshed HVDC Grid

- Purpose
- Topology
- Cables
- Converters
- System & wind farm control
- Protection system
- HVDC nodes
  - HVDC circuit breakers
  - HVDC gas insulated systems
- Legal, economical, financial & regulatory framework

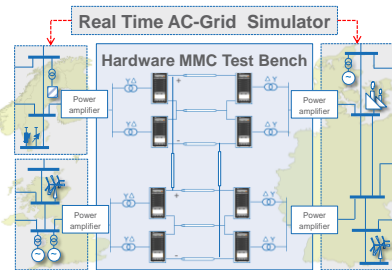


# PROMOTioN Objectives

1. Establish interoperability
2. Develop protection for meshed HVDC offshore grids
3. Demonstrate key technologies
4. Develop a new EU regulatory framework and a suitable financial framework
5. Liaise with working groups and standardization bodies
6. Provide concrete deployment plan

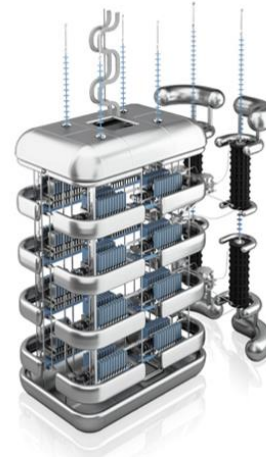


# Demonstrators



## HVDC network control

MMC test bench  
RWTH Aachen  
Aachen, Germany



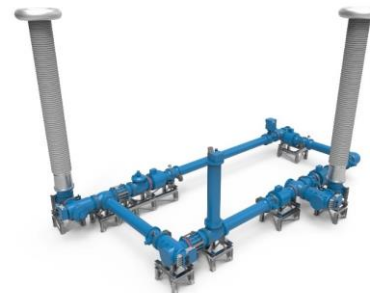
## HVDC circuit breakers

KEMA High Power Lab  
DNV GL  
Arnhem, Netherlands



## HVDC network protection

Multi-terminal test centre  
SHE Transmission  
Glasgow, UK



## HVDC gas insulated systems

KEMA High Voltage Lab  
DNV GL  
Arnhem, Netherlands



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# Statistics



33 partners



11 EU countries



4 years



42 million EUR



# Partners



TSOs



OEMs



Universities



Research  
Institutes /  
Associations



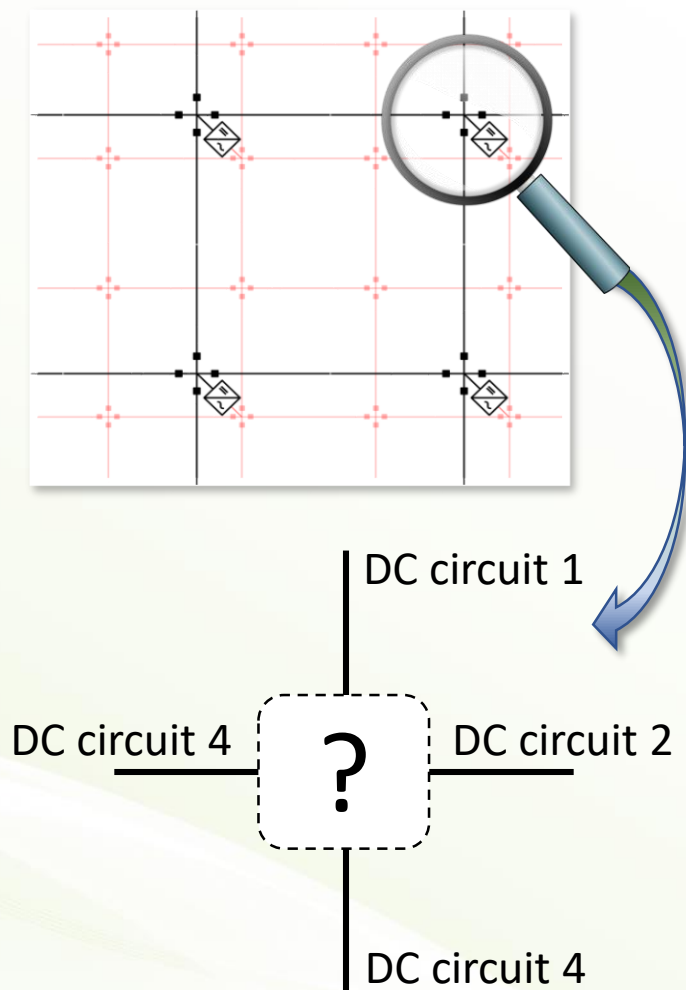
Consultancies



Developers



# HVDC Node Functionality



- To configure grid topology
  - On-line vs off-line
  - On-load vs off-load
- To provide measurements
  - On-line and off-line
- To provide protection
  - From over-voltages
  - From over-currents (faults)
- To control power flow
- To provide a grounding point
  - Metallic return arrangement
  - Pole rebalancing
- To act as transition point





# HVDC Node Equipment

## HVDC switchgear

- HVDC Disconnecting switches
- HVDC Earthing switches
- HVDC Commutating switches
- HVDC Pre-insertion resistors
- HVDC Circuit breakers

## HVDC overvoltage protection

- HVDC surge arrestors
- HVDC choppers & pole rebalancing

## HVDC Instrumentation

- HVDC Voltage sensors
- HVDC Current sensors
- Fault location detection

## HVDC interfaces

- HVDC wall bushings
- HVDC cable terminations

## To provide a grounding point

- Earthing impedance
- Metallic return arrangement

## To control the power flow

- HVDC Power flow controller

## To minimize space requirement

- Gas insulated systems

## To be environmentally friendly

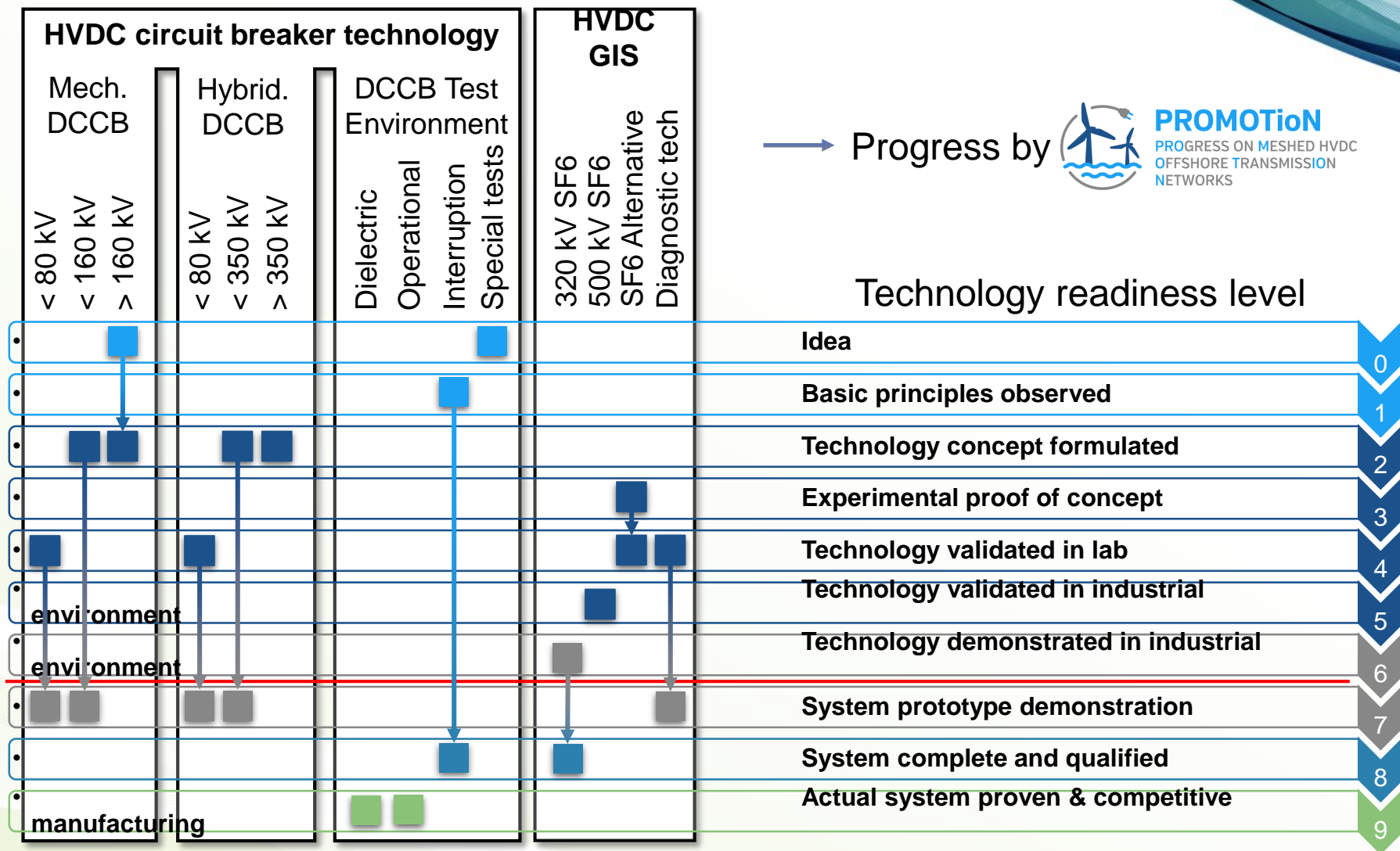
- SF6 alternatives

## To be qualified, safe & reliable

- Test environment



# Technology maturity



# Newsletter



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