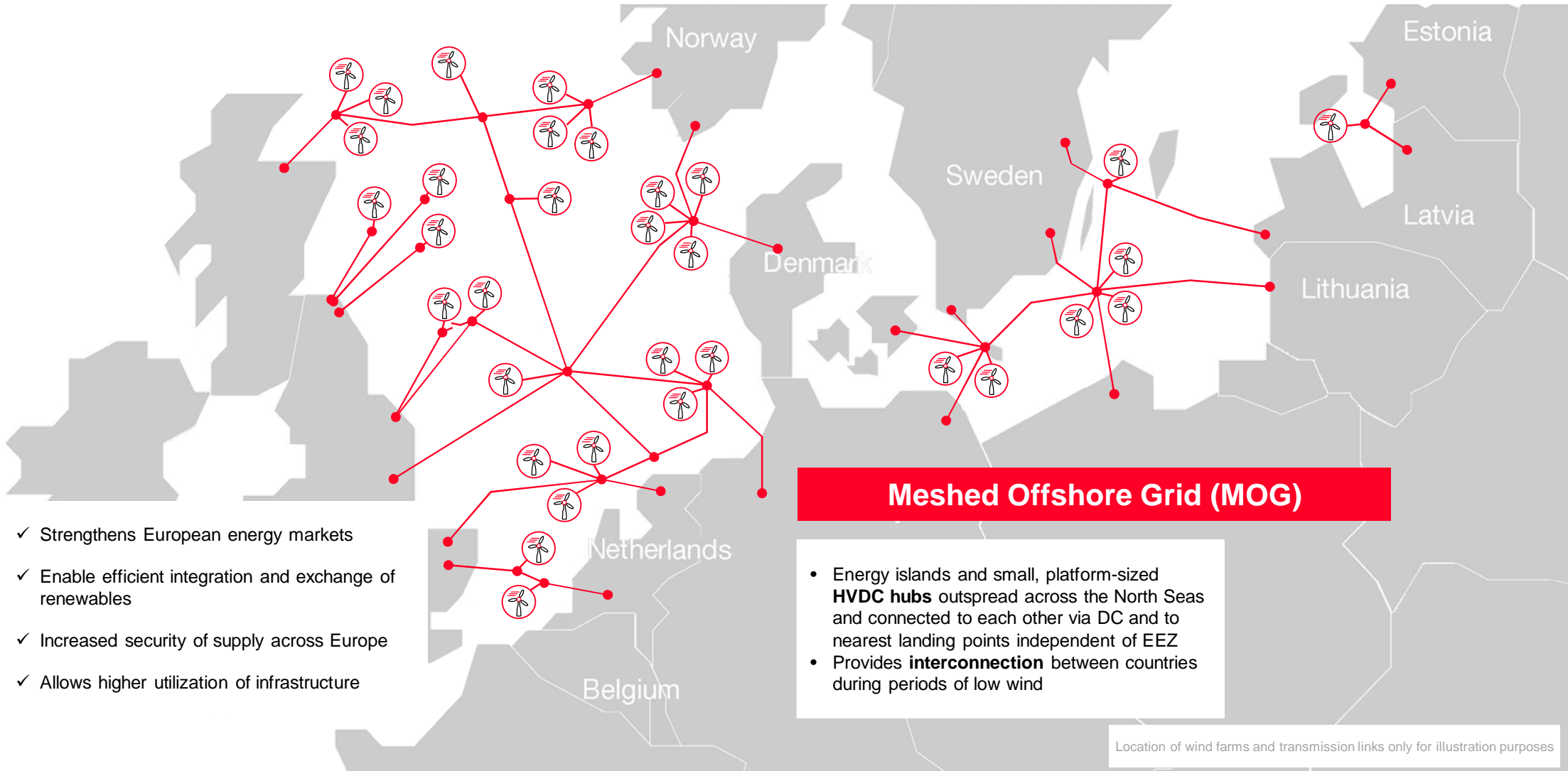


# Transition toward future DC Grids

## BNetzA: Wissenschafts-Dialog 2022

Sebastian Papapanagiotou  
September 23, 2022

# Future scenarios - Offshore wind expansion



- ✓ Strengthens European energy markets
- ✓ Enable efficient integration and exchange of renewables
- ✓ Increased security of supply across Europe
- ✓ Allows higher utilization of infrastructure

## Meshed Offshore Grid (MOG)

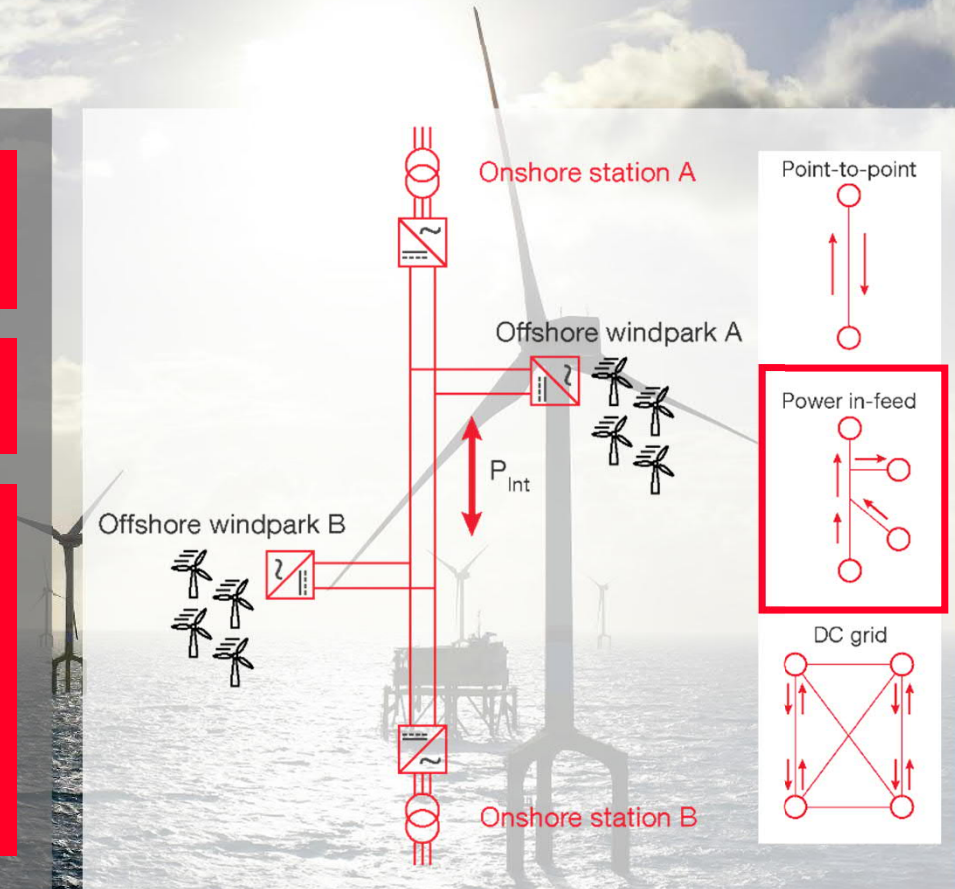
- Energy islands and small, platform-sized **HVDC hubs** outspread across the North Seas and connected to each other via DC and to nearest landing points independent of EEZ
- Provides **interconnection** between countries during periods of low wind

- ✓ Connects two energy markets
- ✓ Integrates (renewable) power sources along the corridor
- ✓ And/or electrifies load along the corridor

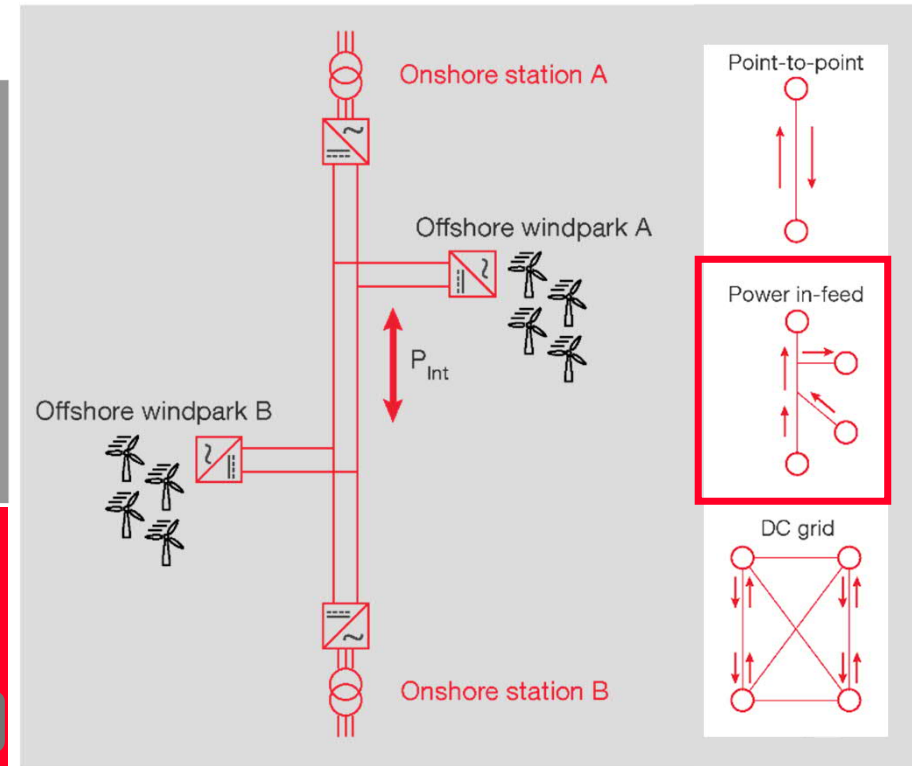
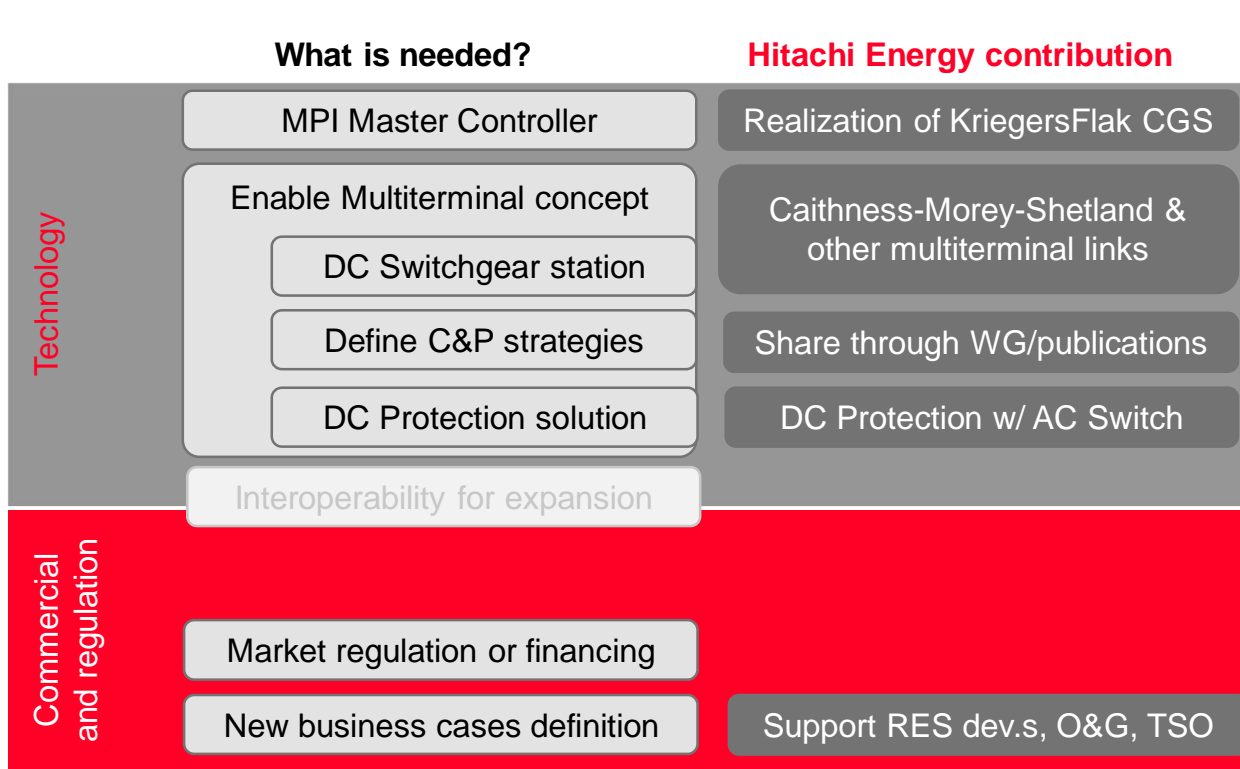
**Can be built today with existing, proven technology**

Typically, a regional DC Grid and defined as a system that constitutes of one protection zone for DC earth faults.

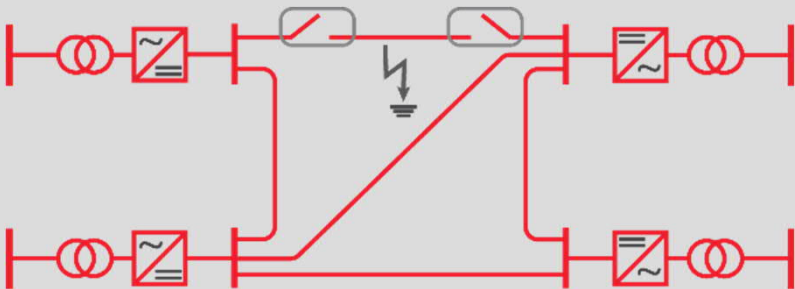
- Normally radial or star network configurations
- Limited power rating
- To temporarily and rarely lose the whole HVDC system has a limited impact on the overall power system.
- Different optimization functions – Control & Protection (Master Control) for multi-terminal operation and grid control

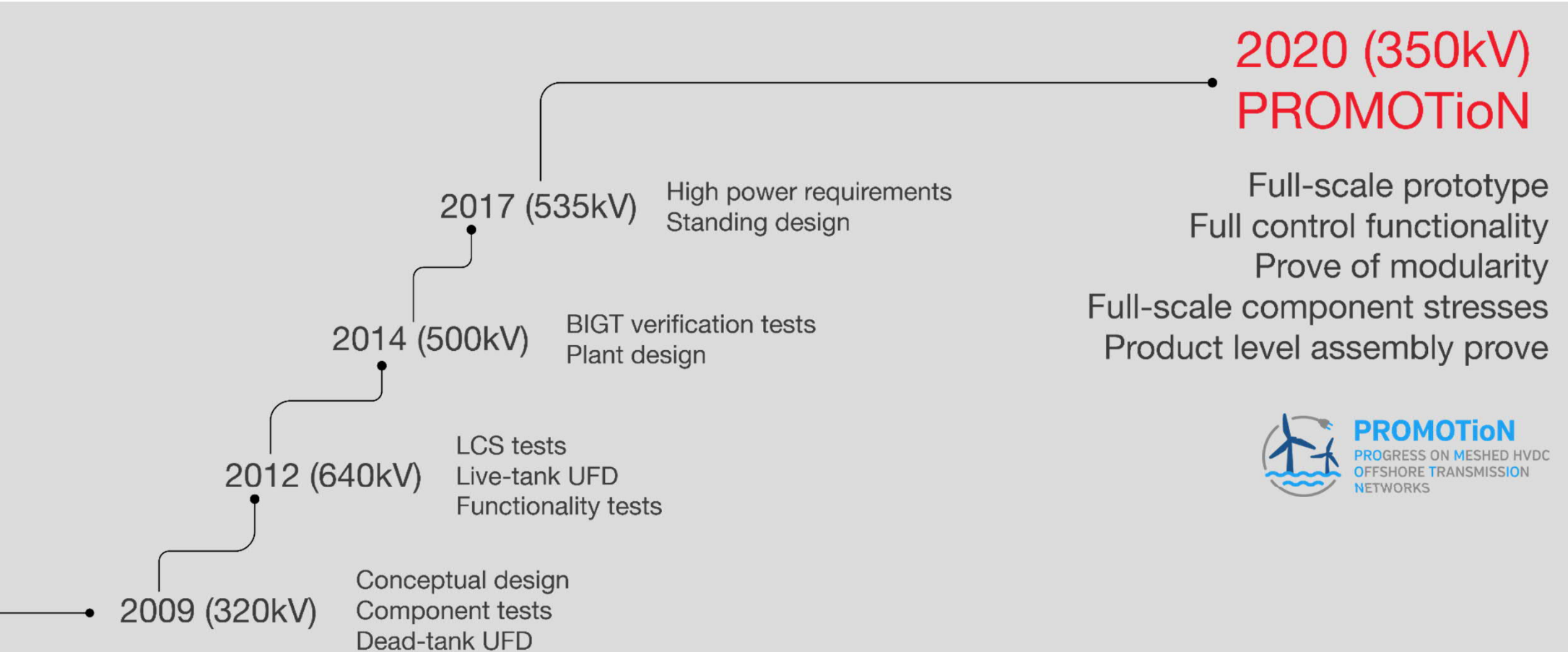


## Paving the way



- Enabler for Meshed HVDC grids
- In case of a fault, ensures that only affected part of the grid is disconnected
- Increasing availability and reliability of the system
- Conventional breakers are not suitable for DC grids
- To enable different protection zones in the DC grid
- ... through fast response, high reliability, low losses





## Paving the way



Strengthens energy markets



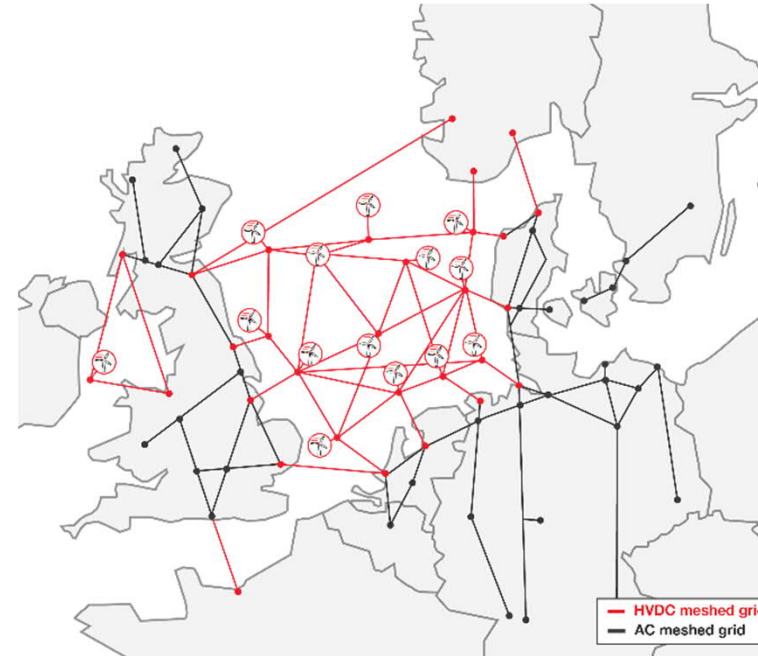
Enable efficient integration and exchange of renewable energy in line with environmental goals



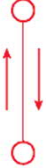
Increased security of supply across the Region



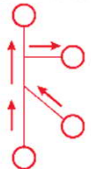
Allows higher utilization of infrastructure



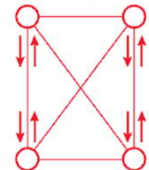
Point-to-point



Power in-feed

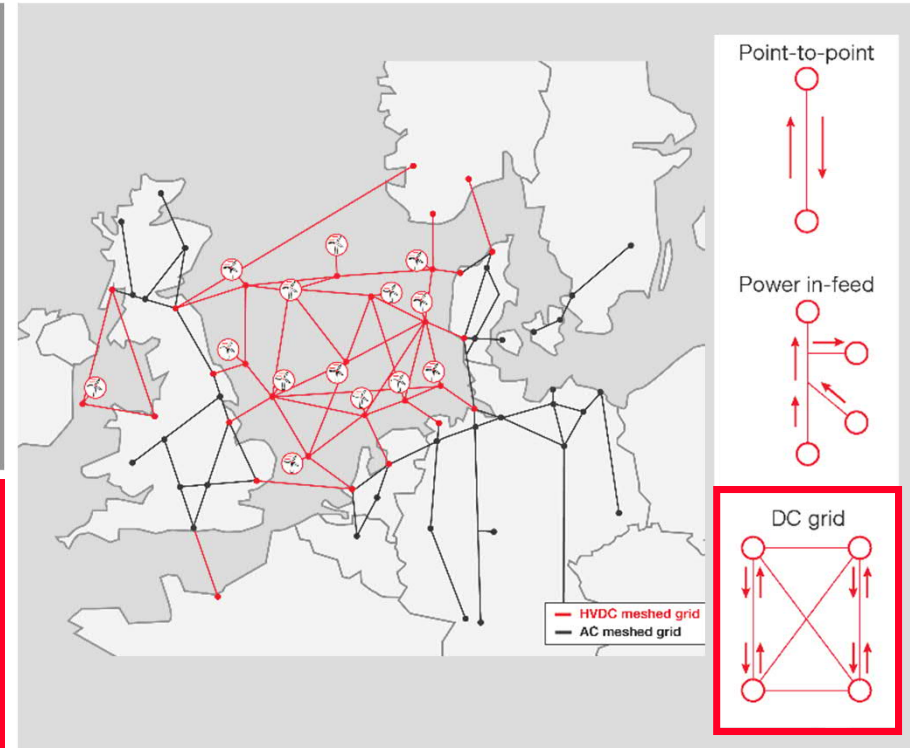


DC grid

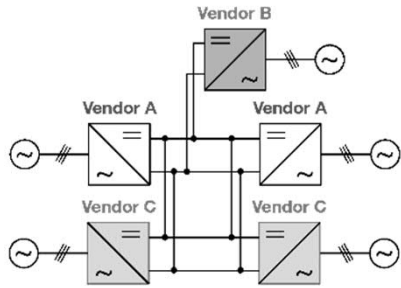


## Paving the way

	What is needed?	Hitachi Energy contribution
Technology	MPI Master Controller	Realization of KriegersFlak CGS
	Enable Multiterminal concept	Caithness-Morey-Shetland & other multiterminal links
	DC Switchgear station	Share through WG/publications
	Define C&P strategies	DC Breaker development
	<b>DC Protection solution</b>	
Commercial and regulation	<b>Interoperability for expansion</b>	
	Technical interoperability	Active in trade associations
	DC GridCode / Ownership	Support industrial consultations
	New Procurement Process	Support RES dev.s, O&G, TSO
	New business cases definition	







## VSC Multi-terminal

Ability to manage different DC lines from 1 station

- Hitachi Energy demonstrated the technology
- Multi-terminal ready and multi-terminal prepared
- Project examples: NordBalt and Shetland

## DC breaker

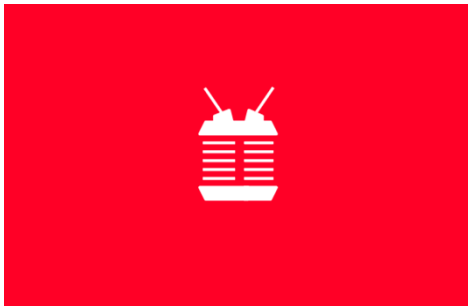
Ability to isolate fault current on DC mesh

- Hitachi Energy demonstrated the technology
- Demonstration in 2020: 350 kV, 20 kA power range
- Demonstration as part of EU-funded PROMOTioN project

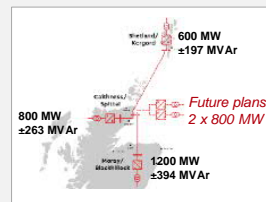
## DC meshed grid C&P

Ability to supervise power flows across a DC meshed grid

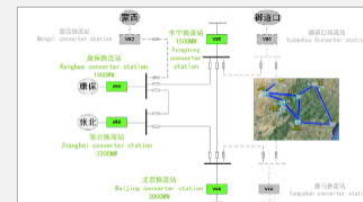
- Hitachi Energy active at CIGRE WG
- Technology development of control and protections algorithm done
- Simulation part of DC grid program



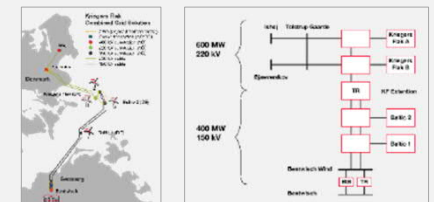
## Caithness-Moray Shetlands grid



## Zhangbei DC grid project



## Kriegers Flak CGS





Ability of a system  
to work **together with other  
systems**, now or in the  
**future, without restriction**

**Needed for expansion  
possibility of DC Grids**

**System**

Defined by its external  
interfaces and  
functionalities

**Together  
with other  
systems**

Ability to communicate and  
coordinate with other systems  
directly connected

**In the  
future**

Multi-stage (stepwise)  
development

**Without  
restrictions**

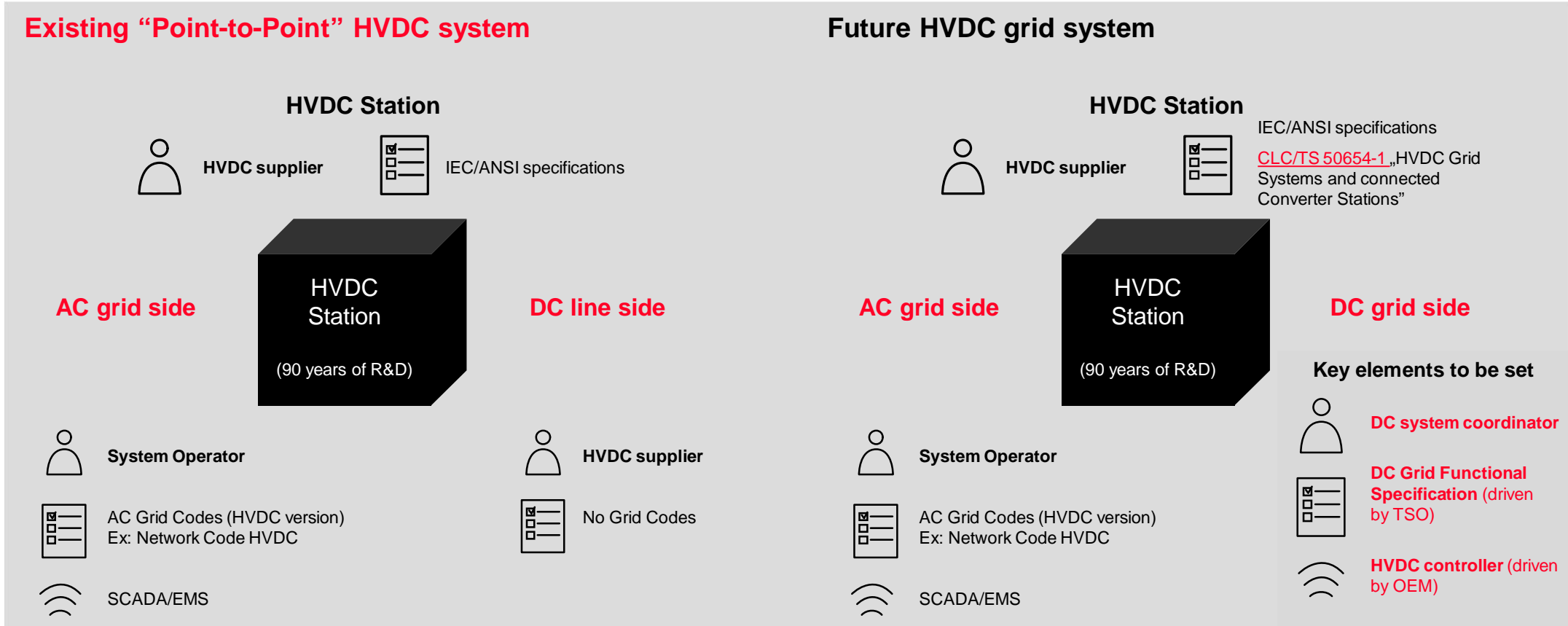
Performance according  
to specifications

## Current situation

Point-to-Point (P2P) connection	
Standalone “black-box” dual converters	
Single vendor	
System design after EPC award	
Examples	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><b>Dogger Bank</b> P2P Developer connection</p> </div> <div style="text-align: center;"> <p><b>Dolwin5</b> P2P TSO connection</p> </div> </div>

## Upcoming situation – Multivendor setup

Meshed grid connection	
Collection of “open-box” single converters	
Multi-vendors	
System design before EPC award	
Examples	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><b>Ijmuiden Ver</b> Possible NL-UK single line multi-terminal</p> </div> <div style="text-align: center;"> <p><b>North Sea offshore</b> meshed DC grid</p> </div> </div>



Ensuring interoperability with AC grid codes and DC functional specifications



**Hitachi Energy has been, is and will be main active player in defining DC Grids of the future**

Project driven by consortium of (HVDC system manufacturers, TSOs, third party HVDC system integrators, wind turbine manufacturers, offshore wind farm devel.

Main objective:

Enable interoperability of multi-vendor HVDC.

Main Hitachi Energy task:

Control and Protection Development and System Integration in Multi Vendor Environment

With nearly 40 leading organizations from research, industry, utilities, and transmission systems operators. Hitachi Energy part of the project, together with Siemens, GE, Toshiba. 50Hertz, Elia, Terna, EnerginetDK, Statnett, RTE, Red Electrica examples of Utility partners.

Main Objective:

Project will help to overcome the challenges of integrating renewable energies into Europe's energy mix.

Technical Committee with participation from Hitachi energy, Siemens, GE and different European TSOs.

Main Objective:

Development of guidelines for HVDC Grids Systems.

Task completed, approved EU standard

“HVDC Grid Systems and connected Converter Stations – Guideline and parameter List for Functional Specification” Base for InterOPERA work.

Ongoing translation to an IEC standard.

- DC Grid is enabler to energy transition
- The DC Grid will evolve (Point-to-Point – Energy HUB – MPI – Meshed)
- Hitachi Energy has been, is, will be key active player in industrial initiatives
- All concepts are in place, risk is manageable
- We support DC Grid scalability through Multi-Vendor Interoperability
- Interoperability is not only OEM technical matter!  
(Regulations, DC Grid Code, Functional Spec, planning activities, business models, procurement...)

### The drivers behind future DC Grids

**World energy trends**

- 1.3% global growth (Energy demand to 2040)
- >50% wind and solar PV of the additional power generation to 2040
- 30 million people employed in global renewable energy sector
- \$1 trillion potential investment in clean energy infrastructure and projects
- 20 Gt CO<sub>2</sub> emission reductions in the Sustainable Development Scenario
- 40% cost declines in battery costs (technology breakthroughs)

**Energy shift and grid interconnections are interdependent**

Large-scale RES | 100% RES

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### Future scenarios - Offshore wind expansion

**Meshed Offshore Grid (MOG)**

- Integrate distant energy markets
- Enable efficient integration and exchange of renewables
- Secure and connected to each other via DC and to nearest onshore power transmission of AC
- Prevents interconnection between countries during periods of low wind
- Energy flows and work in different time zones
- MOG links equipped across the time zones
- Secure and connected to each other via DC and to nearest onshore power transmission of AC
- Prevents interconnection between countries during periods of low wind

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### The first regional DC Grid in Europe

**Customers**  
Scottish and Southern Electric to Network (SSEN) Transmission

**Customer needs**  
To link Scotland to the UK transmission system

**Our response**  
7.48 mile regional HVDC interconnector in Europe, with unique offshore transmission

**Customer benefits**  
- Enhance energy security and provide flexibility to transfer power in multiple directions, based on supply and demand, with minimal power losses  
- Boost renewable energy used and overall capacity of power supply  
- Help to control and transfer and connect power well on the island in the UK  
- Contribute to meeting all greenhouse gas emissions (1 and energy) goals

Year: 2021

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### Hitachi Energy Involvement

Hitachi Energy has been, is and will be main active player in defining DC Grids of the future

Project driven by SuperGrid Institute and collecting consortium of (HVDC) system manufacturers, TSOs, third party HVDC system integrators, wind turbine manufacturers, offshore wind farm devel. Main objective: Enable interoperability of multi-vendor HVDC. Main Hitachi Energy task: Control and Protection Development and System Integration in Multi-Vendor Environment

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### Enabling DC Grid – HVDC Breaker

- Enabler for Meshed HVDC grids
- In case of a fault, ensures that only affected part of the grid is disconnected
- Increasing availability and reliability of the system
- Conventional breakers are not suitable for DC grids
- To enable different protection zones in the DC grid

... through fast response, high reliability, low losses

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### HVDC Interoperability – Functional Grid Code solution

**Existing "Point-to-Point" HVDC system**

**Future HVDC grid system**

Ensuring interoperability with AC grid codes and DC functional specifications

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Inspire the Next 