STOCKHOLM 12.03.2019

Offshore wind connection

Challenges and solutions

Peter Sandeberg, Global Product Manager

ABB: the pioneering technology leader

What (Offering)	Pioneering technology		
	Products 58%	Systems 24%	Services & software 18%
For whom (Customers)	Utilities	Industry	Transport & Infrastructure
	~35% of revenue	~40% of revenue	~25% of revenue
Where (Geographies)	Globally		
	Asia, Middle East, Africa 38%	Americas 29%	Europe 33%

~$34 bn revenue	~100 countries	~147,000 employees

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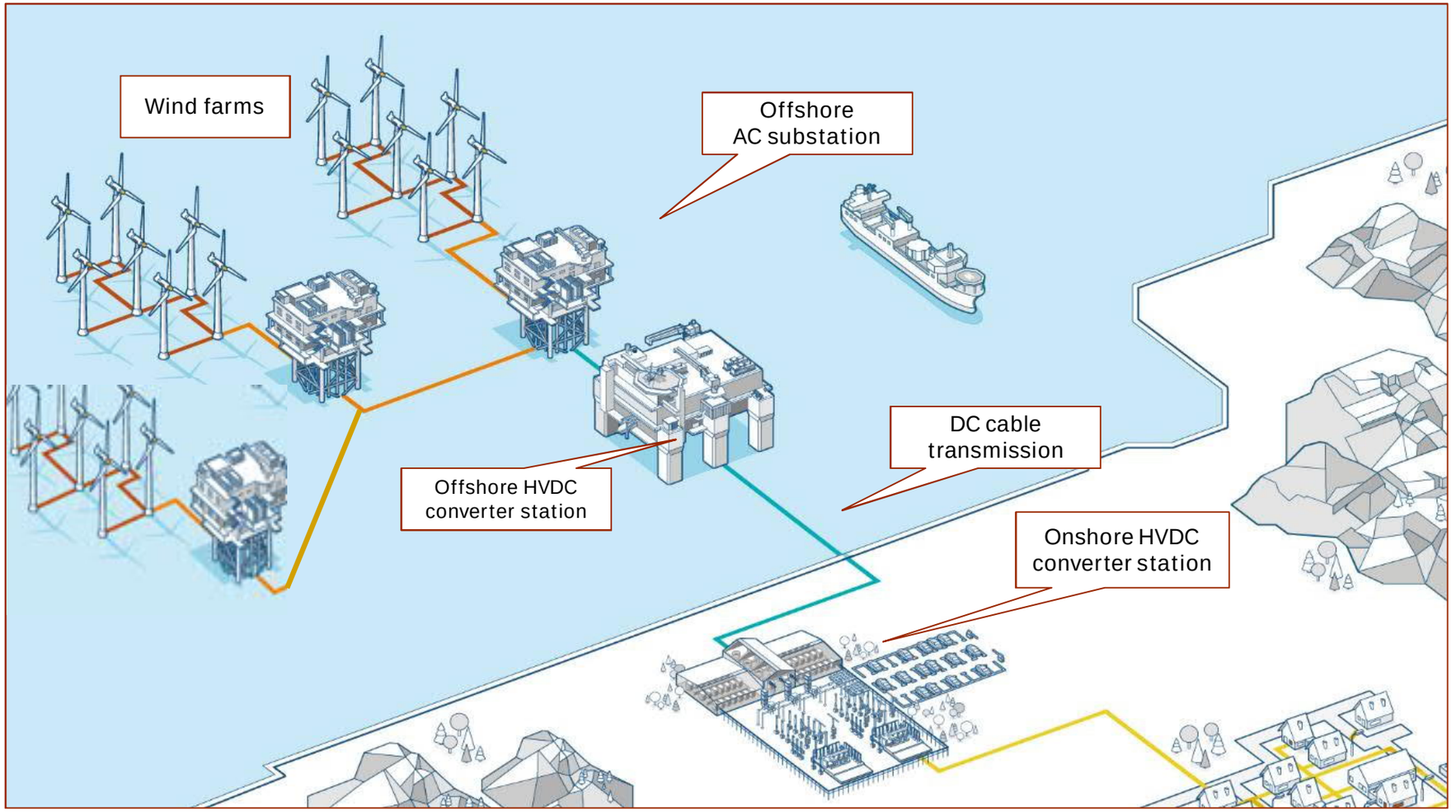
Offshore Wind Connections



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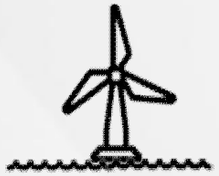
Offshore wind connections

Challanges

- General
  - High market demand
  - Limited supply base in some areas
  - LCOE too high
- Huge and complex projects involving many stakeholders
  - Long lead times
  - Coordination
  - Interface management
- Grid
  - Security of supply
  - Remote connections
  - Grid resiliency
  - Lack of standards
- Harsh environment
- ……

Offshore wind connections
Customized solutions

Generation



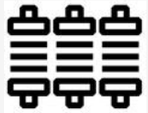
5 – 8 MW

Collection

33 kV

66 kV

LFAC



Transmission

HVAC

LFAC (16.7 Hz)

HVAC with reactive power comp.

HVDC best suited for long distances

Power grid

Grid codes must be met with any solution

Holistic design is necessary to have the optimal grid connection solution

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ABB in Offshore Wind
Solutions for offshore segment – AC concept

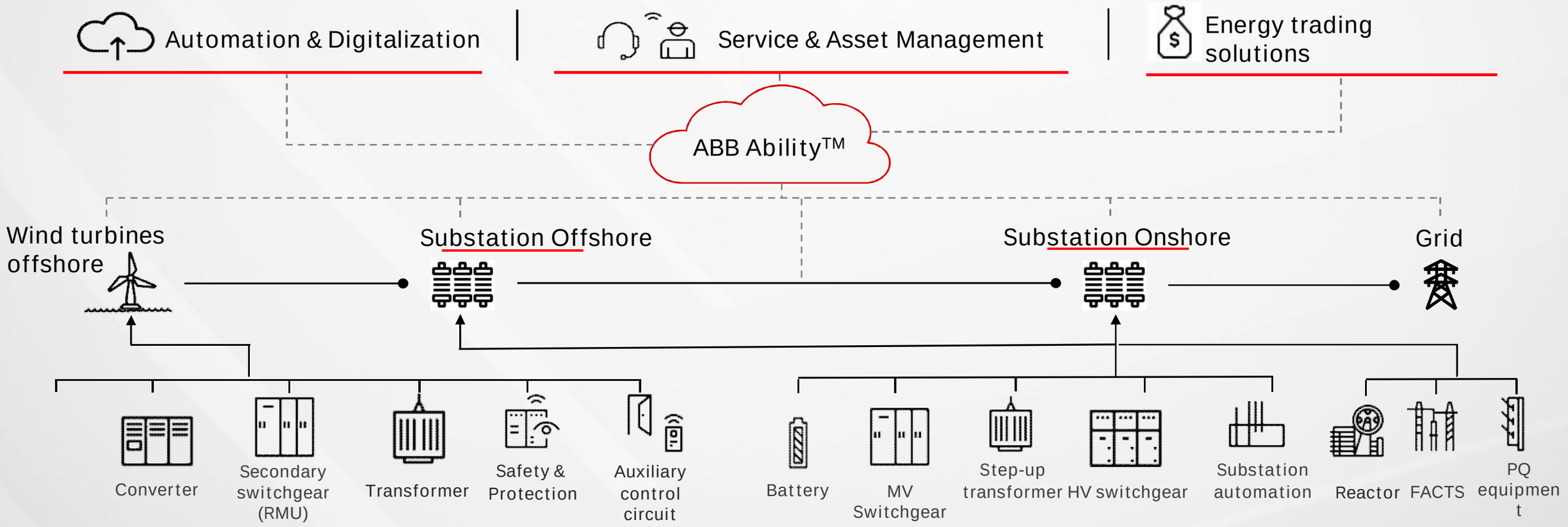

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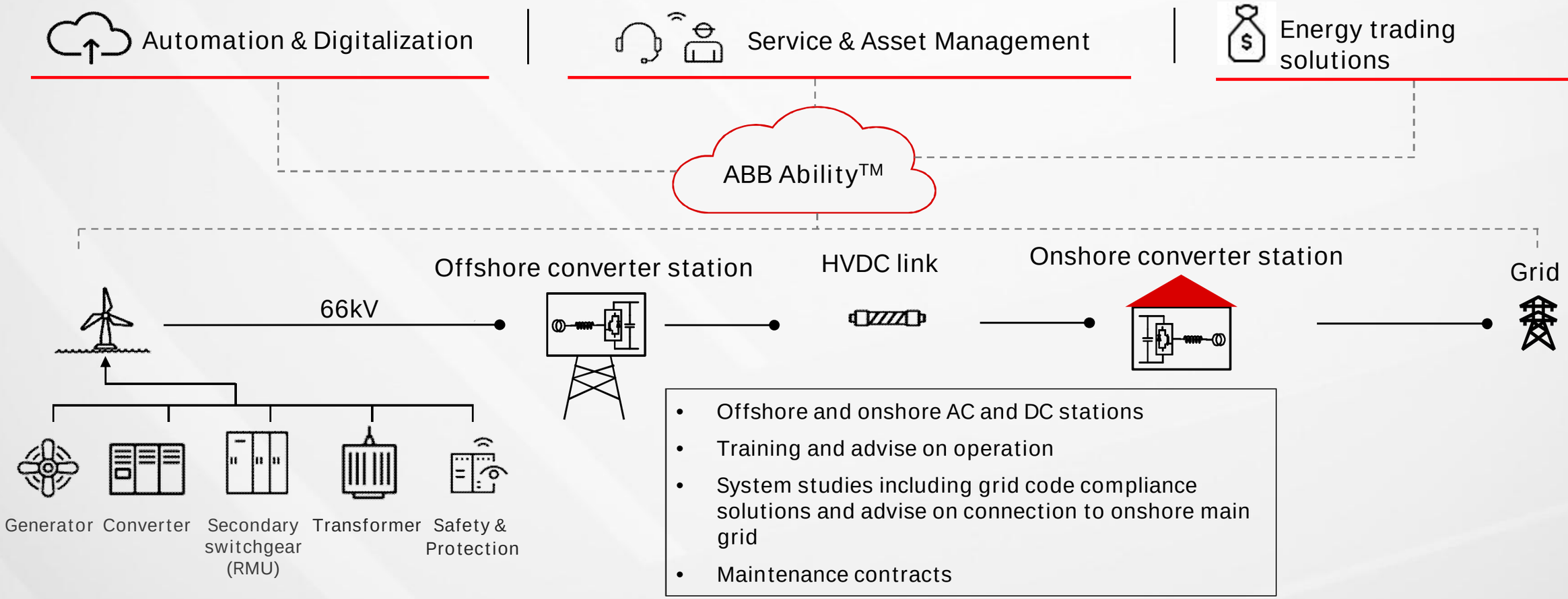
ABB in Offshore Wind
Solutions for offshore segment – HVDC concept



- Offshore and onshore AC and DC stations
- Training and advise on operation
- System studies including grid code compliance solutions and advise on connection to onshore main grid
- Maintenance contracts

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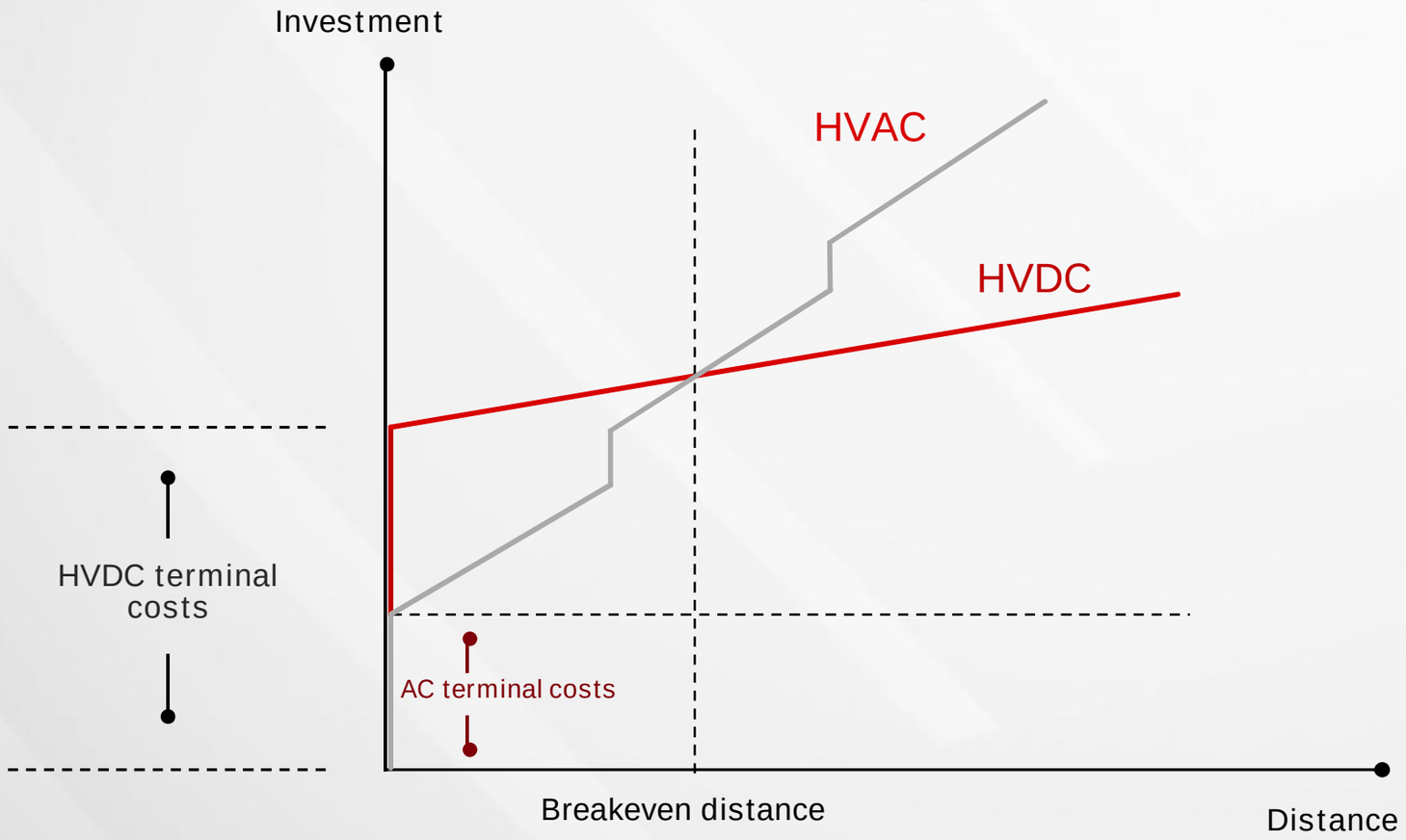
There is a place for everyone – DC vs. AC with cable connection

Applies to subsea and underground connections

Investment



HVDC Value

- Lower losses
- More power
- Controlled power flows
- More stability and versatility
- Smaller footprint
- More sustainable

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HVAC vs. HVDC
Pros and Cons

HVAC

+ Well known and proven technology
+ Short deliver time
+ Moderate sized offshore platforms => Large supply base
+ Light weighted platforms => Many HLV

– Limitation in maximum cable length due to high charging currents
– Long distances may require mid point compensation
– Higher losses
– Many cables => Capacity issues on supply side?
– Demanding ROW
– Cable installation
– May require Statcoms to fulfill Grid Code Requirements

HVDC

+ Superior dynamic behavior and features
+ Onshore and offshore grid support e.g. AC voltage and frequency stabilization
+ Black start capability
+ No minimum short-circuit power requirement for weak AC networks
+ Inherent Statcom functionality => easy to fulfill Grid Code req.
+ Less cables => Easy cable installation and ROW
+ Low losses
+ No limitation in distance

– Large offshore platforms
– Longer lead time than AC
– Less cost efficient if short distance and / or low power rating

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HVDC becoming mainstream in all corners of the world
Interconnecting Grids

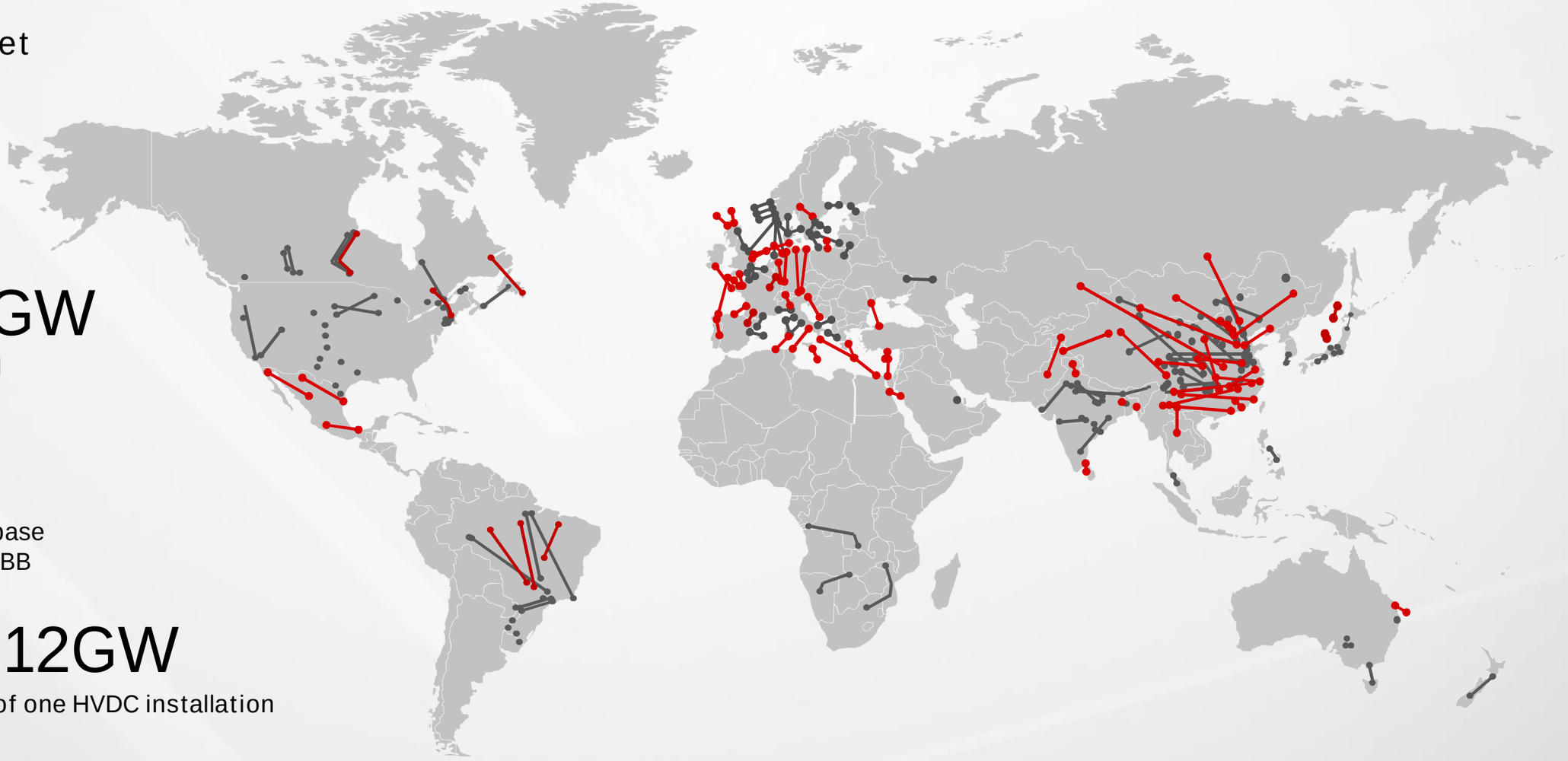
Heavyweight market

~3x
Growth rate
vs. world GDP

~200 GW
Operating world
Installed base

70%
World installed base
equipped with ABB

Up to 12GW
Capacity range of one HVDC installation



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(1) *Average over 5 years, subject to substantial fluctuation year on year*
(2) *Average over 10 years*

HVDC is a growing technology

Applications

Connecting remote generation

Power from shore

Interconnecting grids

City center infeed

Offshore wind connections

Connecting remote loads

DC links in AC grids

Upgrades

HVDC technologies

HVDC Classic 300 – 12,000 MW

- Thyristor controlled
- Switched reactive power control
- Typical design: valve building plus switchyard
- Overhead lines or mass impregnated cables

HVDC Light 50 – 4,800 MW

- Transistor (BIGT) controlled
- Continuous reactive power control
- Easily expandable to more terminals
- Dynamic voltage regulation
- Black start capability
- Typical design: more equipment in compact building
- Extruded cables

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HVDC technologies

Technology features and customer benefits

Customer value	HVDC features	Benefits
Security of supply	Frequency decoupling No limitation in circuit lenght Fast control of active and reactive power	Possibility to interconnect grids Enabling markets
Remote RES integration	Lower transmission losses Higher power per circuit No limitation in circuit lenght	Connection of large scale hydro Connection of offshore wind
Grid resiliency	Fast control of active and reactive power Fast detection and restart at DC line faults Black start capability Power oscillation damping	Special protection schemes Increased stability margins Support during grid restoration
Operational flexibility	Fast control of active and reactive power	Variable RES integration Better utilization of existing AC system
Public acceptance	Compact overhead lines Lower magnetic fields, corona and noise No limitation in circuit length	Smaller Right-of-Way Undergrounding Easier permitts

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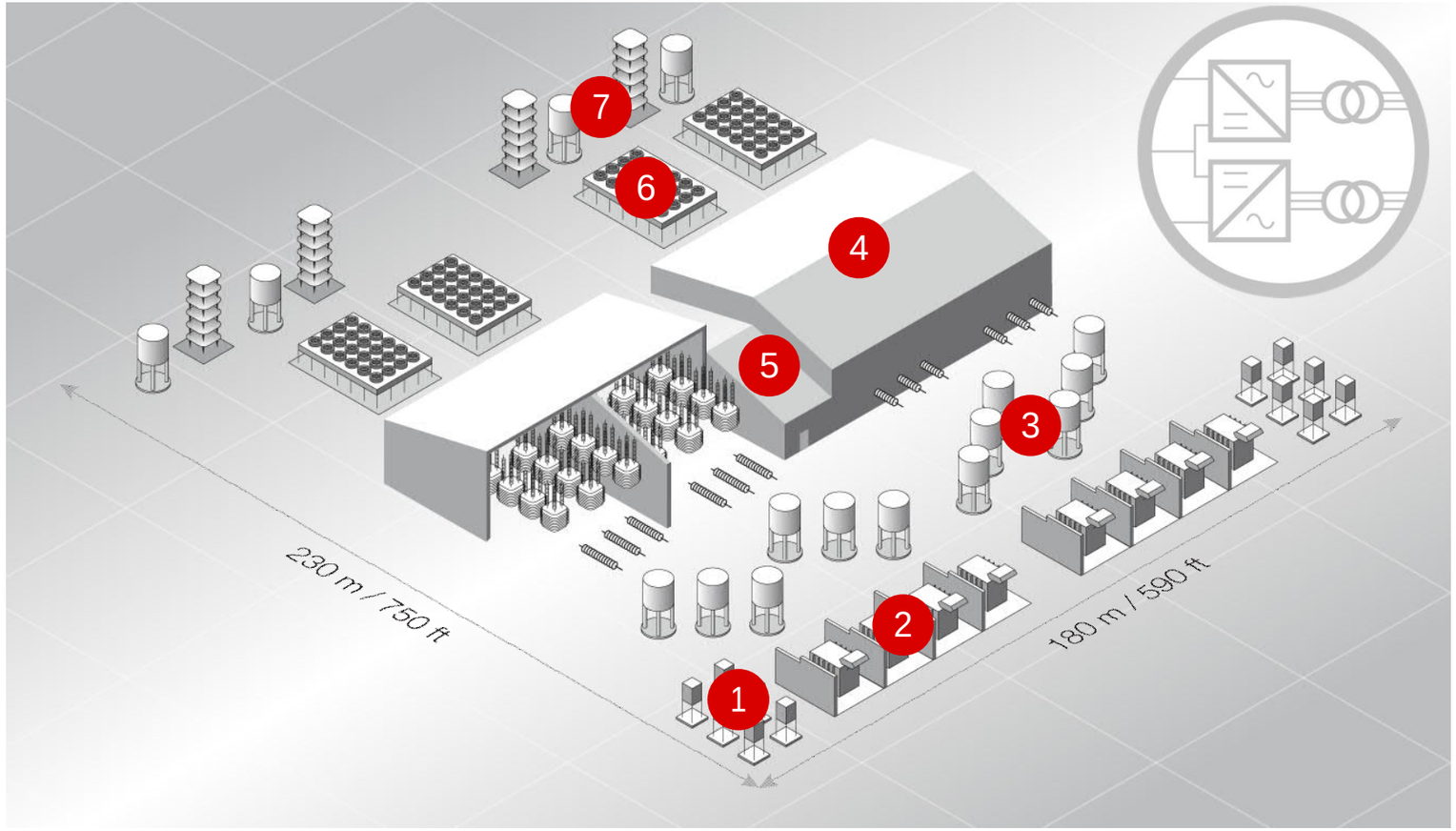
Footprint and layout

Example bipole – operational flexibility

3,600 MW, ±640 kV

1. AC equipment
2. Transformers
3. AC Yard
4. Valve hall
5. Control building
6. Cooling
7. DC switch-yard



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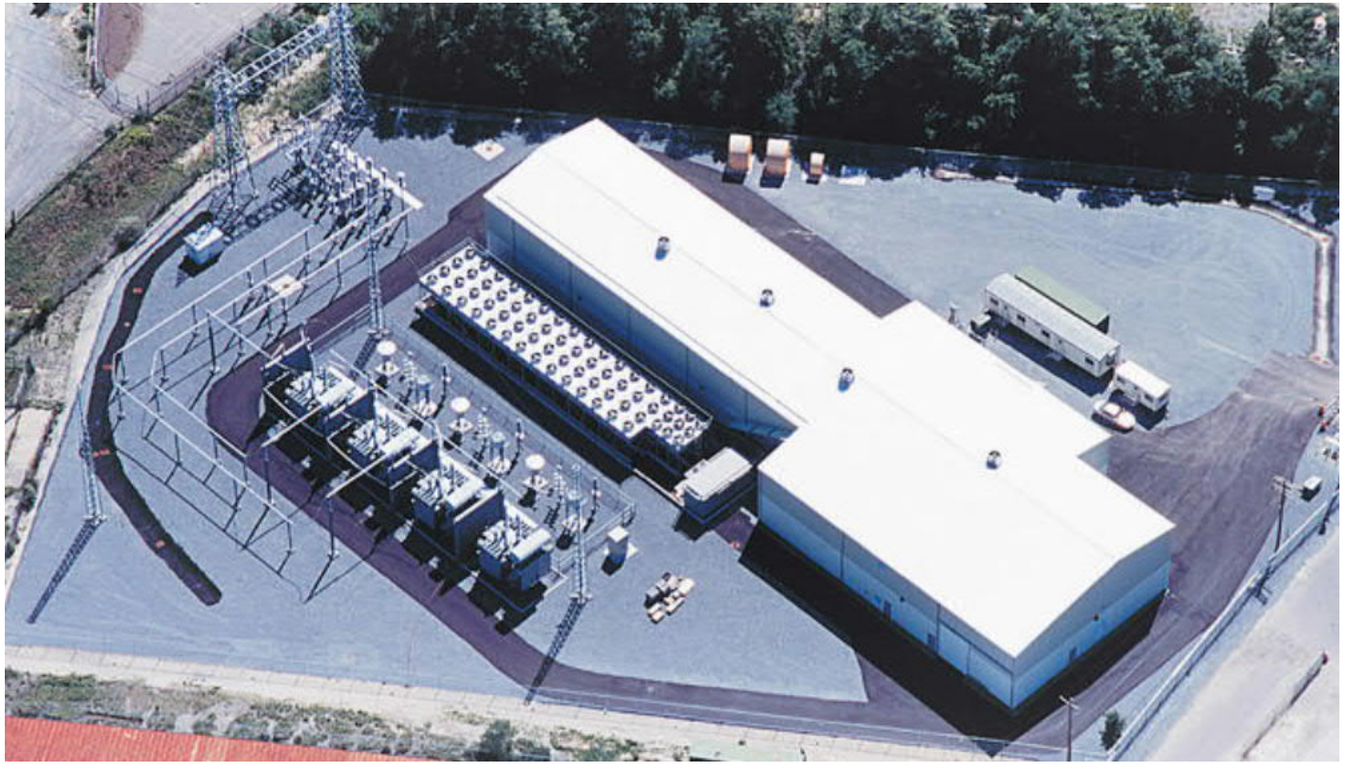
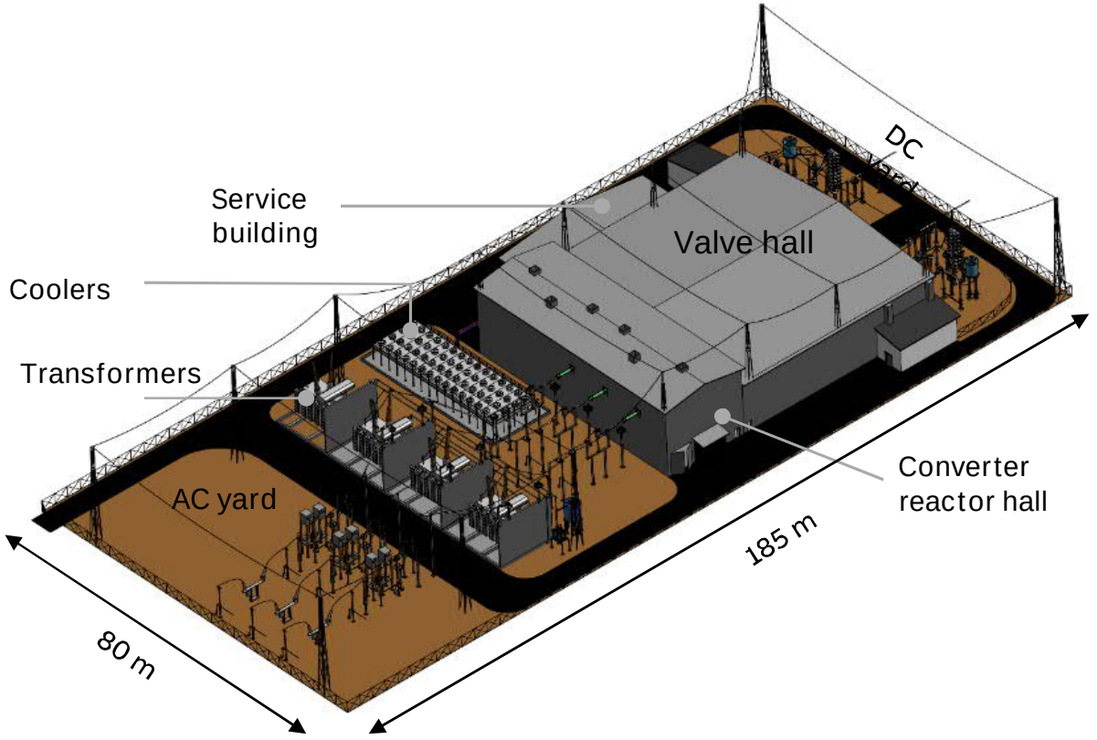
VSC HVDC Light onshore station

1000 MW, 320 kV





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Offshore HVDC converter station

Integration of HVDC Light into an offshore platform

- Continues improvement of HVDC modularized design and interface management
- Adaptable for different types of platform concept, e.g. GBS or topside/jacket
- Primary equipment
  - Converter Valve Hall (2)
  - Converter Reactor Hall (can be divided into 2)
  - Transformer Room (2 or 4)
  - 66kV AC GIS, 400kV AC GIS
  - Auxiliary Power Transformer Room (2)
- Secondary Equipment
  - HVDC Control Equipment
  - HVDC Cooling Equipment
  - HVDC Auxiliary Power Distribution

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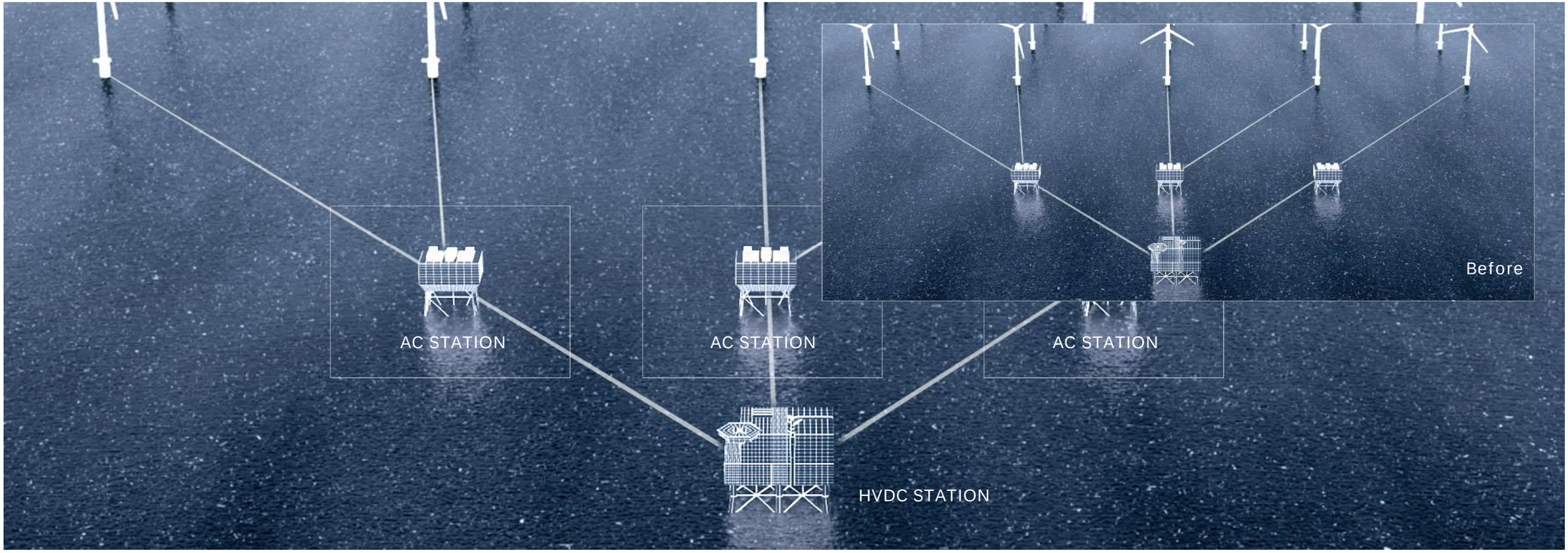
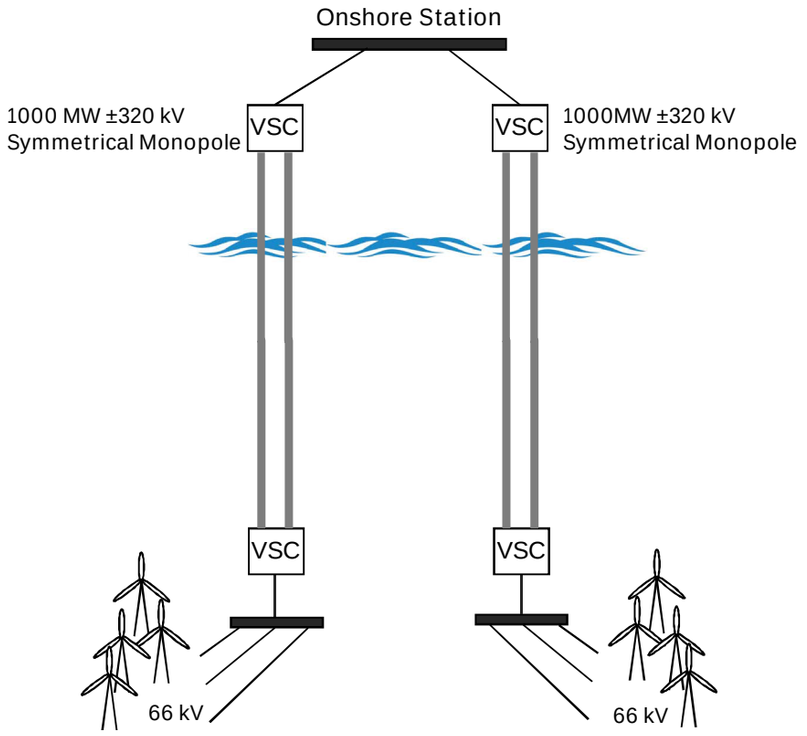
HVDC offshore wind solution concept

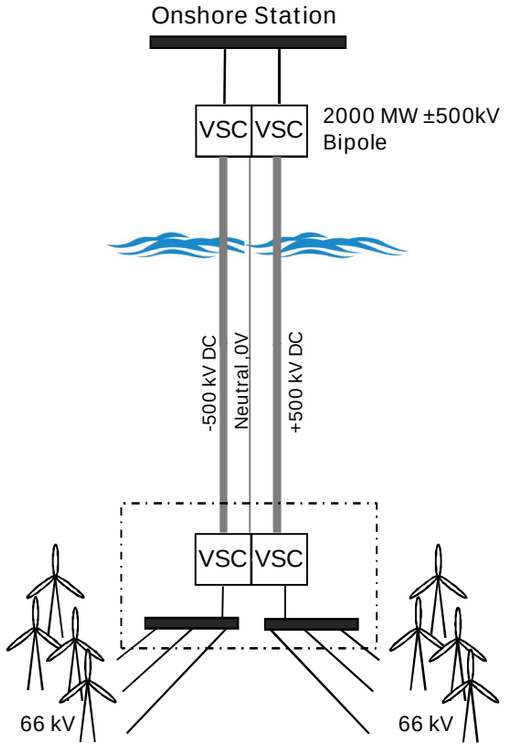
Eliminating the need for AC substations

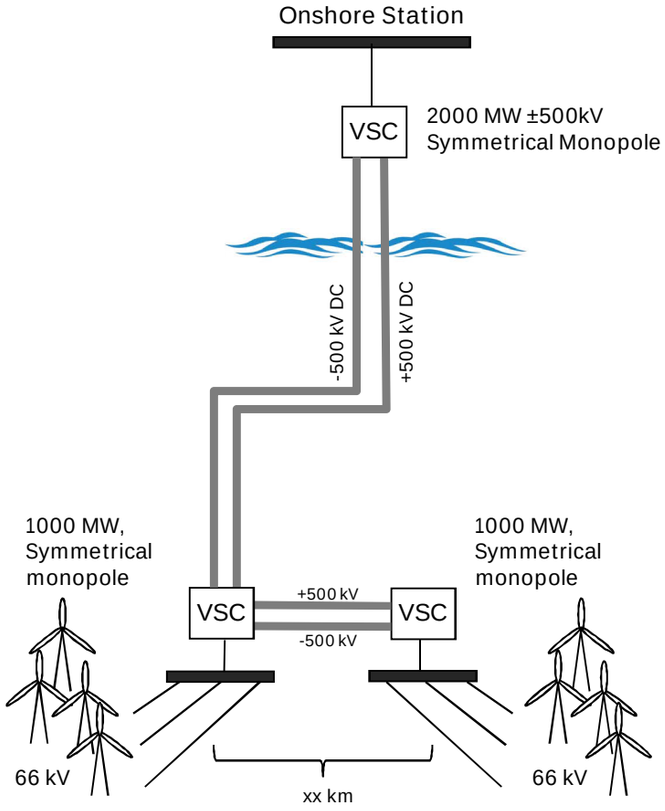


Connection arrangements

Example of different options for 2000 MW







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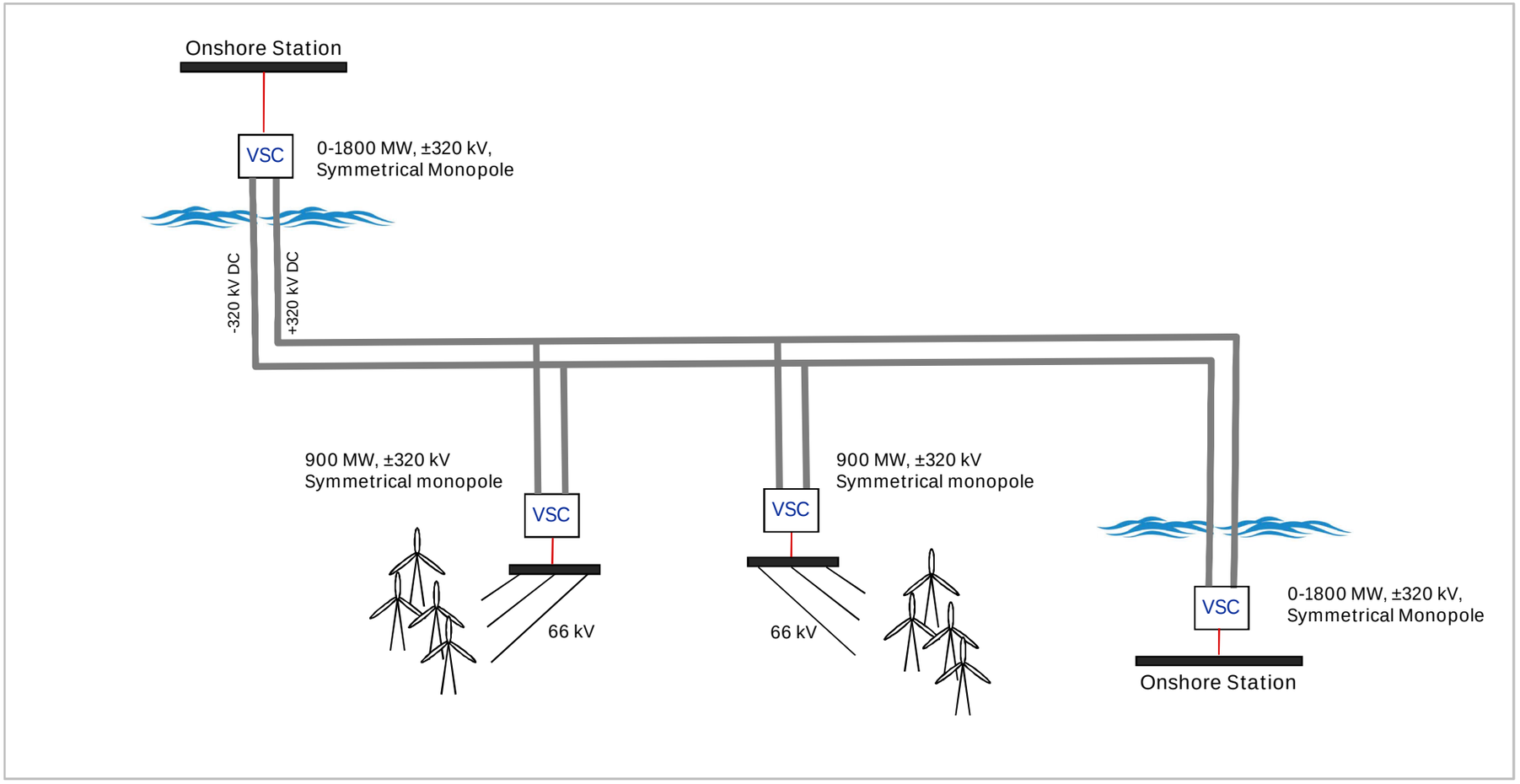
Connection arrangements

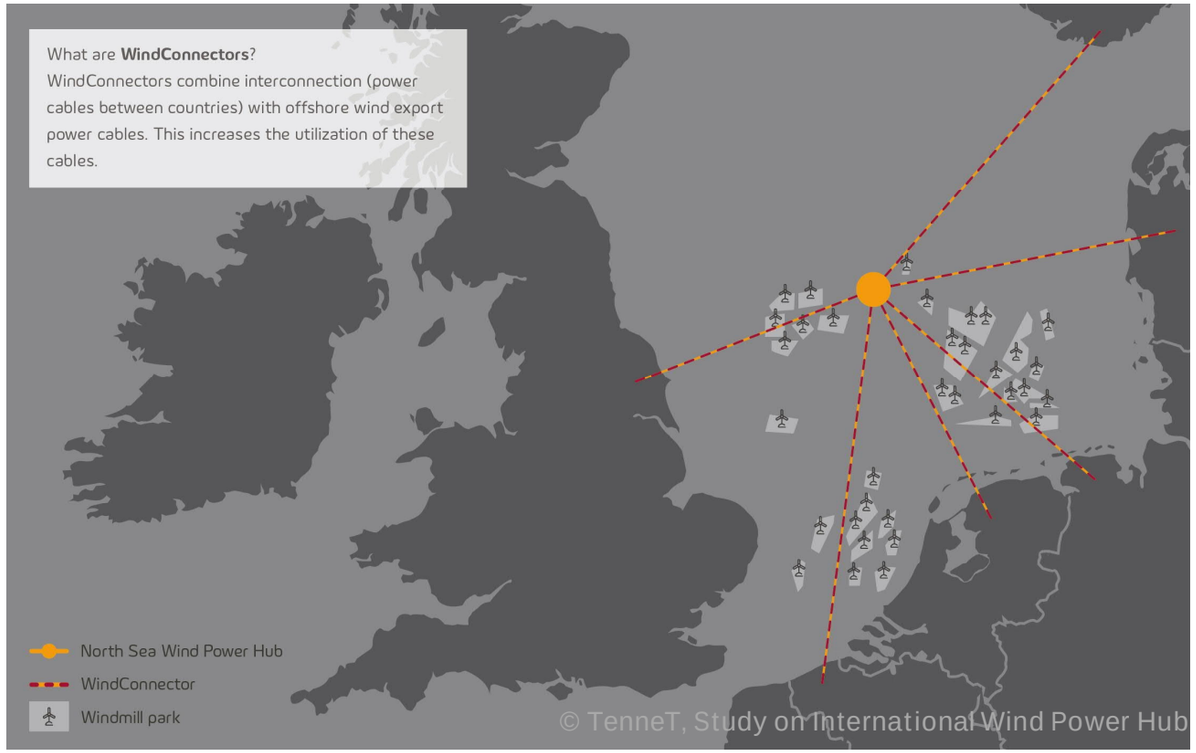
Examples of different options



Dual-purpose interconnections

Connecting markets and integrating remote generation

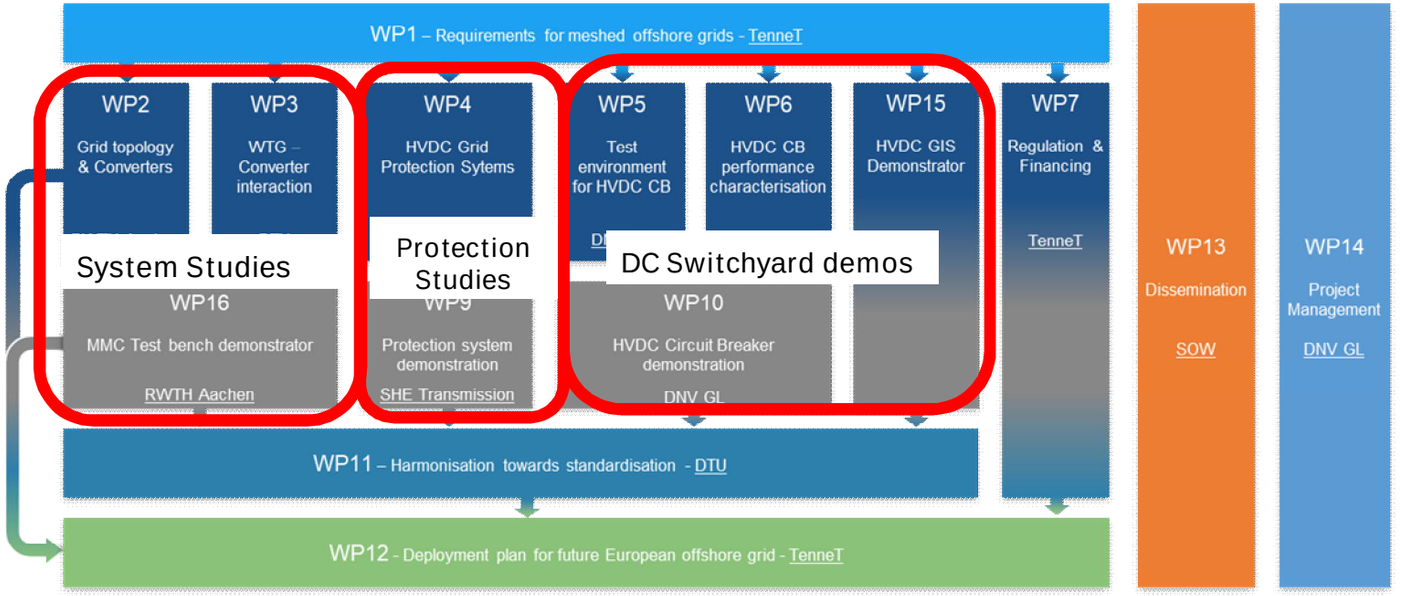
Example: North Sea Power Hub

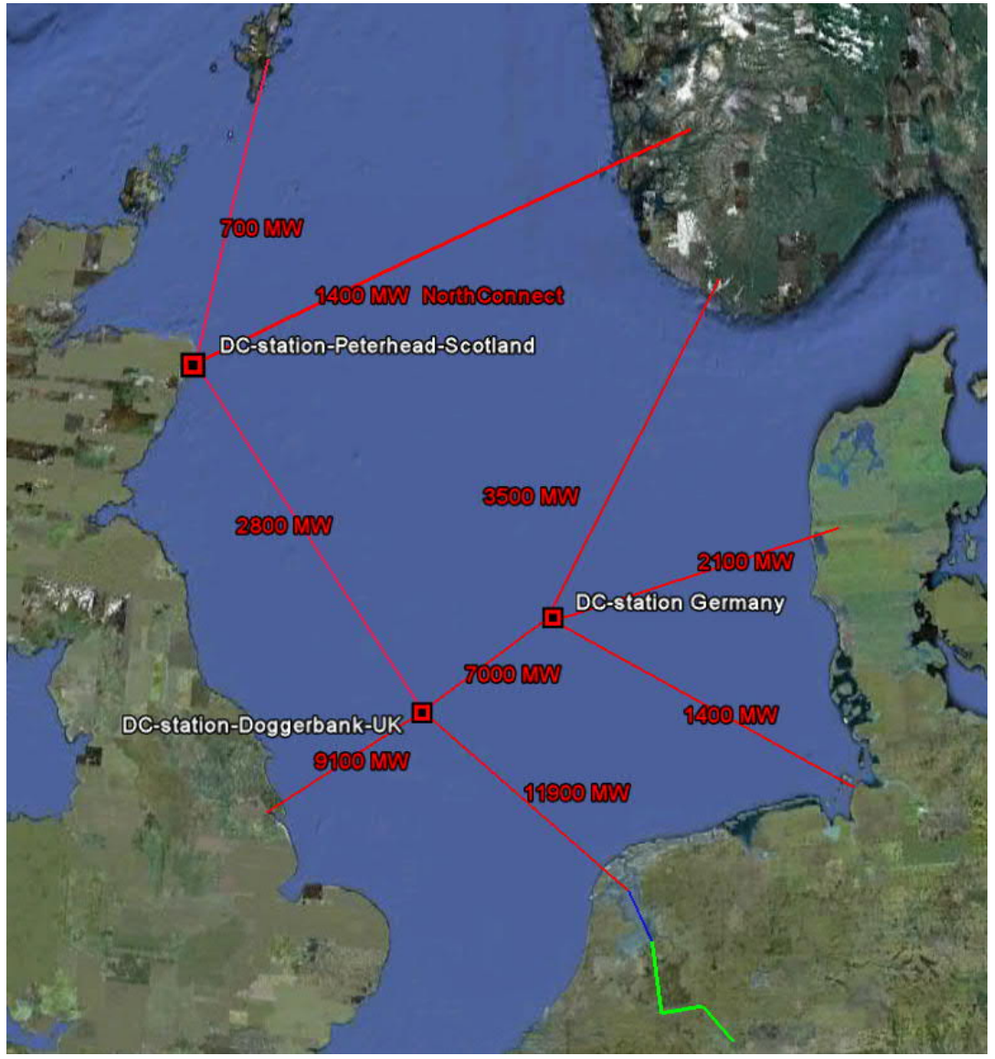


Advantages

- Strengthens European energy markets
- Increases security of supply across Europe
- Allows higher utilization of infrastructure
- Supports larger volumes of offshore wind

PROMOTioN 2016-2019





Source: Doggerbank.nl

ABB references in offshore wind

Design based on experience

Borwin 1

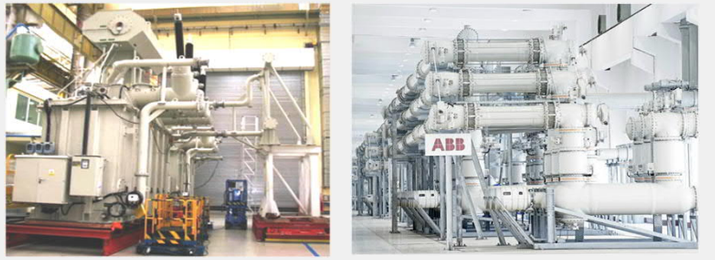
Dolwin 1

Dolwin 2

Thornton Bank

Princess Amalia (Q7)

Various projects: equipment supply



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BorWin1

Germany

Main data

Customer	TenneT
Customer needs	• 200 km long subsea and underground power connection • Robust grid connection
ABB's response	• Turnkey 400 MW HVDC Light system • Full grid code compliance
Customer benefits	• Environmentally friendly power transport • Reduce CO2 emissions by nearly 1.5 million tons per year by replacing fossil-fuel generation • Supports wind power development in Germany
Year	• 2015

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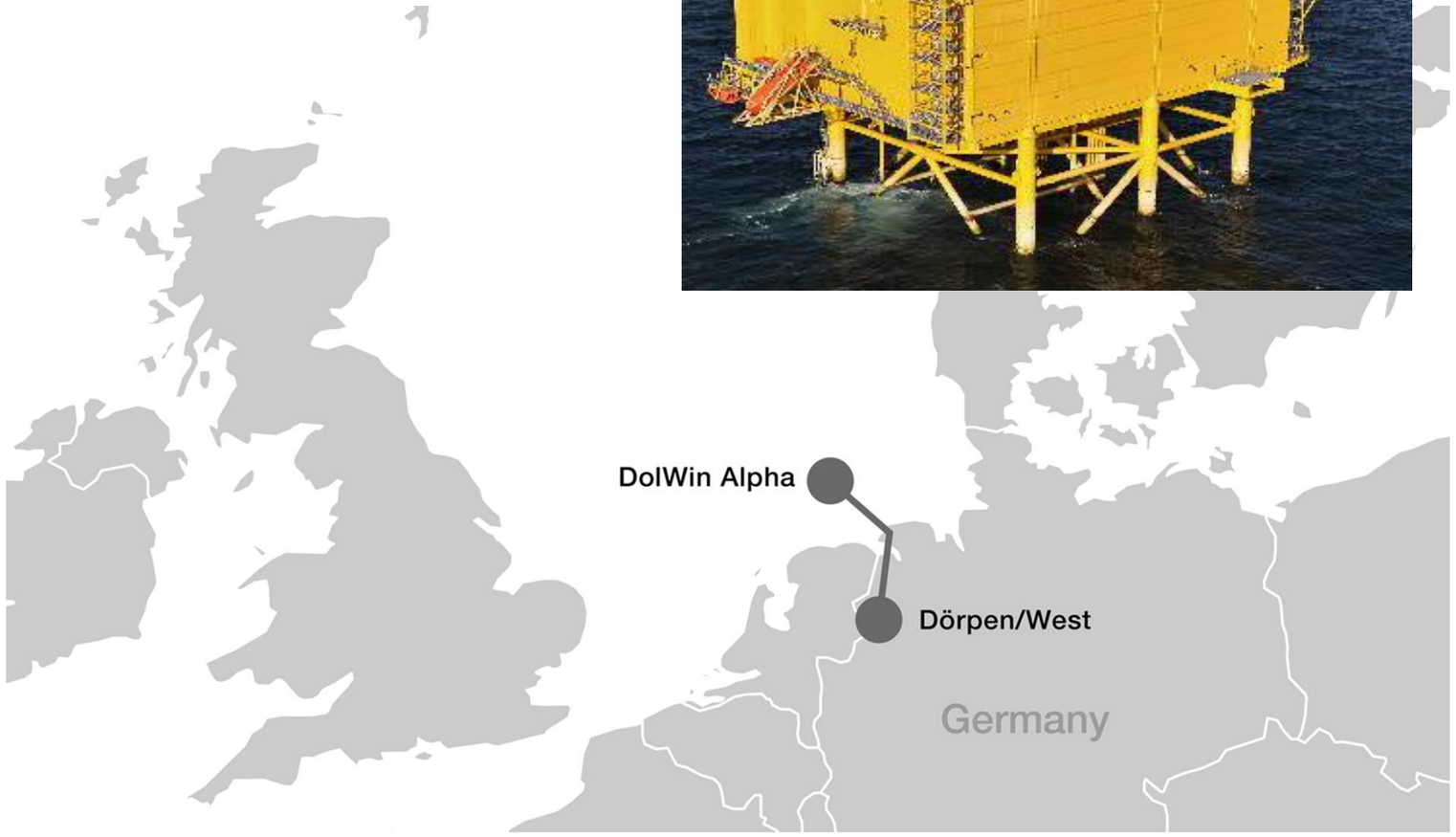
DolWin1

Germany

Main data

Customer	TenneT
Customer needs	• 165 km long subsea and underground power connection • Robust grid connection
ABB's response	• Turnkey 800 MW HVDC Light system • First ± 320 kV extruded cable delivery
Customer benefits	• Environmentally sound power transport • Low losses and high reliability • Reduce CO2 emissions by 3 million tons per year by replacing fossil-fuel generation • Supports wind power development in Germany
Year	• 2013



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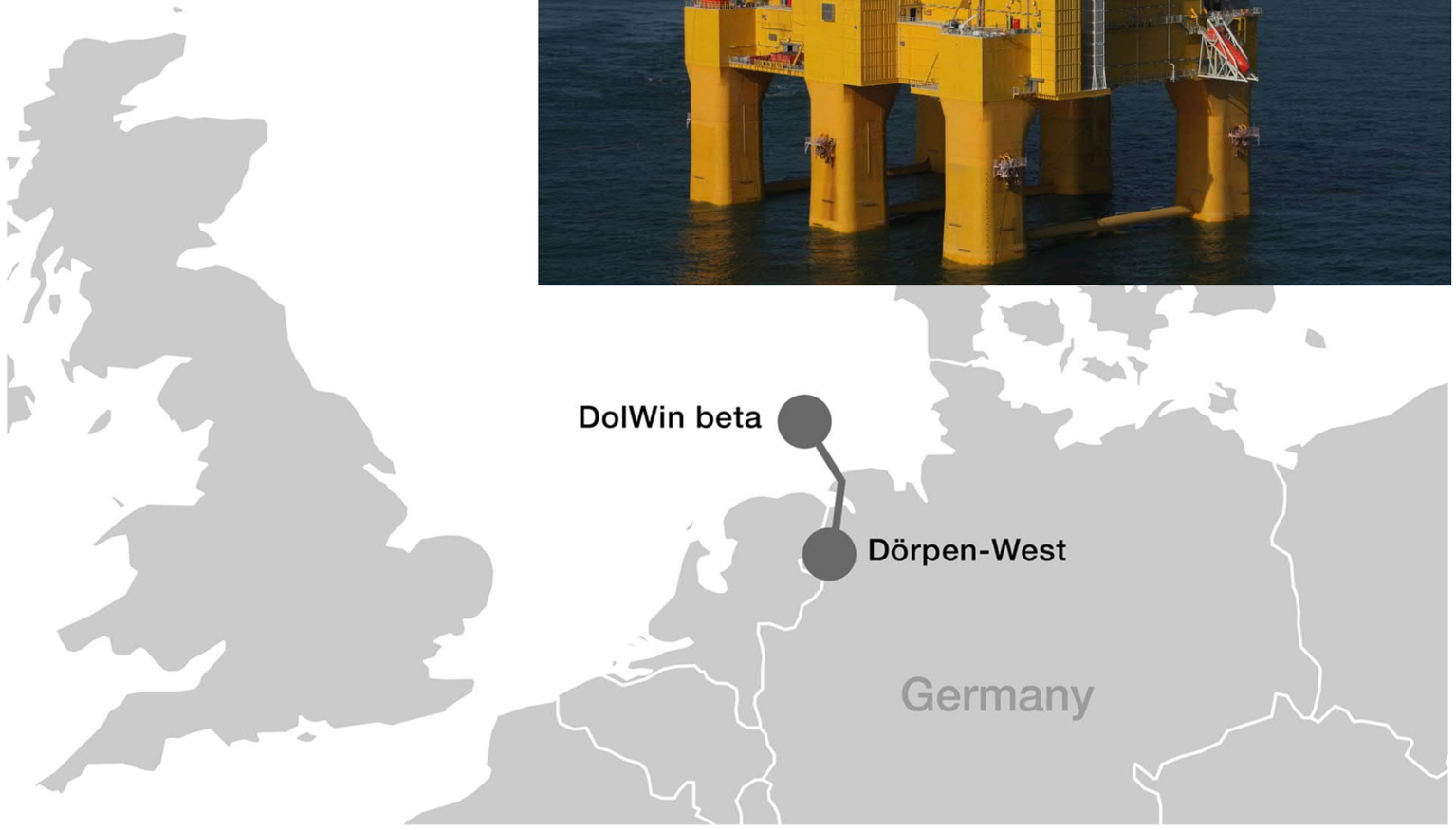
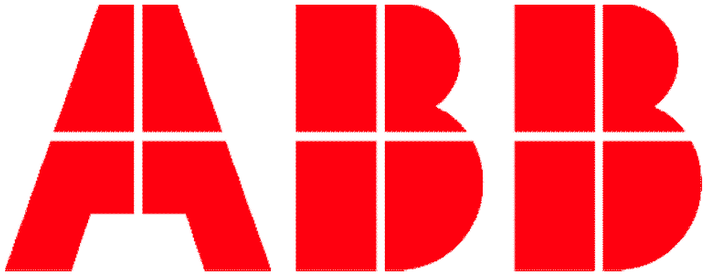
DolWin2

Germany

Main data

Customer	TenneT
Customer needs	• 135 km long subsea and underground power connection • Robust grid connection
ABB's response	• Turnkey 900 MW HVDC Light system • ± 320 kV extruded cable delivery
Customer benefits	• Environmentally sound power transport • Low losses and high reliability • Reduce CO2-emissions by 3 million tons per year by replacing fossil-fuel generation • Grid connection 90 km inland
Year	• 2015