

NOVEMBER 2019



Overview HVAC & HVDC power transmission

Grid Integration - Grids & Power Quality Solutions & HVDC

1

ABB - Grid Integration

Overview

2

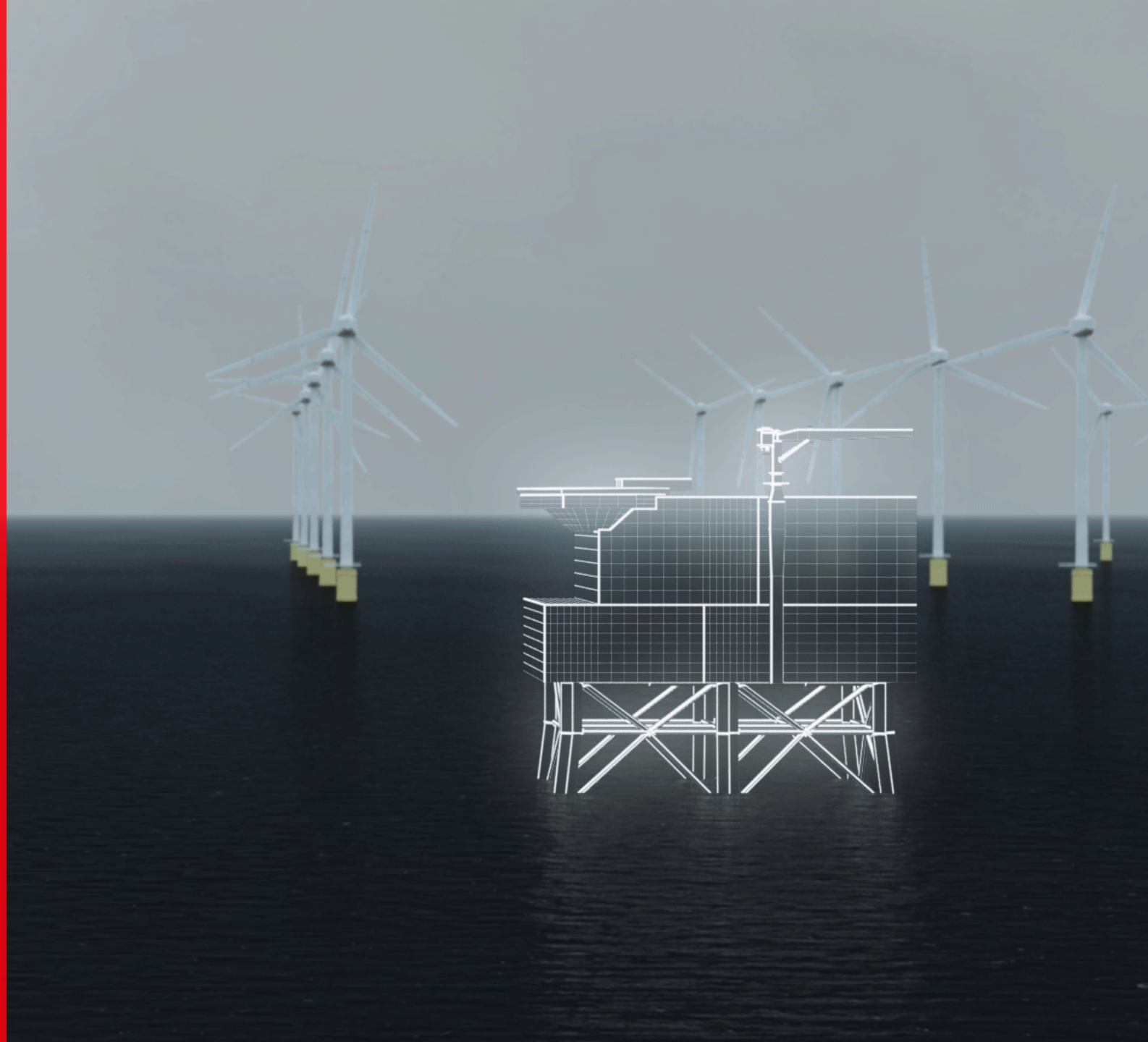
HVDC

Offshore wind connection

3

HVAC

Offshore wind connection



Grid Integration

Overview



6,600
Employees



>500
Projects



60*
Countries



Who
Our customers

77%
Utilities

9%
Transport and
Infrastructure

14%
Industry

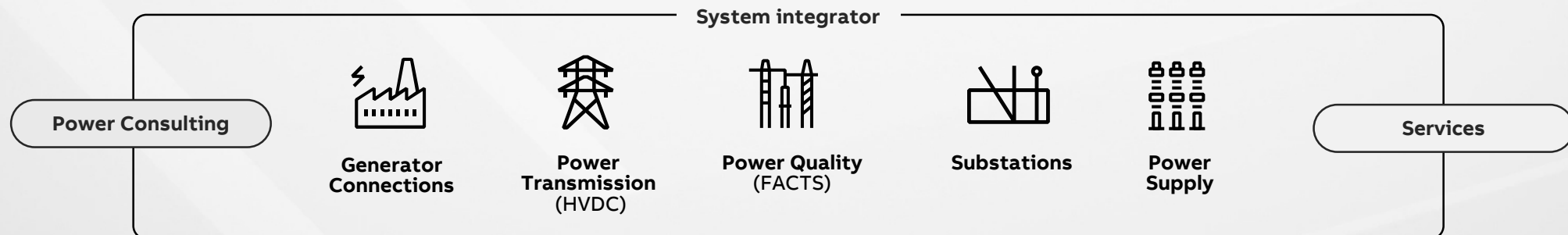


Where
Our customers'
locations

30%
Americas

38%
Asia, Africa
Middle East

32%
Europe



Grid Integration Overview

Generator Connections

- Solar plant
- Wind plant
- Thermal plant

Power Transmission (HVDC)

- Grid interconnectors
- Offshore wind connections
- City infeeds
- Power from shore
- Remote loads and generators

Power Quality (FACTS)

- Fixed Series Compensators
- Thyristor Controlled Series Capacitors
- Static Var Compensators
- Static Compensators
- Static Frequency Convertors

Substations

- AIS substations
- GIS substations
- Digital substations
- Hybrid and mobile solutions

Power Supply

- e-Bus (TOSA)
- Rail
- Ports and ships
- Data centers
- Industrial sites

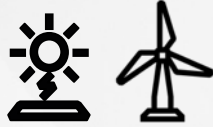
Renewables value chain and ABB presence

ABB is one of the working horses of the renewable industry, with a strong presence across the value chain



Consulting

- Plant design
- Grid code compliance
- Grid impact studies
- Strategic investment plans
- Market Analysis
- Price forecasting



Generation

- Generators
- Wind converters
- Solar inverter
- Transformers
- LV and MV switchgears
- LV products and panels
- Yaw motors and PLCs



Collection & Connection

- Switchgear
- Transformers
- Substations
- Power quality solutions
- Substation automation



Distribution & Transmission

- Transmission substations
- Power quality solutions
- HVDC
- Offshore grid connection solutions



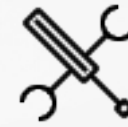
Control & Automation

- Protection and control
- Substation automation
- Communication



Operation

- Fleet monitoring and management solutions
- Power management
- Virtual power plants



Service

- Service agreements
- Installation and commissioning
- Training
- Spare parts and consumable
- Repairs
- Replacement
- O&M software



Trading

- Forecasting
- Market Trading and settlement
- (Market specific)

A broad portfolio: products, systems, service and software solutions

Grid integration

Proven global delivery capabilities

354 ESP
210 TKS

North
America

1,140 ESP
191 TKS

Europe and
Russia

153 ESP
707 TKS

Asia

180 ESP
83 TKS

South
America

164 ESP
550 TKS

Middle East
and Africa



> 3,700

system solutions successfully
delivered over the past 15 years

ESP: # of Engineered System Package delivered
TKS: # Turnkey Solutions delivered

Global footprint

Our people are close to you

Worldwide

~50
units

~2700
employees

Switzerland (2 Locations)
Mannheim, Germany
Madrid, Spain
Athens, Greece
Zagreb, Croatia
Milan, Italy
Rotterdam, Netherlands
Krakow, Poland
Bucharest, Romania
Istanbul, Turkey
Tallinn, Estonia
Dublin, Ireland
Vaasa, Finland
Stone, UK
Oslo, Norway
Moscow, Russia
Vasteras, Sweden
Buenos Aires, Argentina
Sao Paulo, Brazil

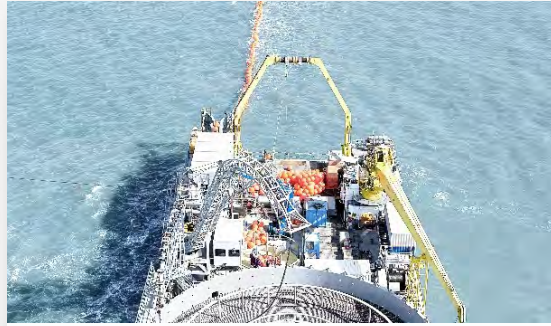
Lima, Peru
Montreal, Canada
Raleigh, USA
San-Luis Potosi, Mexico
UAE (2 Locations)
Cairo, Egypt,
Amman, Jordan
Saudi Arabia (3 Locations)
Doha, Qatar
China (2 Locations)
HK, Hong Kong
Jakarta, Indonesia
India (5 Locations)
Tokyo, Japan
Kuala Lumpur, Malaysia
SG, Singapore
Bangkok, Thailand
Taipei, Taiwan



AC & DC Grid connection Applications



Connecting remote generation



Interconnecting grids



AC & DC Offshore wind connections



DC links in AC grids



**Power from shore /
Ship to Shore**



City center infeed



Connecting remote loads



Upgrades / Life cycle services

1

Portfolio Grid Integration

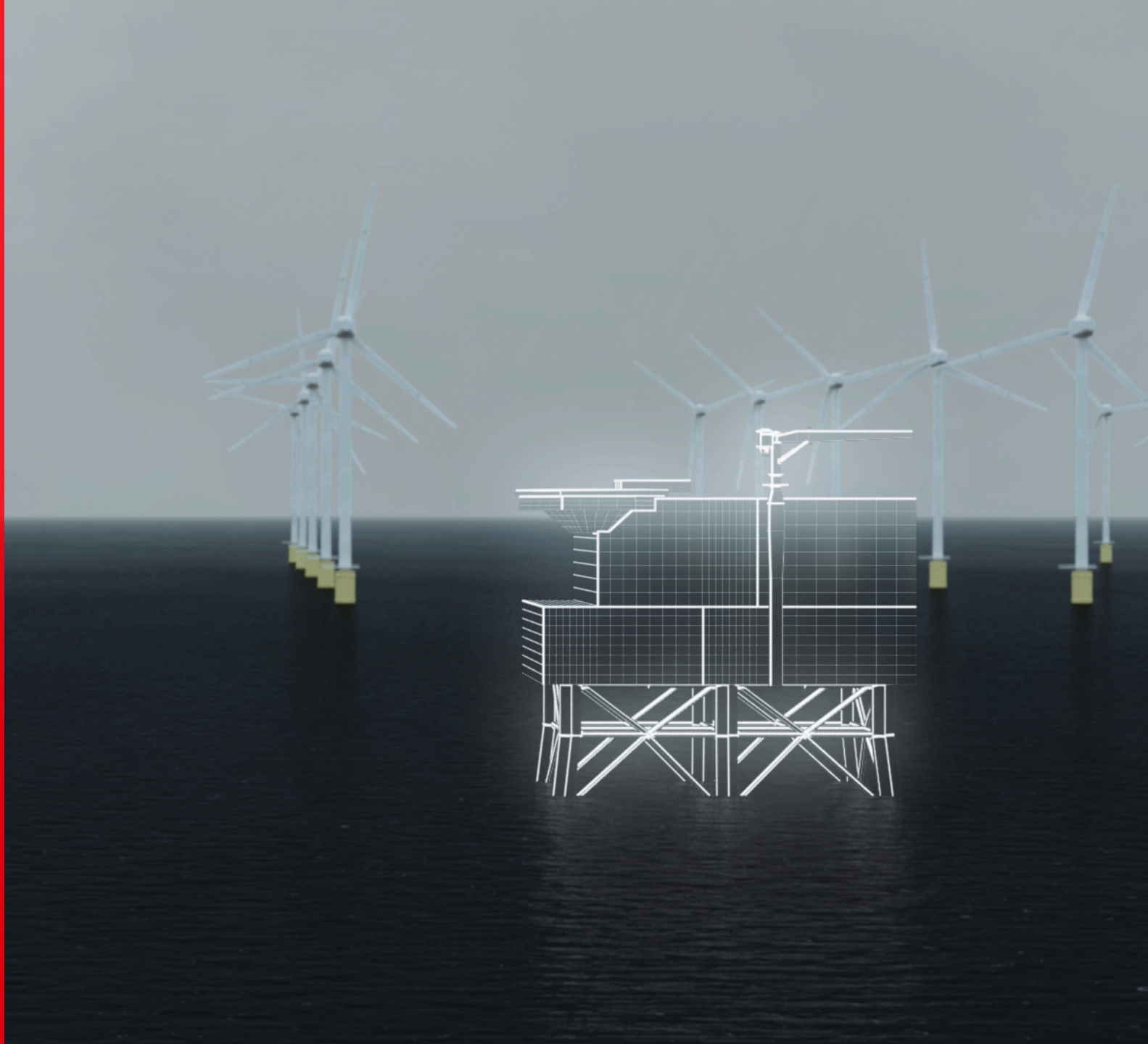
Overview

2

HVAC
Offshore wind connection

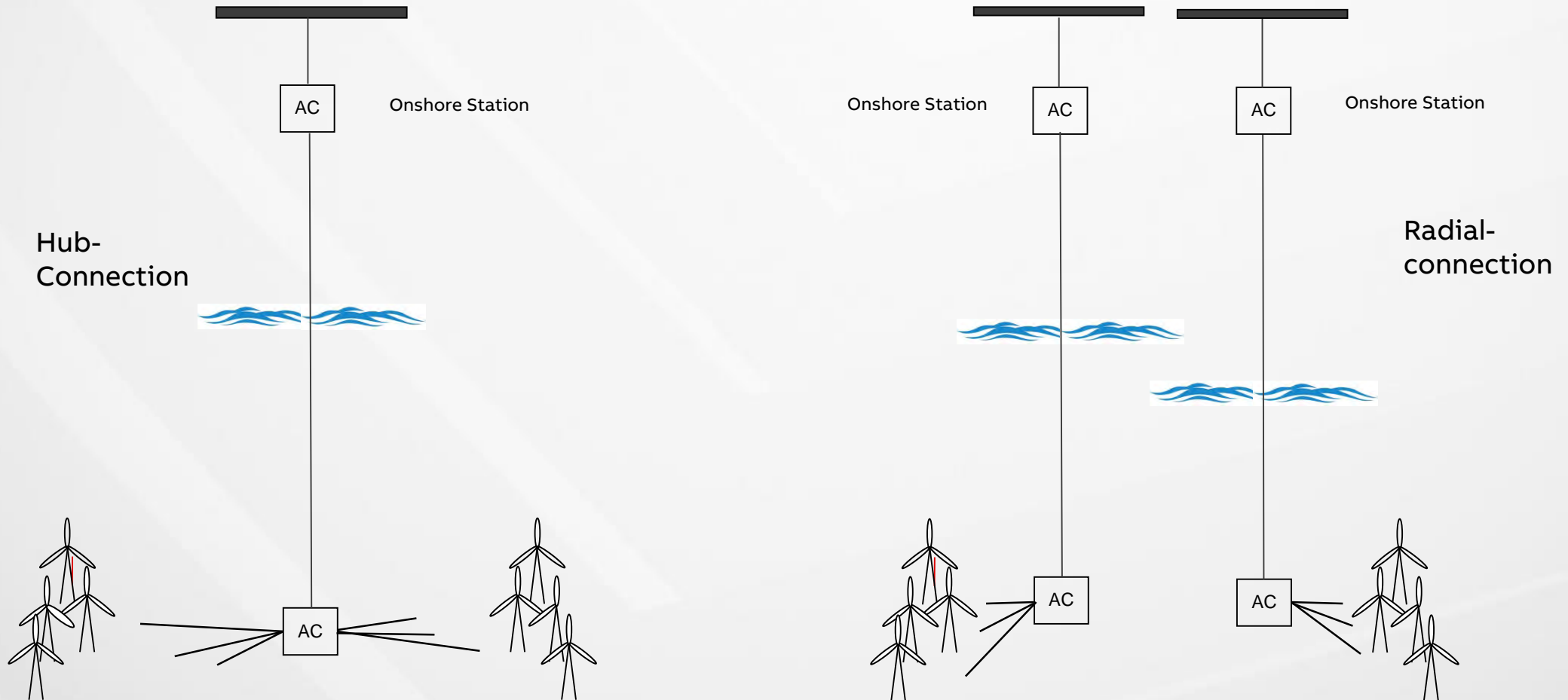
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HVDC
Offshore wind connection



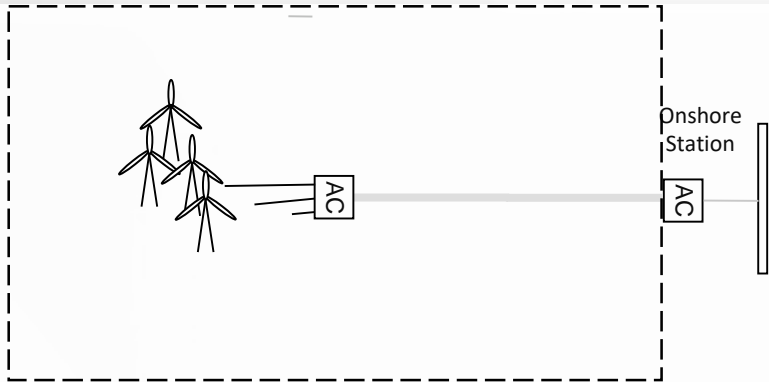
Offshore- grid connection

Hub- and radialconnection



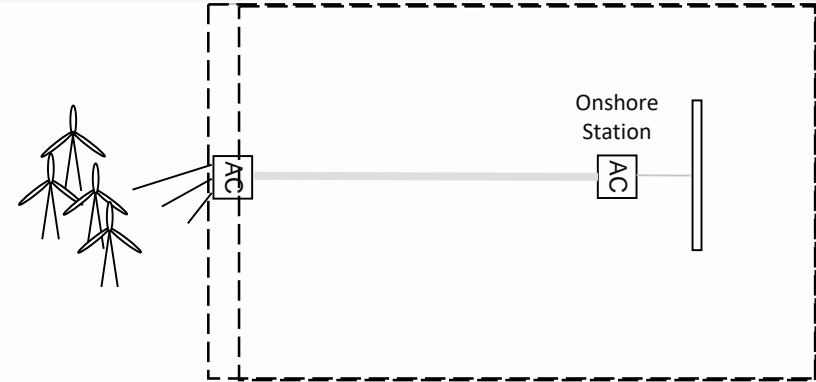
Offshore- grid connection point

Grid connection point – handling of different countries



Awarding by tender process

United Kingdom
Sweden
Dänemark

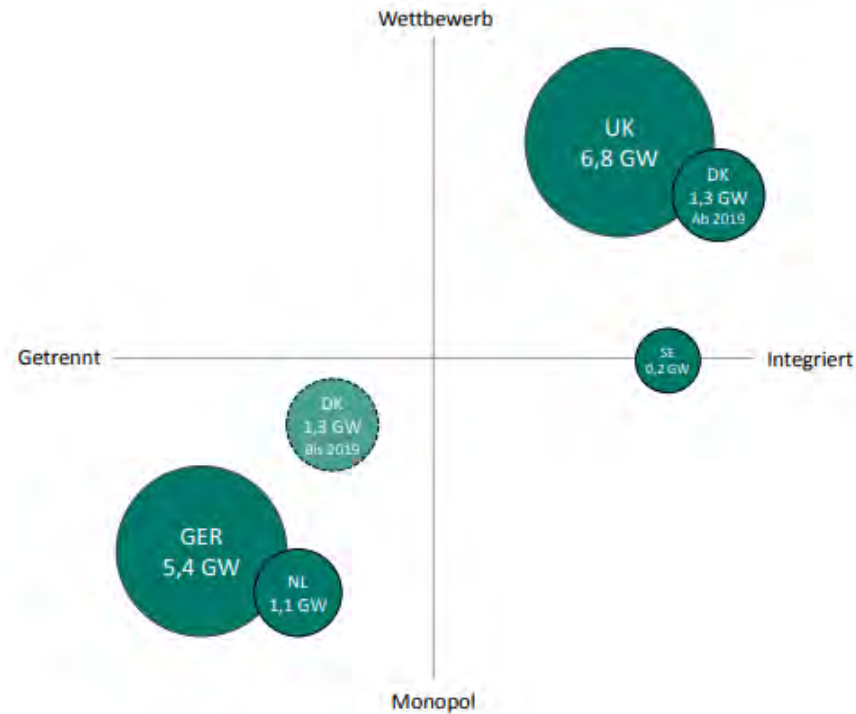


Connection Point established by TSO

Germany – TenneT, 50 Hertz
Niederlande – TenneT

Offshore- grid connection point

Economic classification of the previously considered countries

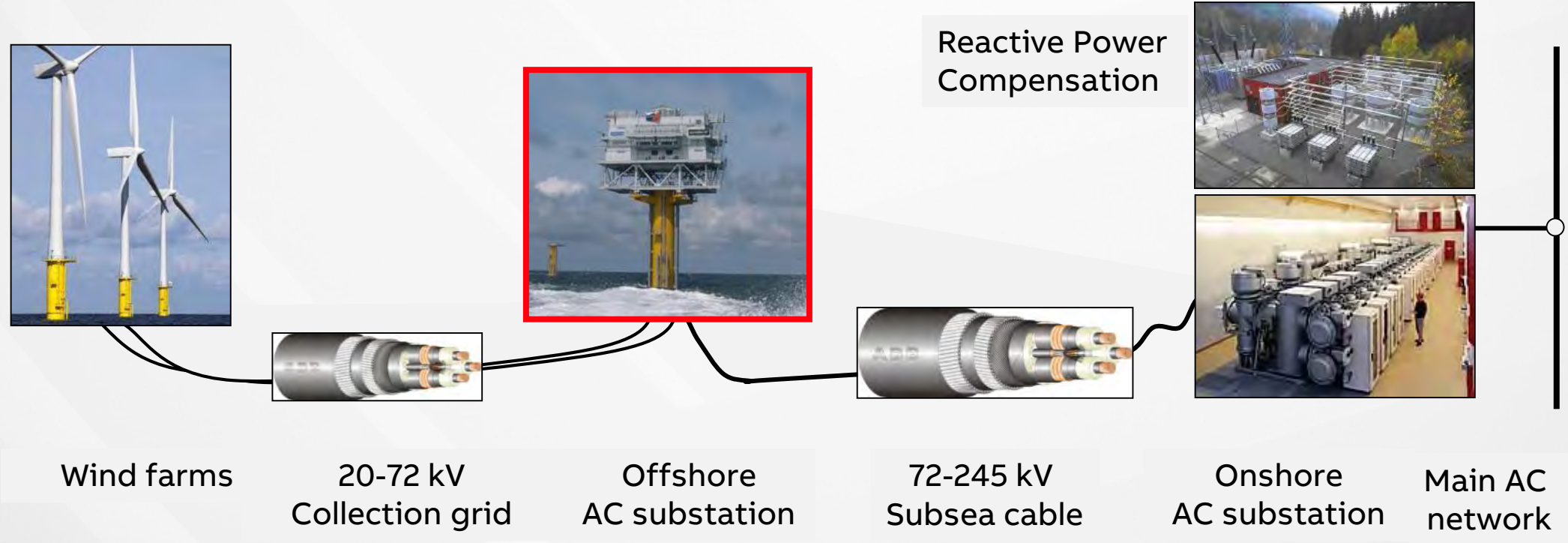


- Awarding offshore grid connection point by a tender process leads to a higher competition
- A higher competition means efficient technologies and lower prices
- UK has based on the regulations the most competitive situation
- In Germany is almost no competition

Source: Global Wind Energy Council (2017) und DIW Econ

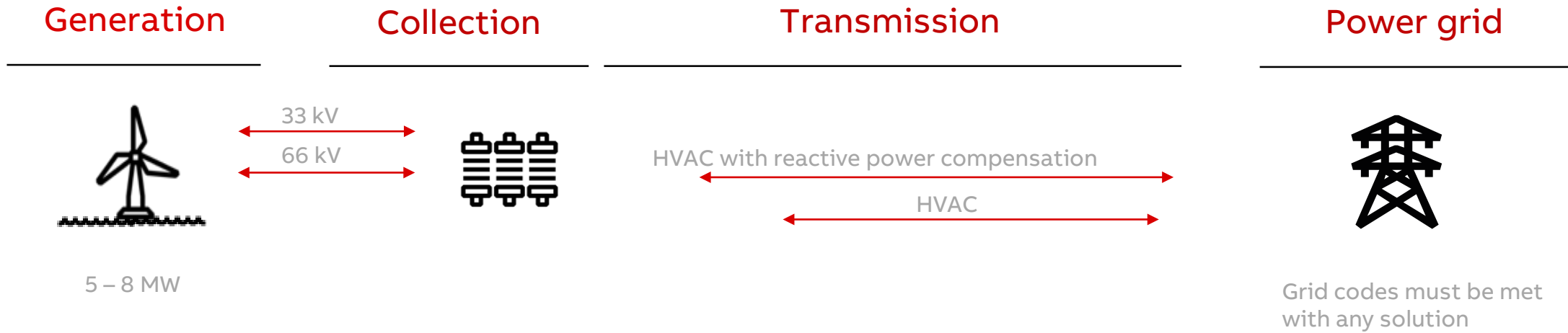
Connecting wind power plants by HVAC

Typical arrangement



Offshore wind connections

No standard design nor winning solution is available today.



Holistic design is necessary to have the optimal grid connection solution

ABB in Offshore Wind

Solutions for offshore segment – AC concept



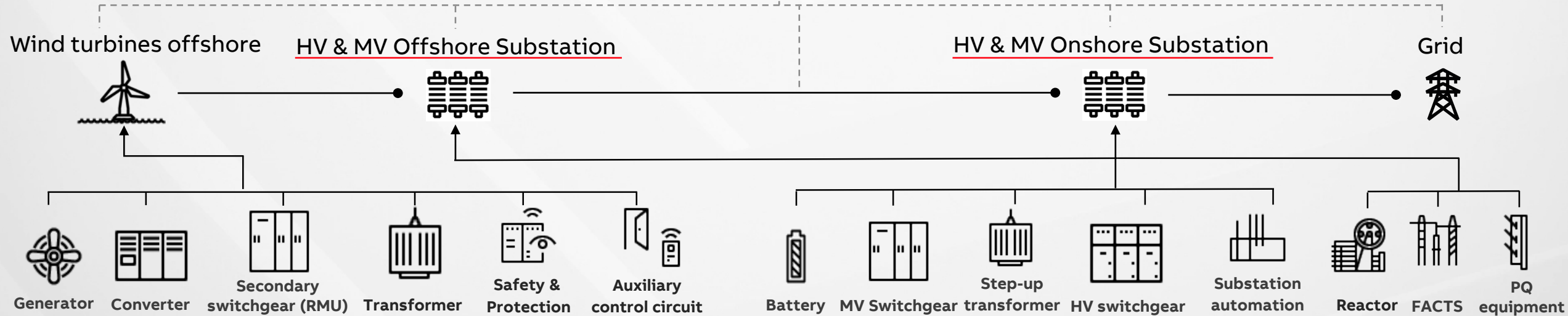
Automation & Digitalization



Service & Asset Management

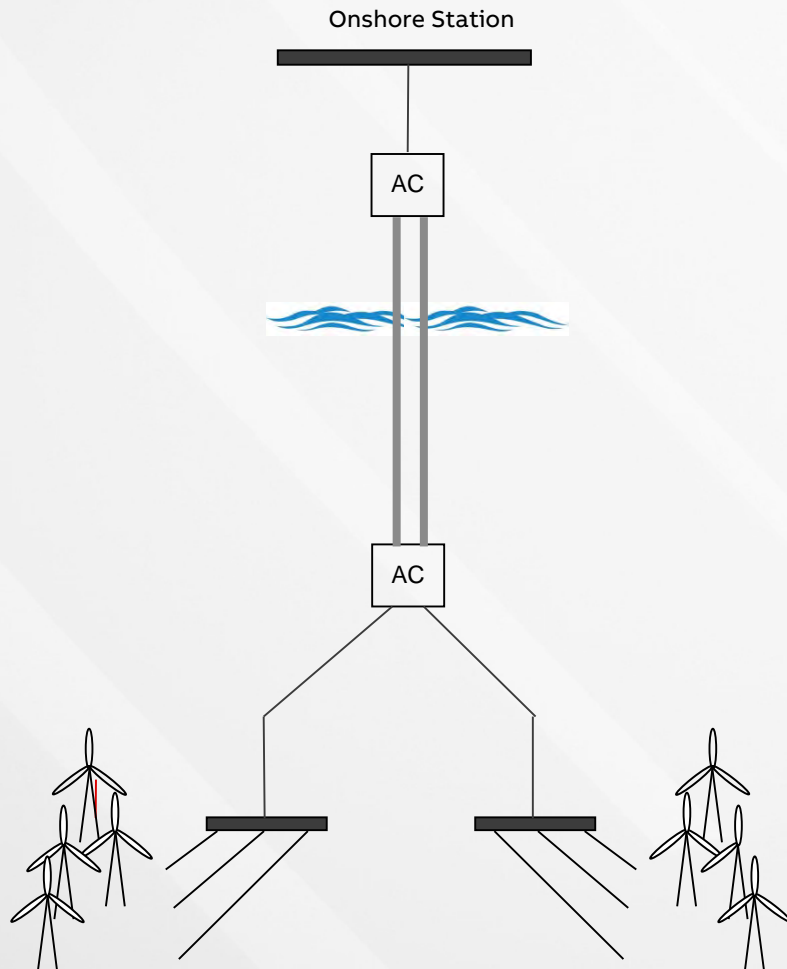


Energy trading solutions



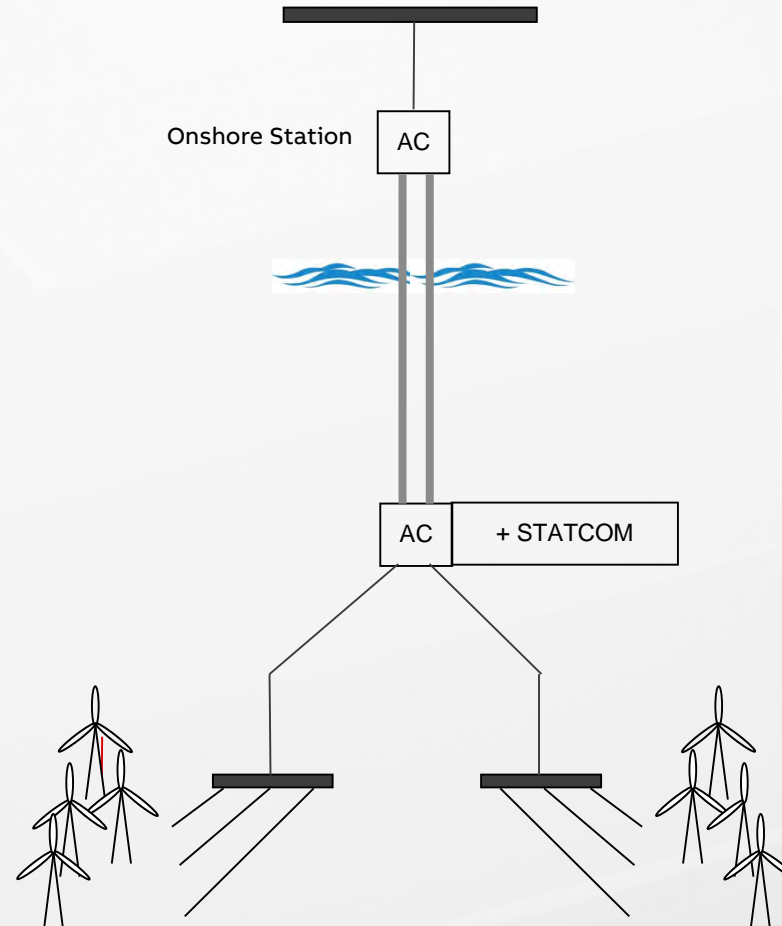
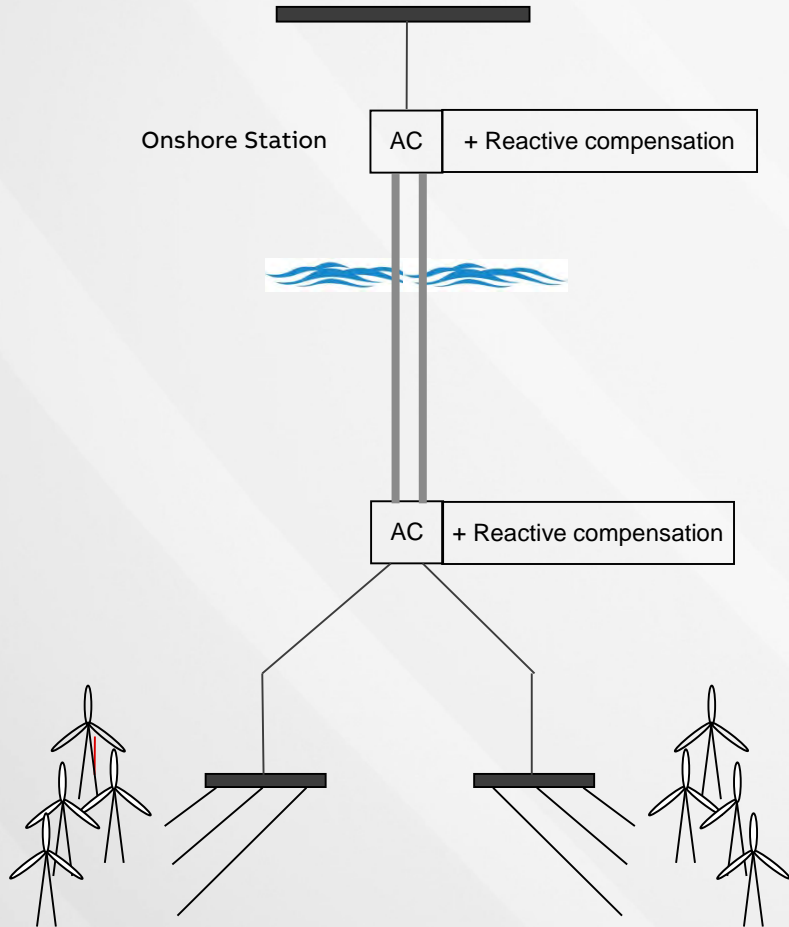
HVDC offshore wind connection

Example of AC - connection



HVDC offshore wind connection

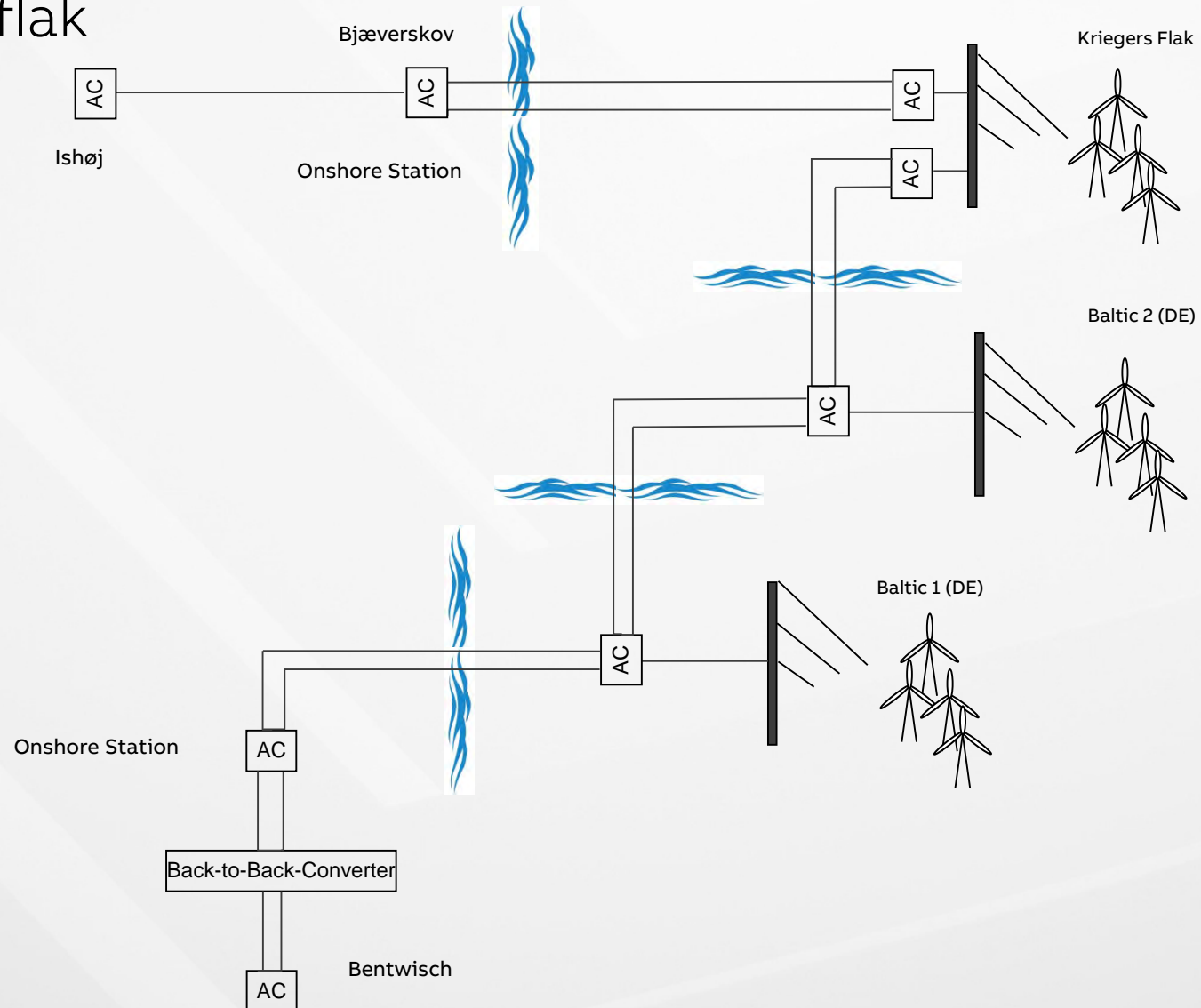
Example of AC - connection



HVDC offshore wind connection

Technical meshing of HVAC in combination with HVDC

Example Kriegersflak



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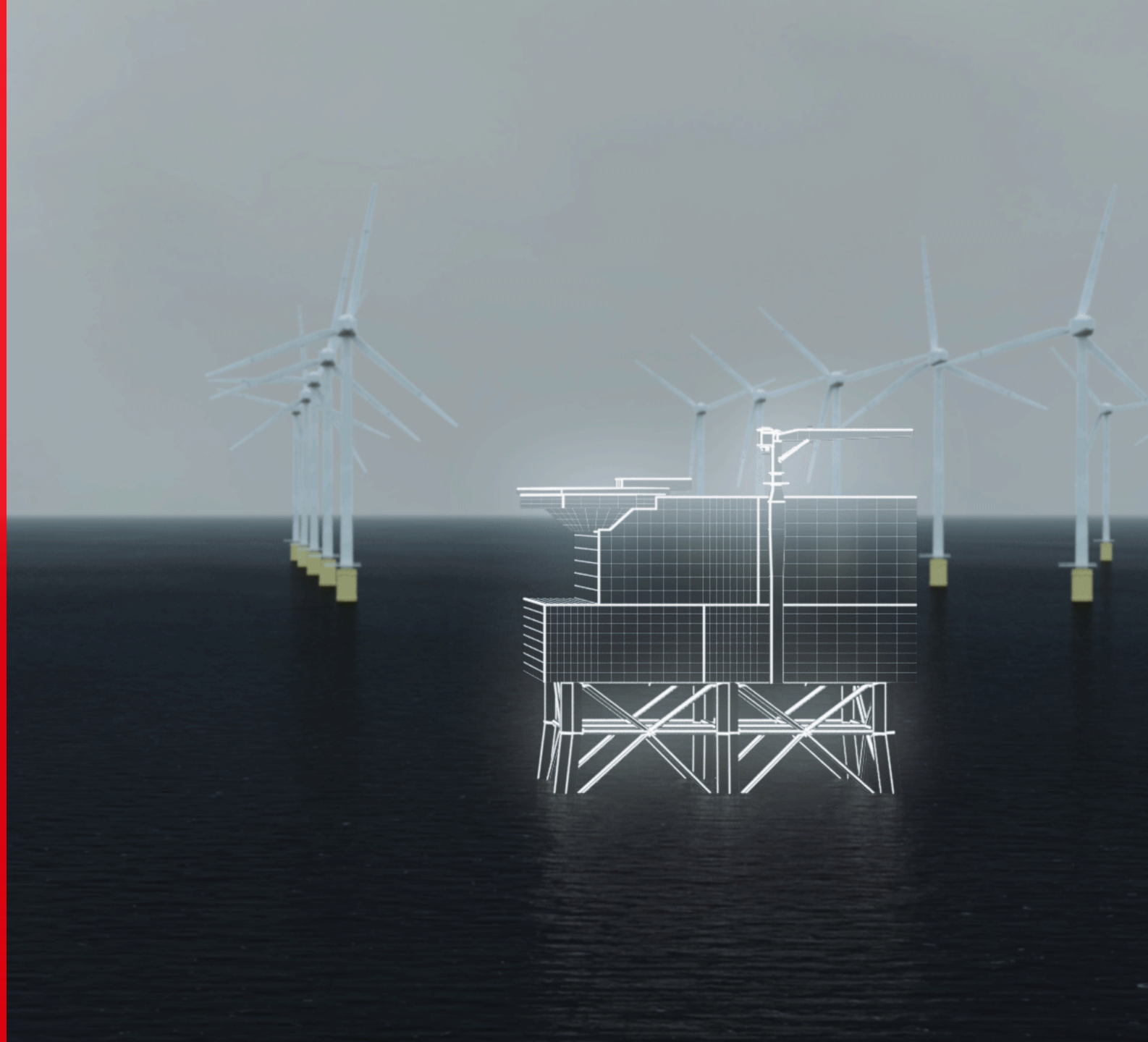
HVAC

Offshore wind connection

3

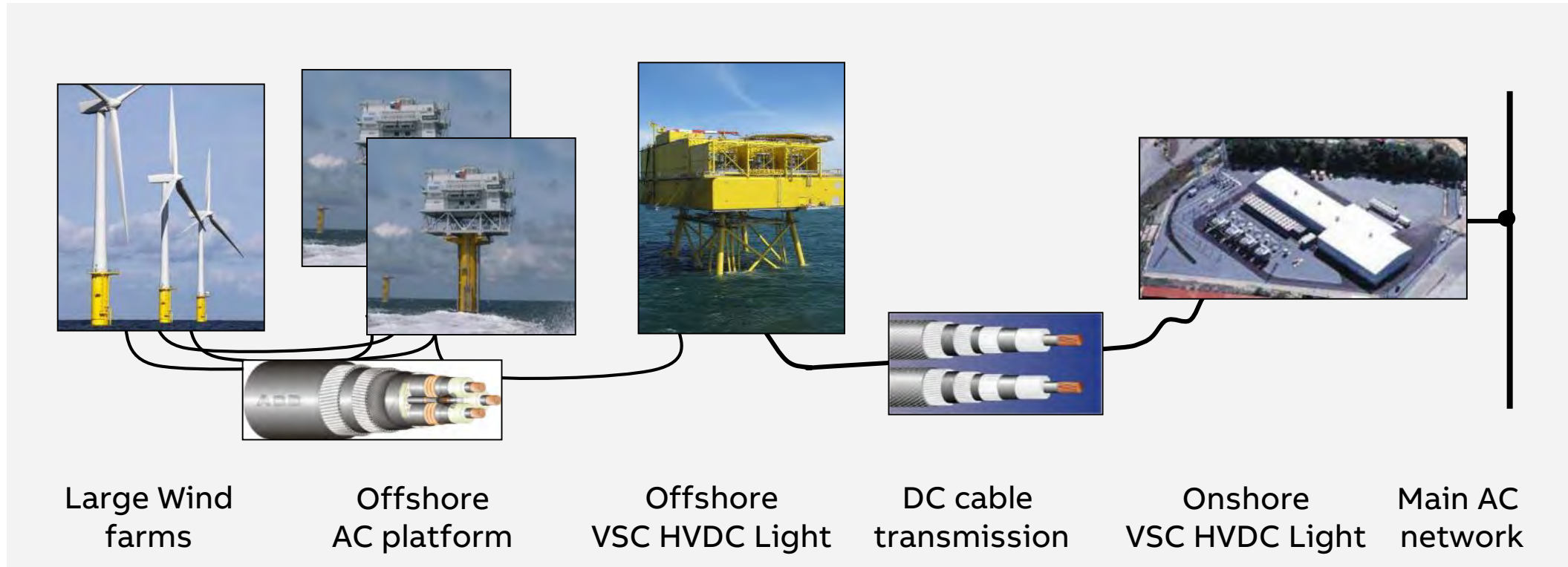
HVDC

Offshore wind connection



Connecting wind power plants by HVDC

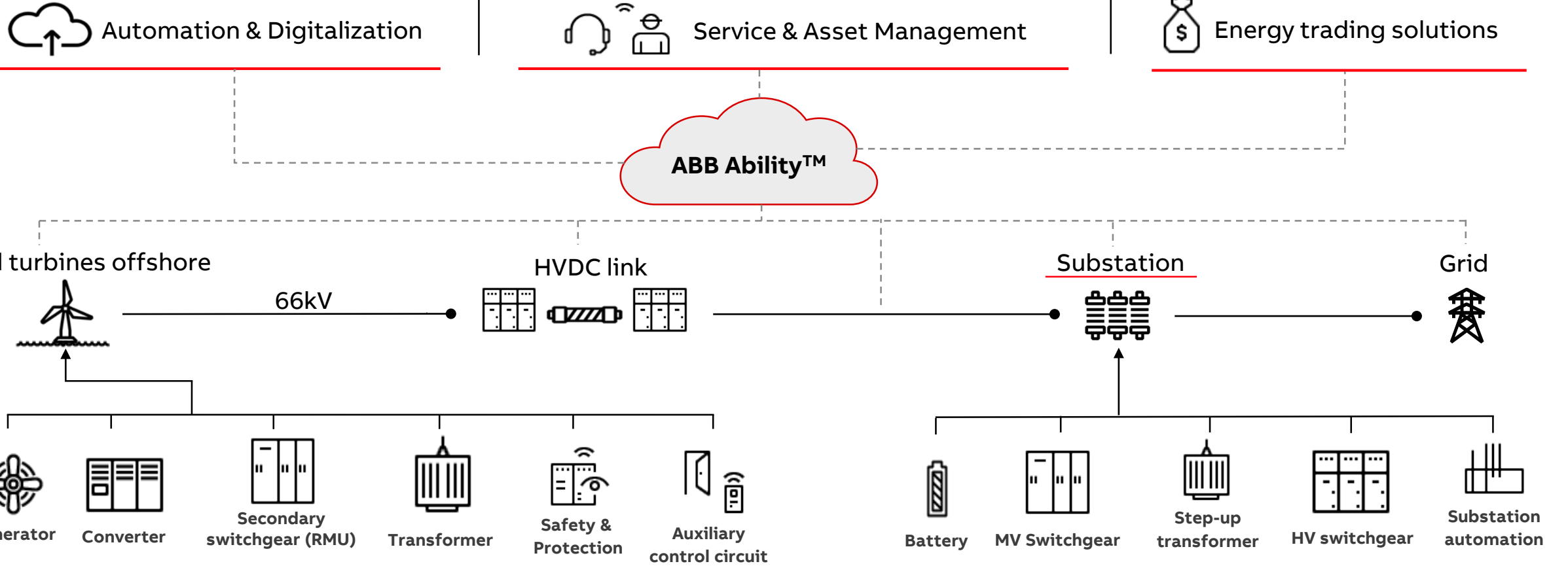
Typical arrangement



100 – 300 MW: ± 80 kV
300 – 500 MW: ± 150 kV
500 – 1800 MW: ± 320 kV

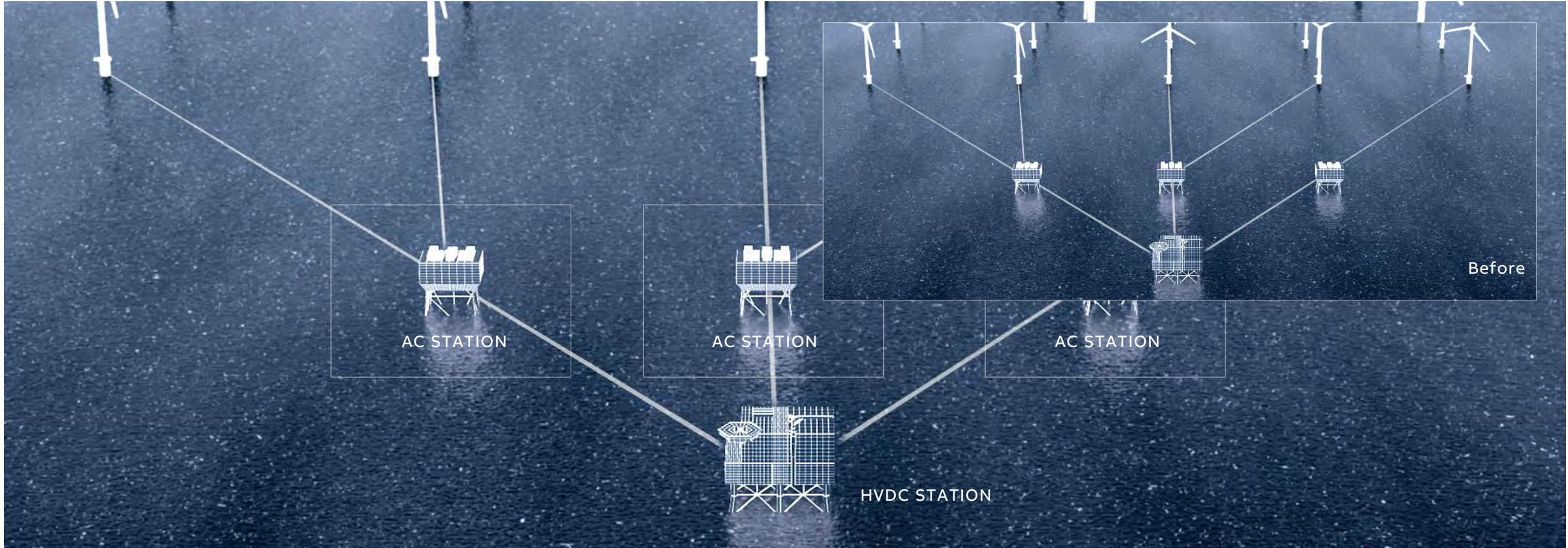
ABB in Offshore Wind

Solutions for offshore segment – DC concept



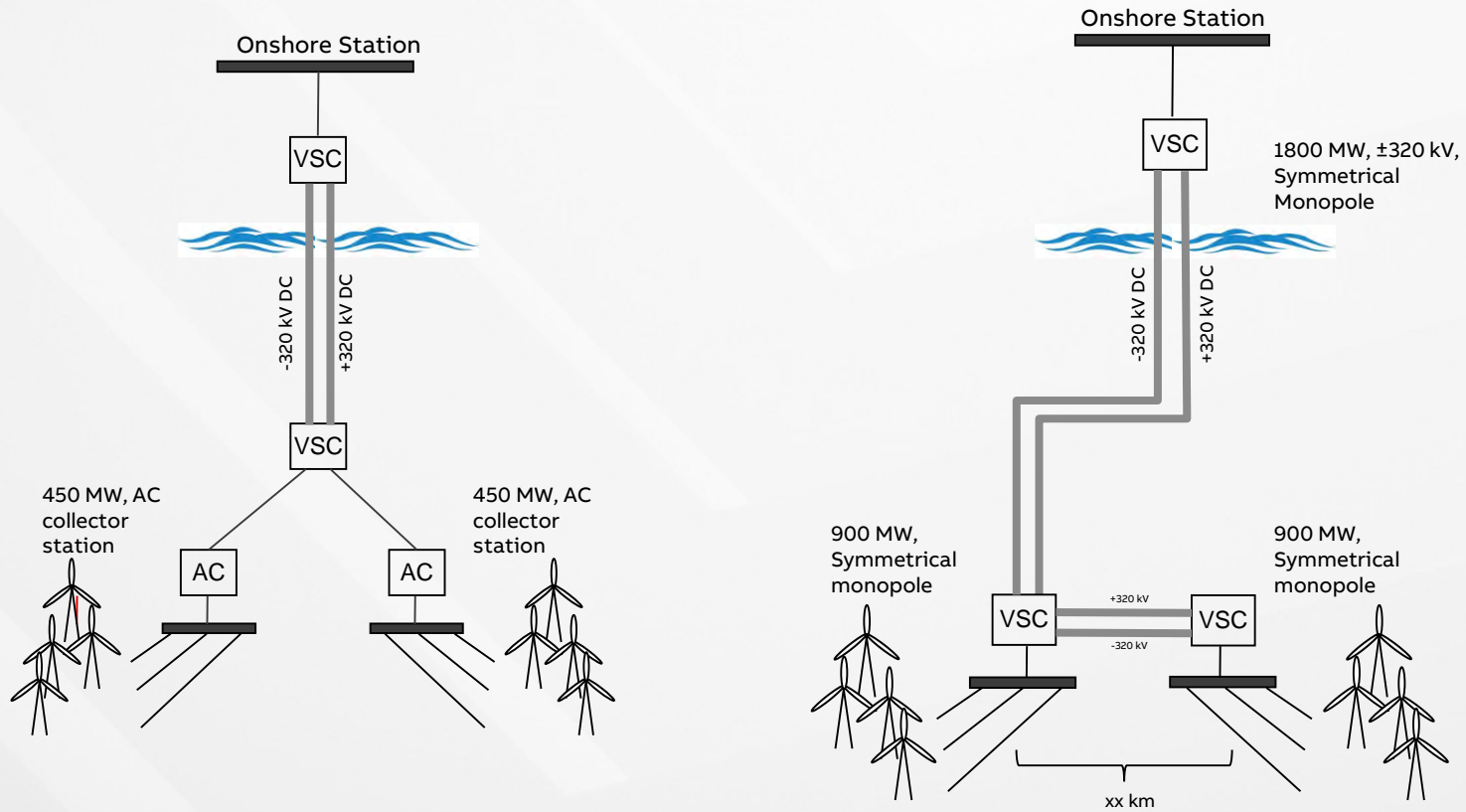
HVDC offshore wind solution concept

Eliminating the need for AC substations



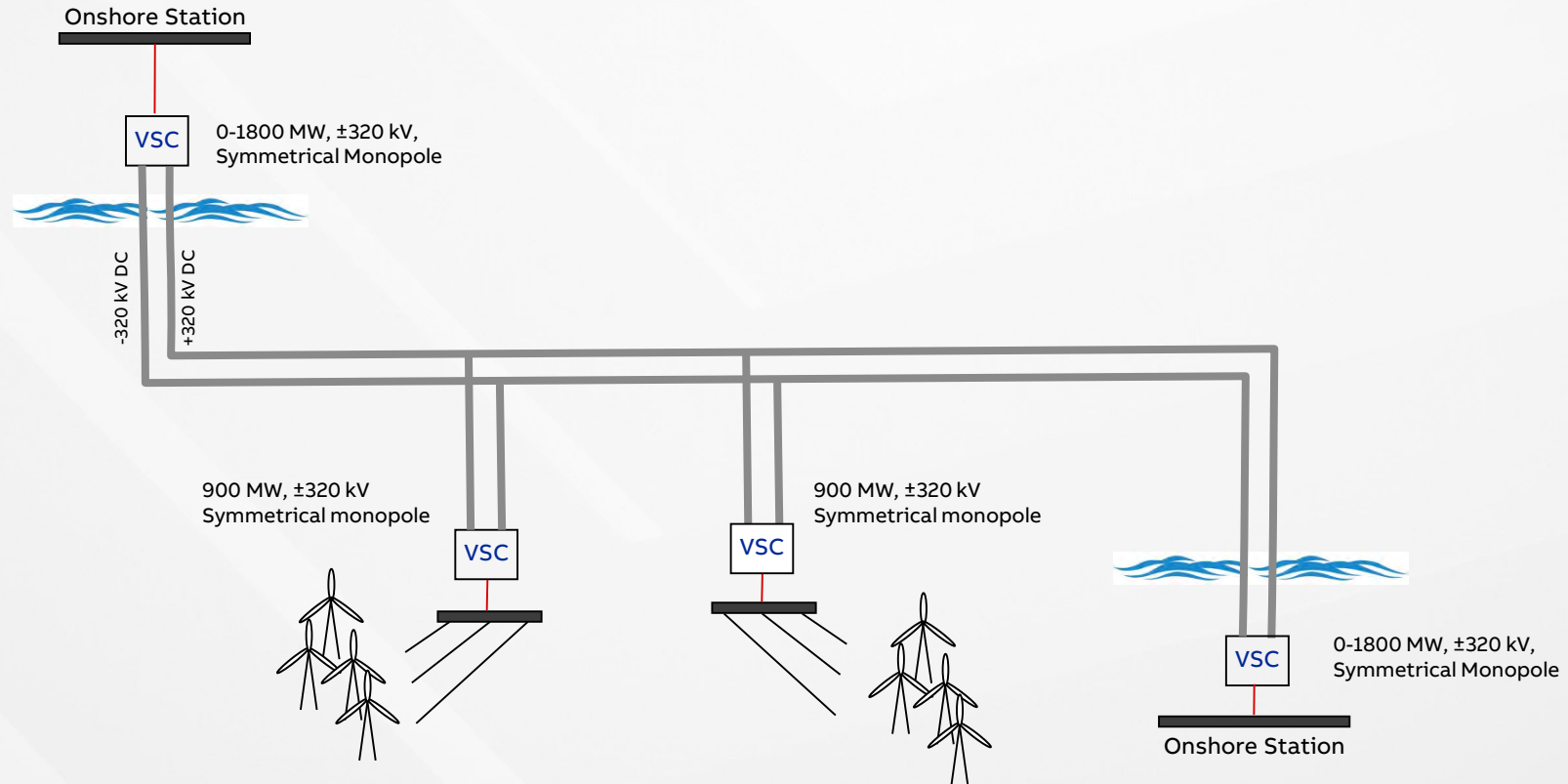
HVDC offshore wind connection

Examples of different options: AC Collectors / DC – direct connection



HVDC offshore wind connection

Examples of different options: Hybrid solution

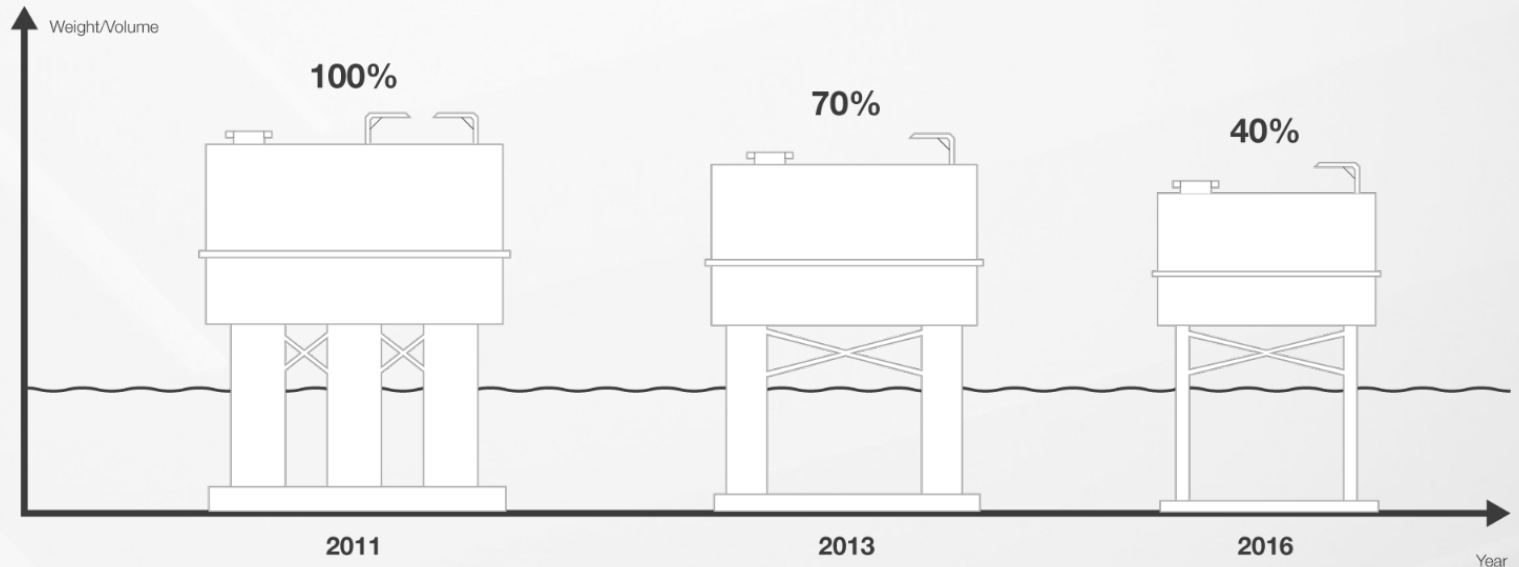


HVDC offshore wind compact solution

60% reduction in weight/volume

Optimization of equipment

- No permanent living quarters
- Optimized redundancy with maintained availability
- Minimize number of active platform systems
- Layout optimization



HVDC offshore wind compact solution

Concept and features

Capabilities

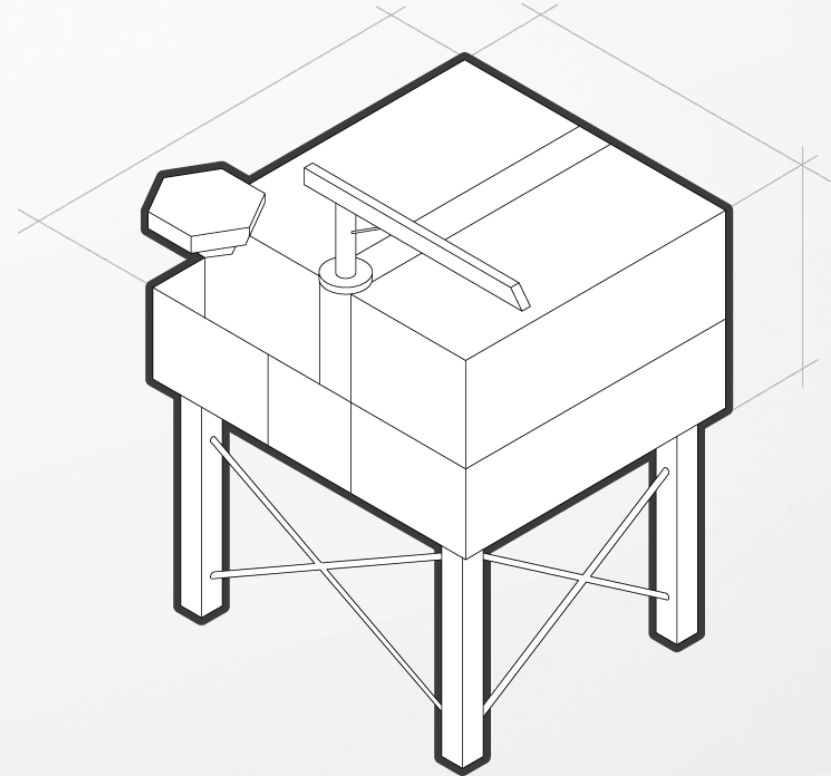
Rated Power:	800-1,200 MW
Design lifetime:	25-30 Y
DC Voltage (outgoing):	± 320 kV
AC Voltage (incoming):	66 kV
Reliability:	98.5%

Dimensions

Size:	~ 40 x 60 x 26 m
Weight:	~ 7,000 T
Volume:	~ 45,000 m ³

Location

North Sea conditions
Water Depth 20-50m
Ambient-T -3 to +30 deg.C
RH = 100% winter
and 51% in summer



Footprint and layout VSC HVDC Light

Example monopole – minimized space and components

1,800 MW, ± 320 kV

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

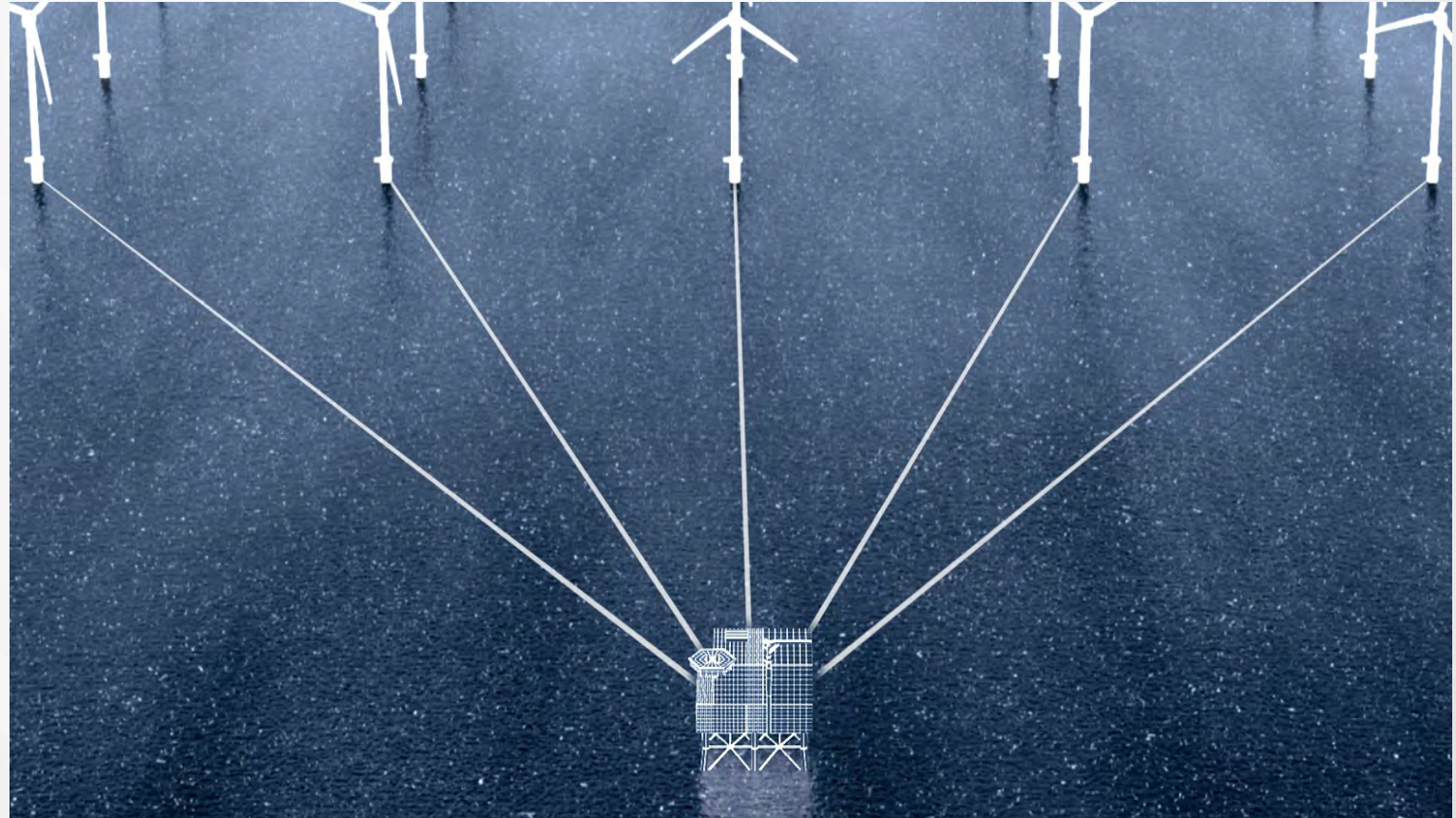


HVDC offshore wind compact solution

Summary

Summary

- Dimension of Platform decreased
- Flexible manufacturing and installation
- AC OSS functionality incorporated into HVDC Platform



VSC HVDC Light

ABB supplied 70% of all VSC links in the world



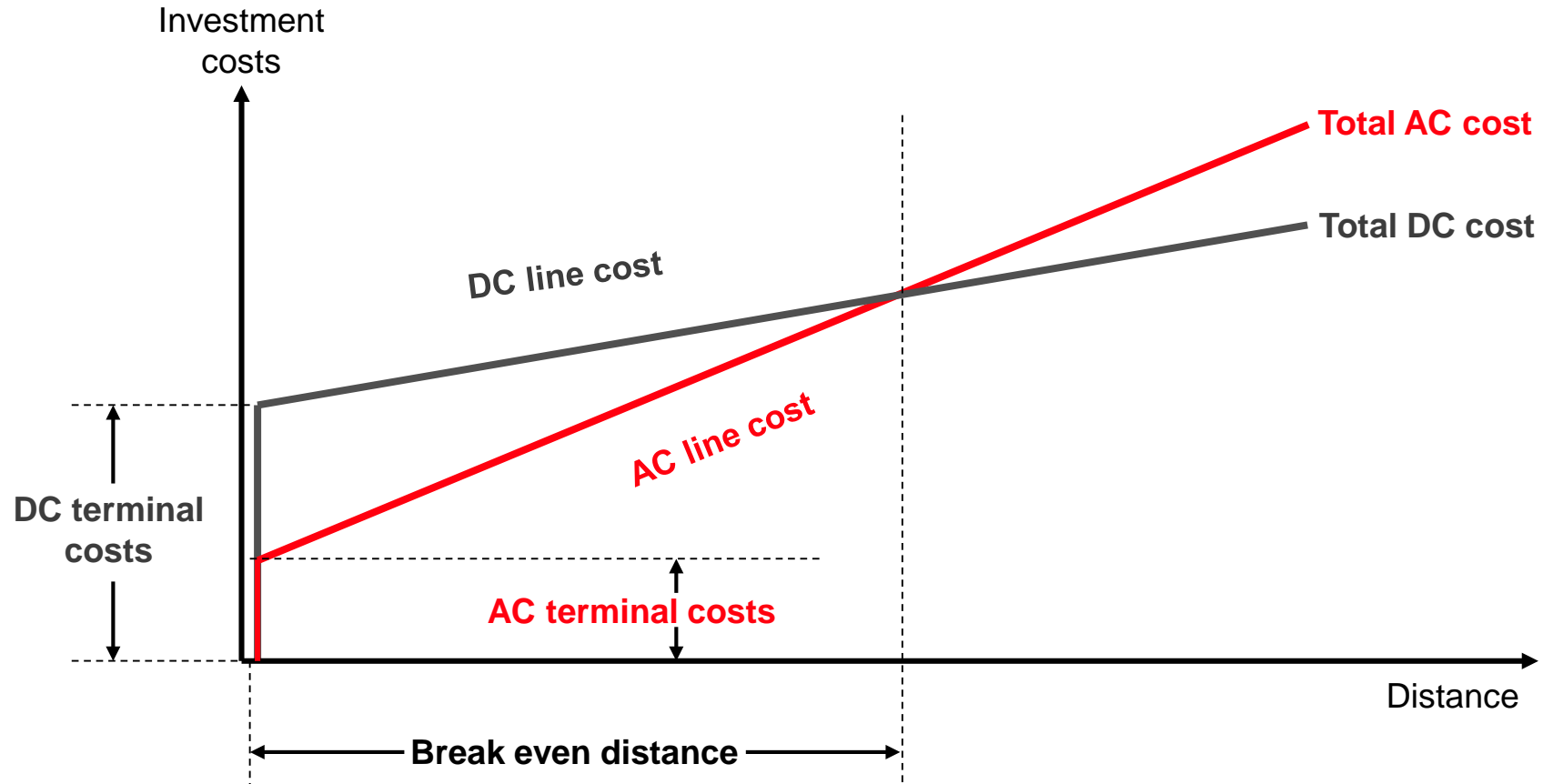
● VSC-HVDC projects commissioned

● In construction

*VSC: Voltage sourced converter

HVAC or HVDC?

Investment costs versus distance



HVAC or HVDC?

Pros and Cons

HVAC

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

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

HVDC

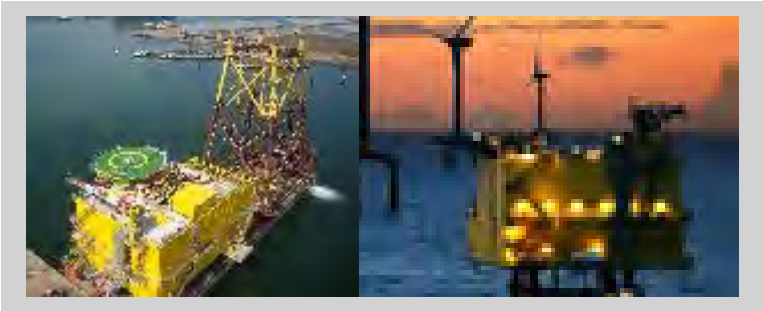
- + Superior dynamic behavior and features
- + Onshore and offshore grid support e.g. AC voltage and frequency stabilization
- + Black start capability
- + No minimum short-circuit power requirement for weak AC networks
- + Inherent Statcom functionality => easy to fulfill Grid Code req.
- + Less cables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

ABB expertise in offshore wind

Pioneer from early start of offshore wind in 2008

Borwin 1



Dolwin 1/2



Dolwin 5



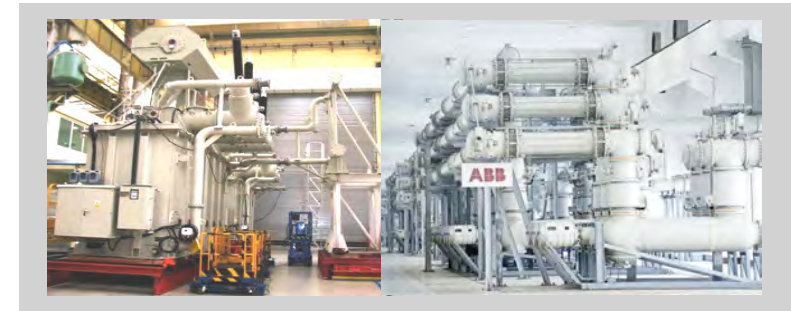
Thornton Bank



Princess Amalia (Q7)



Various projects: equipment supply





ABB