HVDC Multi-terminal Systems: Benefits and Challenges

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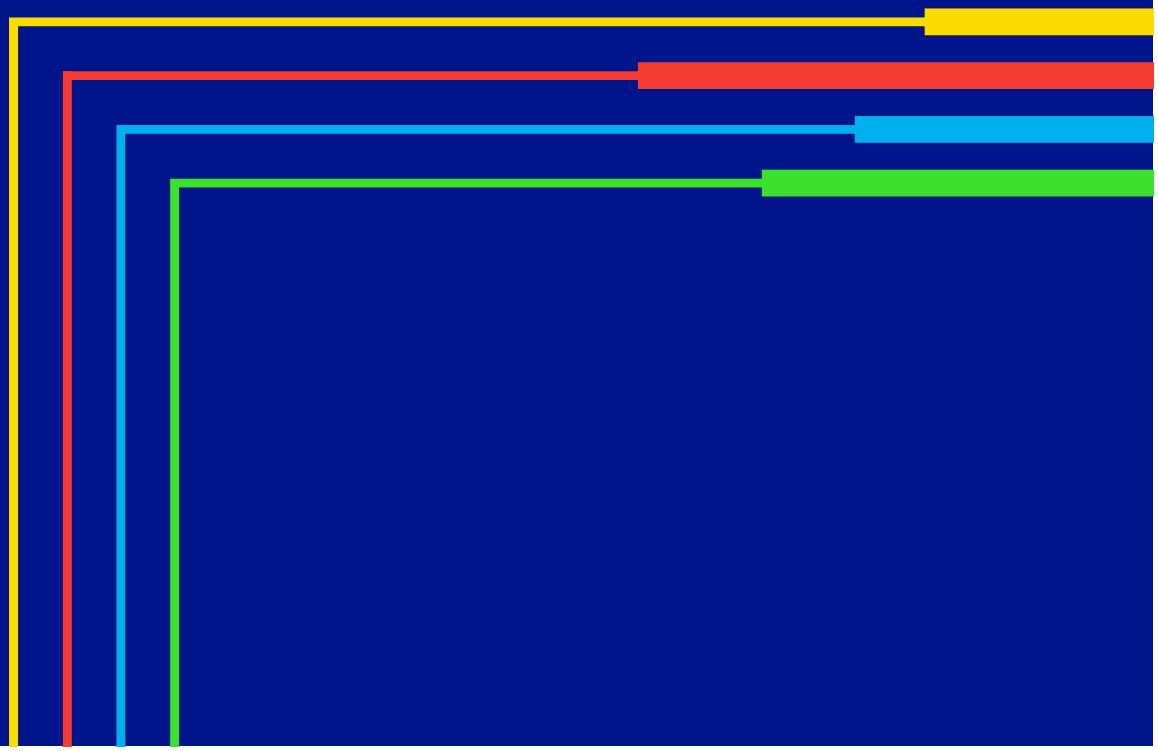
Agenda

01	An Introduction to HVDC Technology
02	HVDC Multi-terminal HVDC Systems
03	DC Circuit Breakers
04	Lion-Link HVDC Project NGV
05	Questions
06	AOB

An Introduction to HVDC Technology



Why/When do we use HVDC?

HVDC has the following fundamental advantages over conventional AC transmission;

- Ability to connect two asynchronous systems
- Ability to control power flow proportionally
- Ability to transmit power over very long distances

- Long Distances
- Asynchronous Links
- Subsea Transmission
- Islanded System

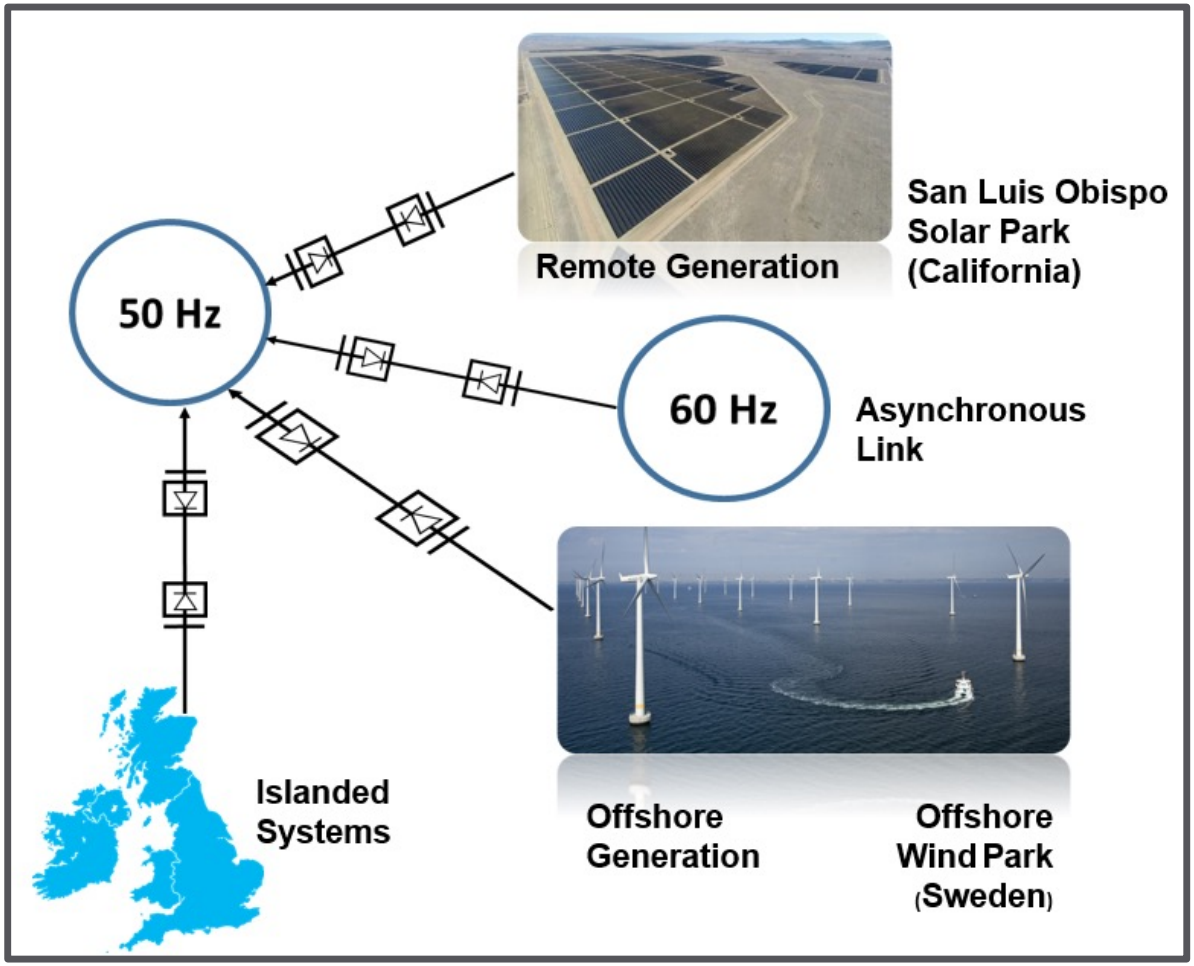


Figure 1: HVDC Application (Source DNV)

HVDC World's Records

When does it make sense to use HVDC?

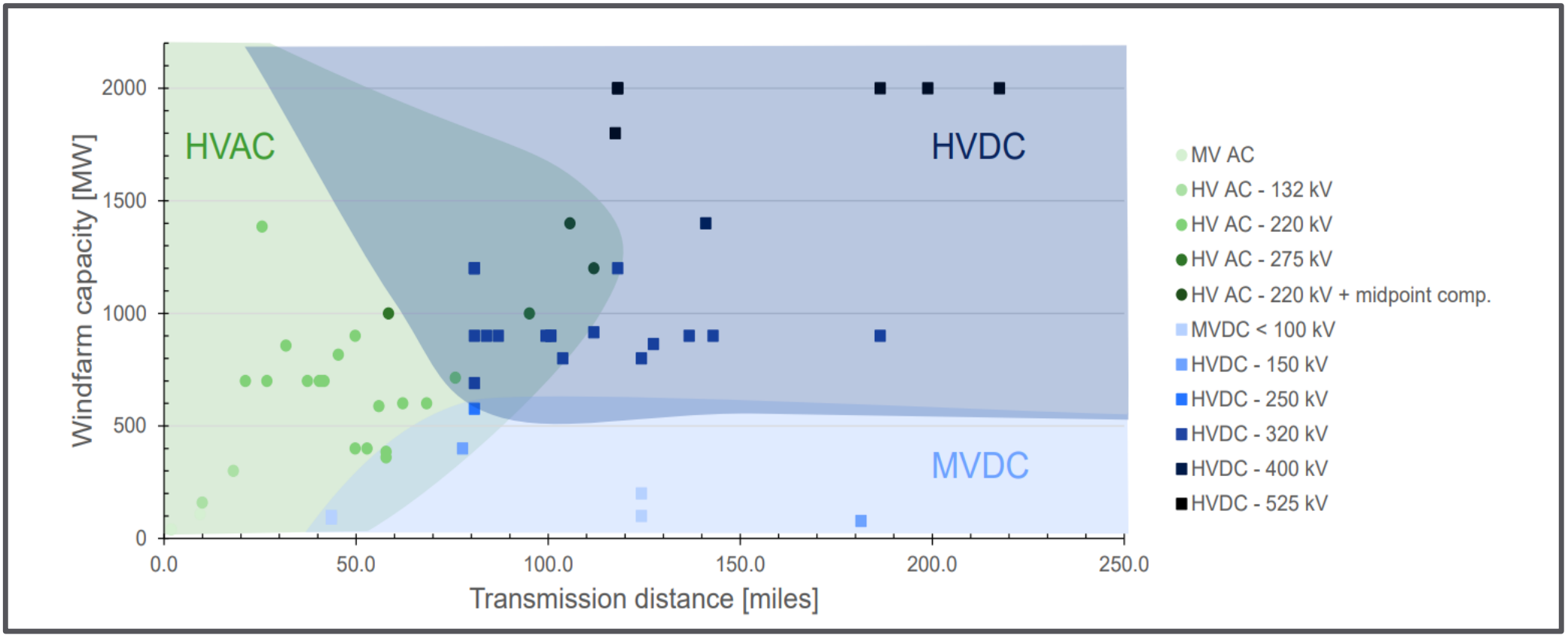
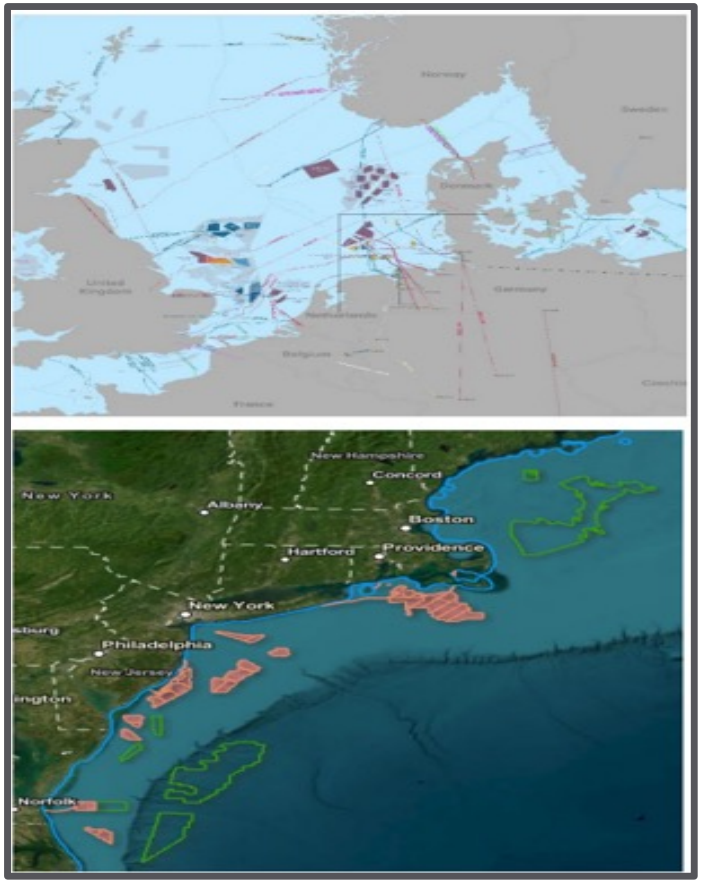


Figure 2: AC/DC Distance versus Capacity (Source DNV)

HVDC World's Records

Where are we now?



- Strong global growth expected (both onshore and offshore)
- First multi-terminal (radial) VSC-HVDC grids
- Multi-purpose HVDC infrastructure appearing
- Policy moving towards multi-terminal HVDC grids

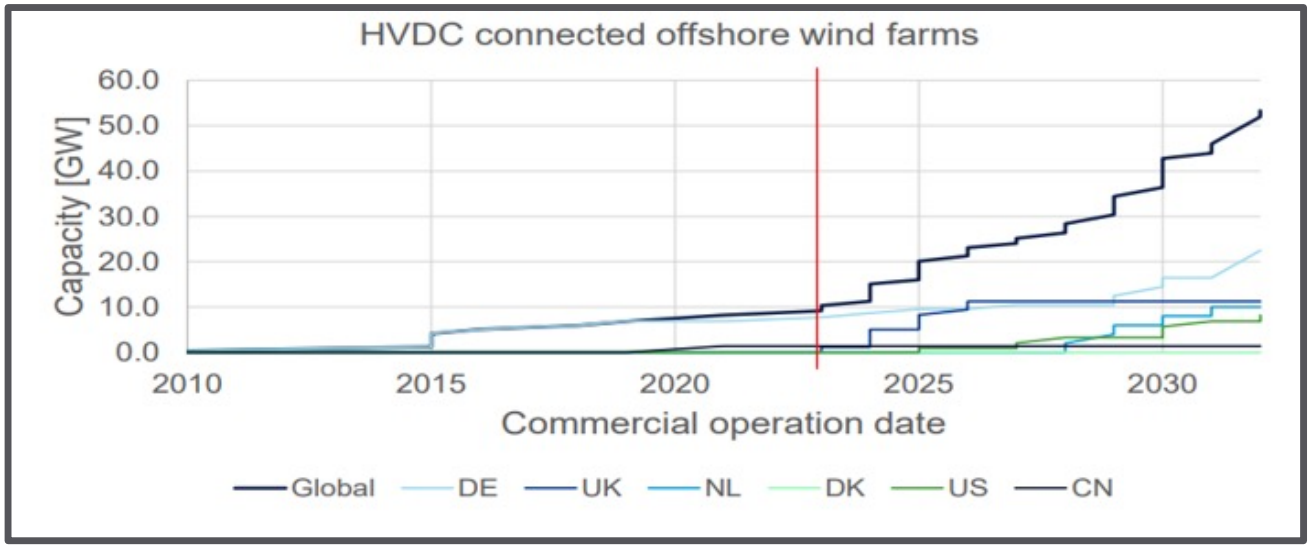
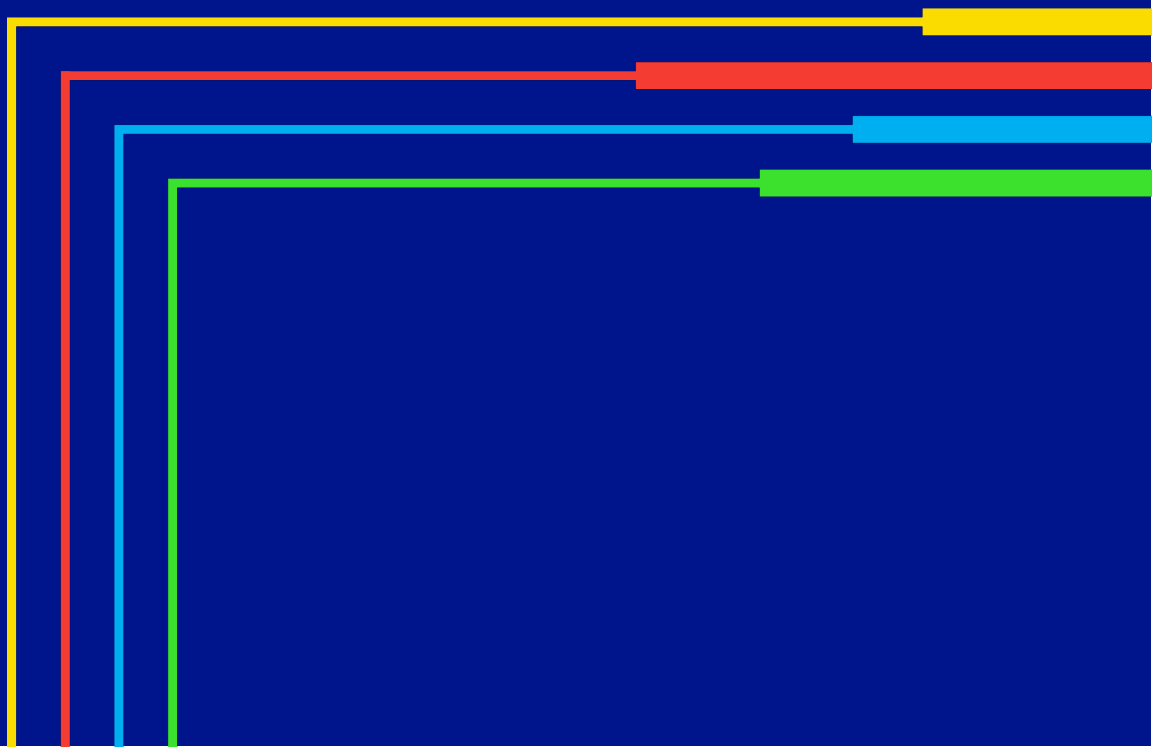


Figure 3: HVDC Connected offshore Windfarms

HVDC Multi-terminal Systems



HVDC World Records

How can HVDC systems be used?

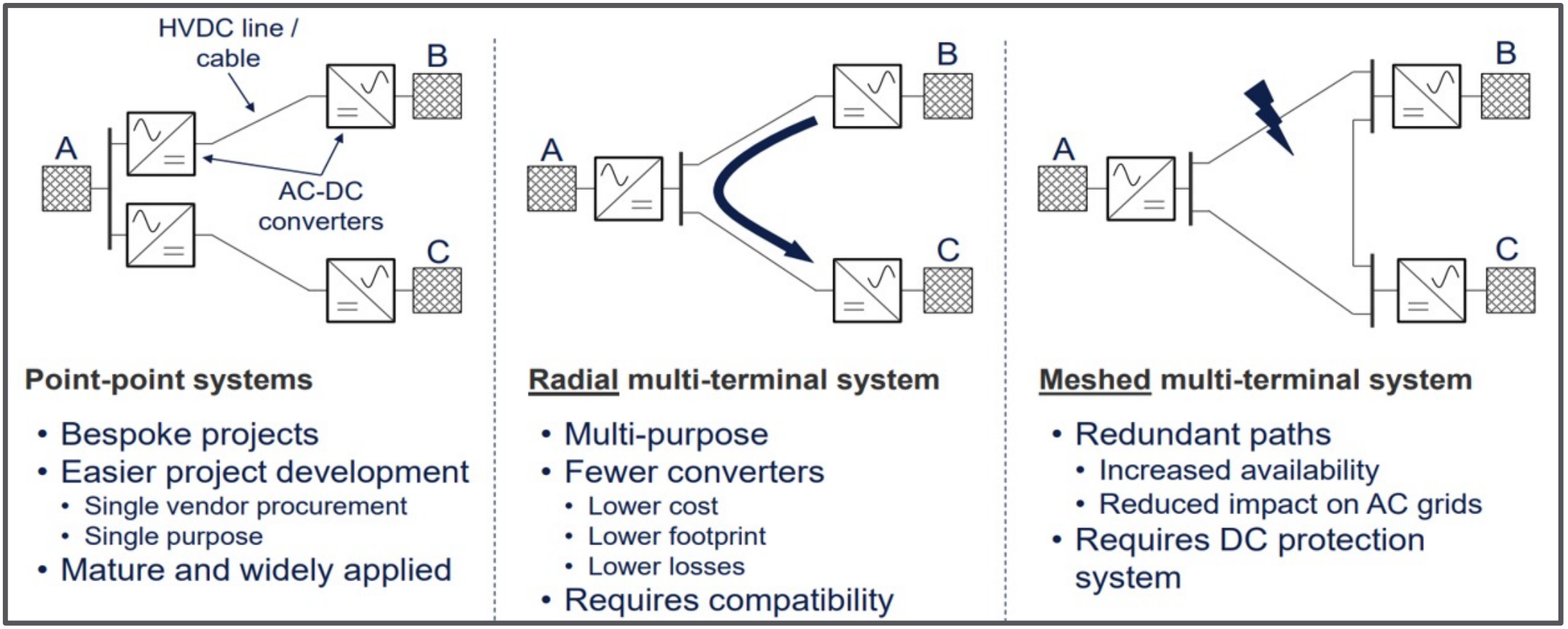


Figure 4: Multi-terminal Configurations (Source DNV)

HVDC World Records

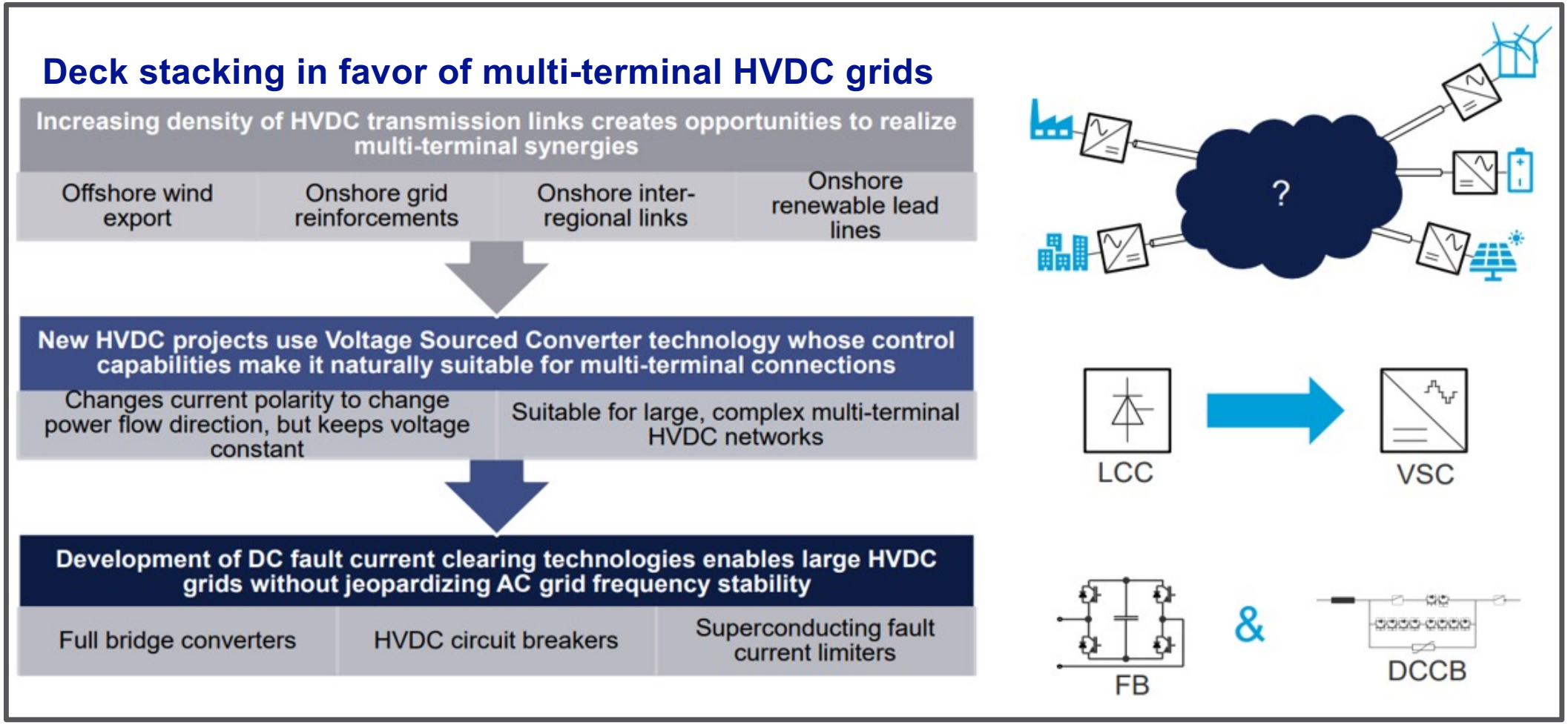


Figure 5: DC Grids (Source DNV)

HVDC World's Records

HVDC Technology Growth

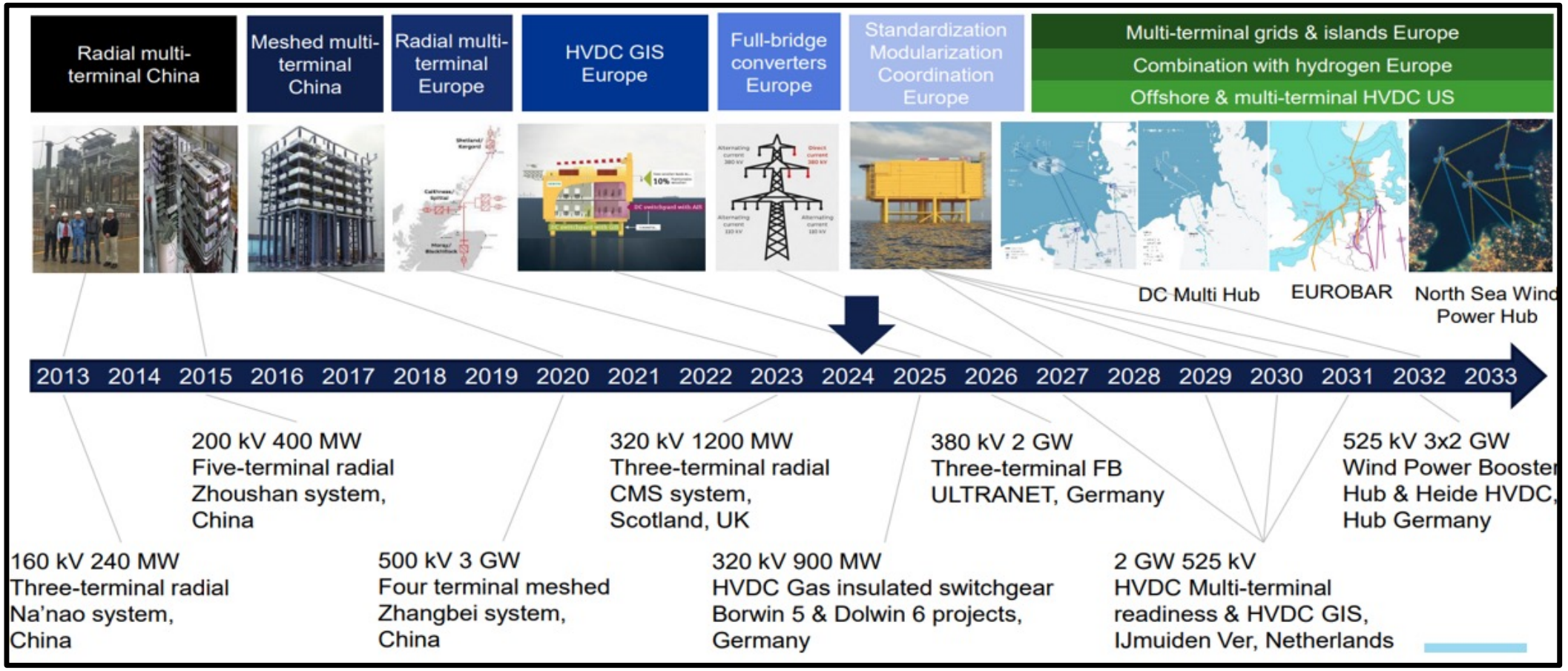
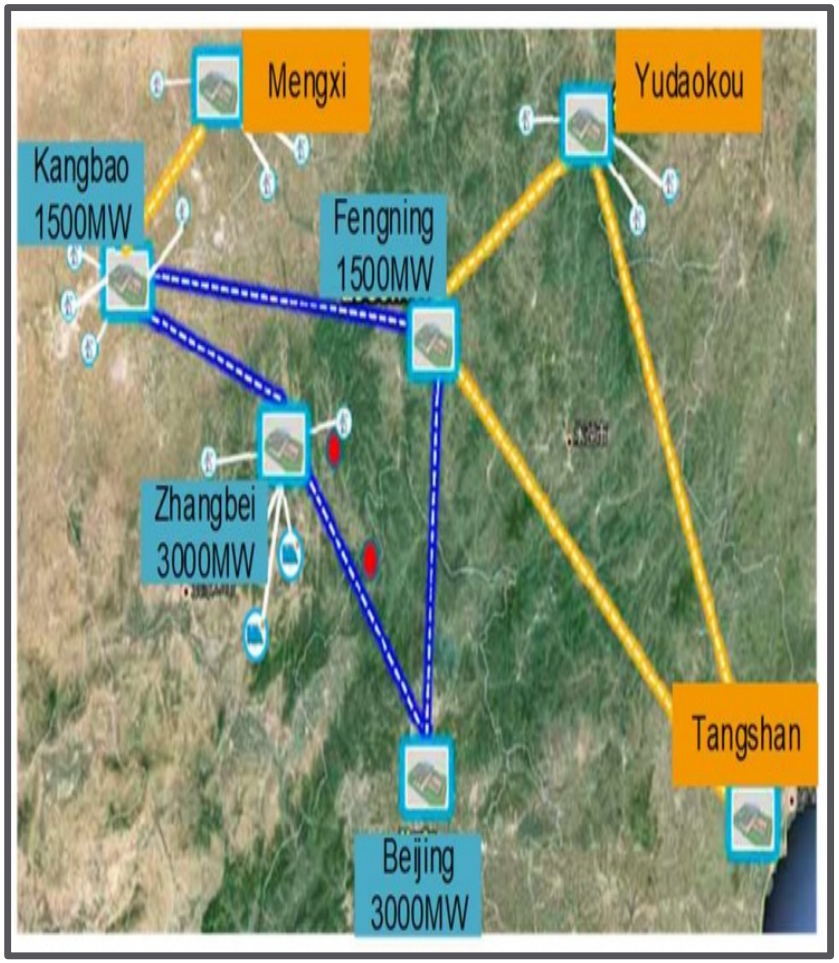


Figure 6: DC Technology/Project Growth (Source DNV)

Zhangbei HVDC 4 terminal VSC-HVDC project + DCCBs



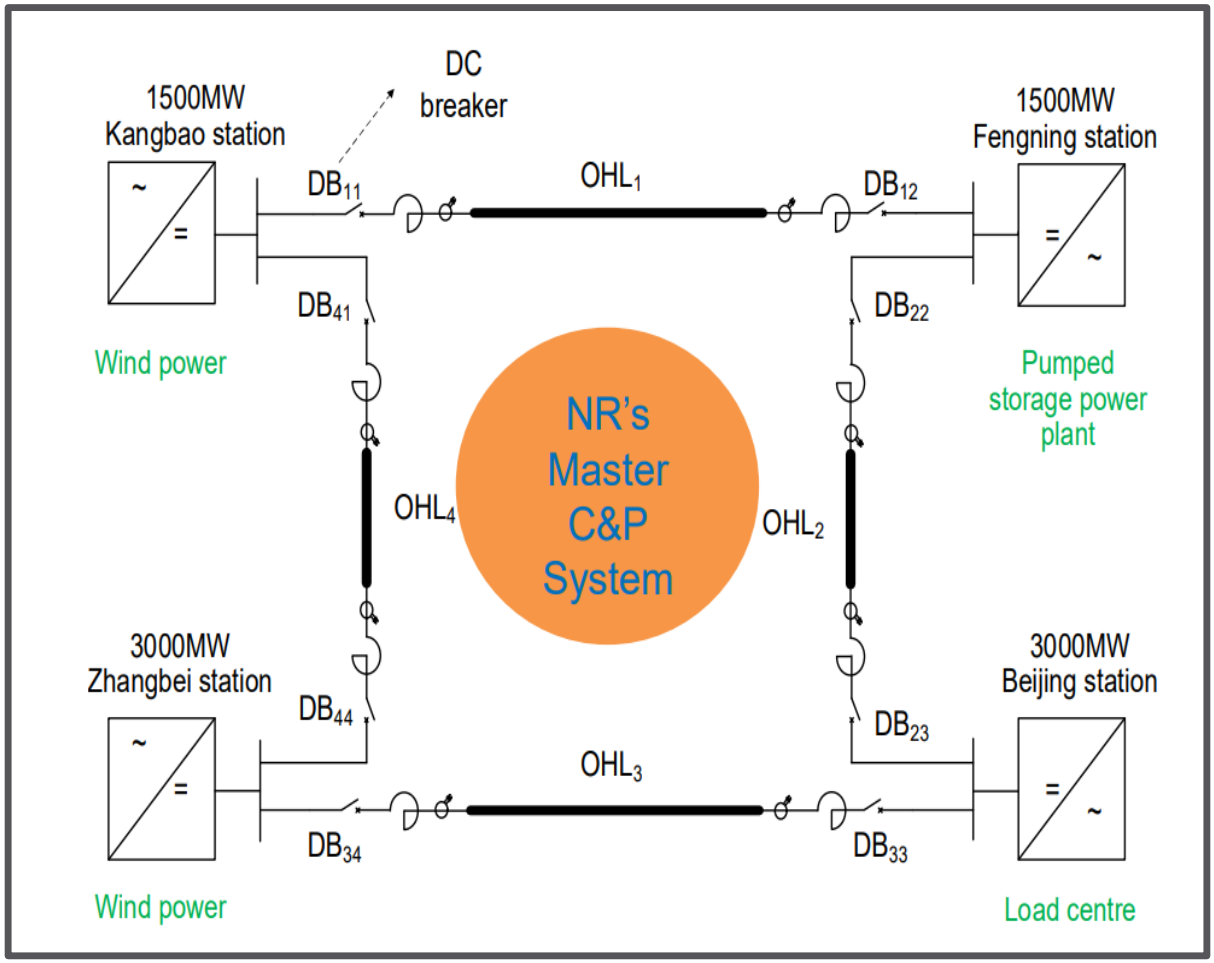


Figure 7: Zhang-Bei HVDC MTDC Project

Zhang-Bei HVDC Multi-terminal Project with future expansion

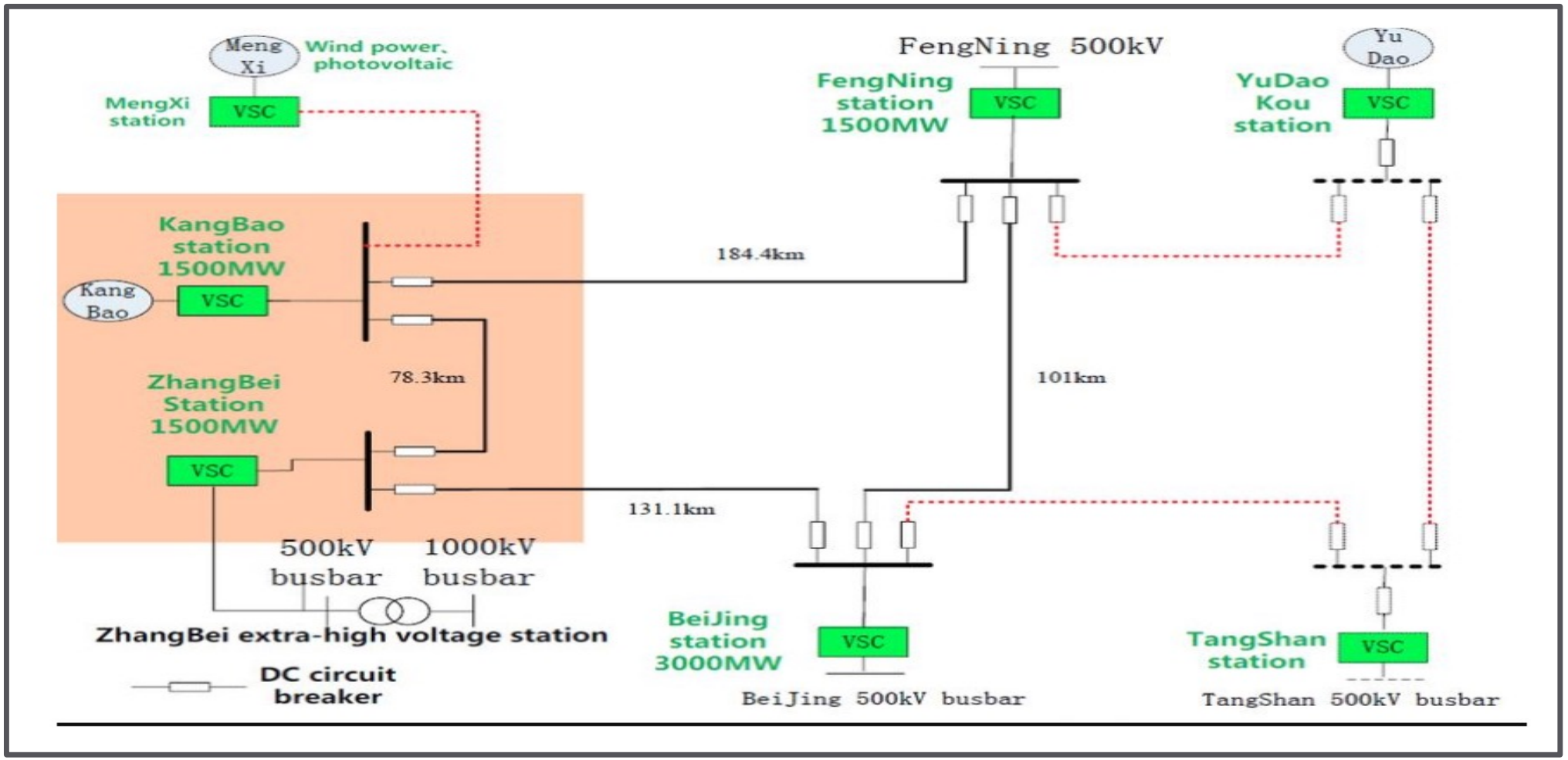
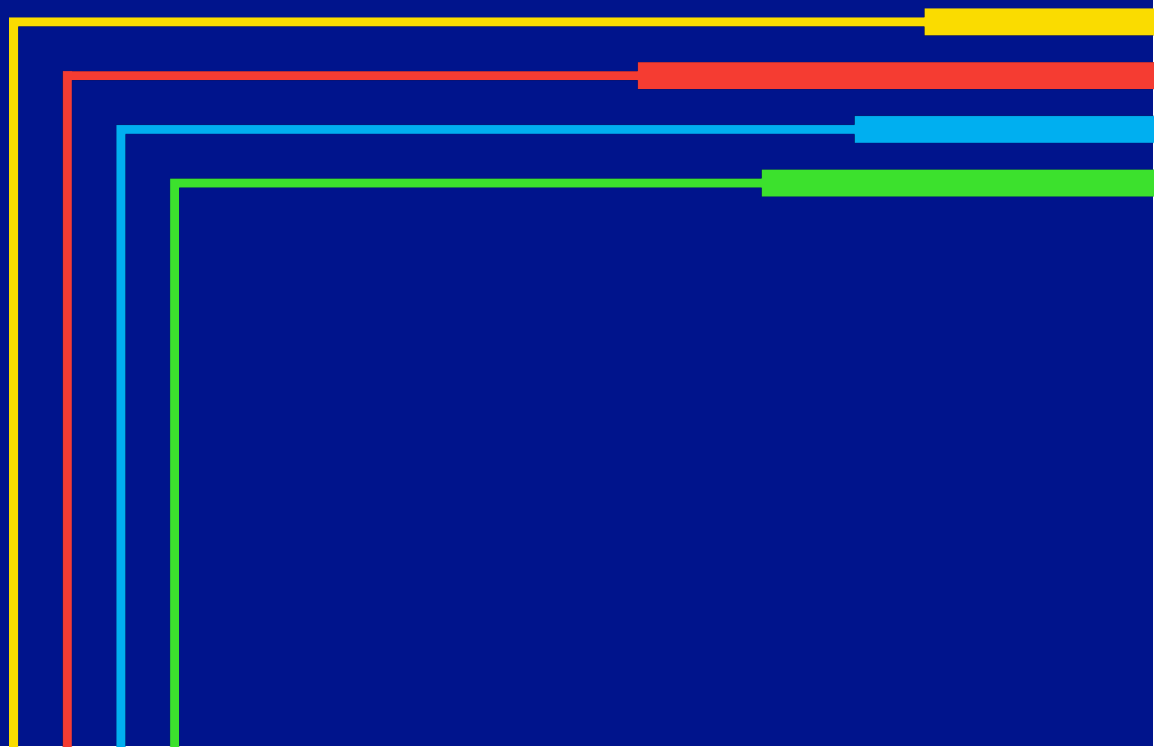


Figure 8: Zhang-Bei HVDC MTDC Project planned expansion

DC Circuit Breakers



500kV DC Breaker Type test

500kV DC Breaker Ratings & Type Test

Rated Voltage	535KV
Rated Current	3KA
Breaking Current	25KA
Breaking Time	<3ms
Fast re-closure	Yes

DC breaker

CONCLUSIONS:

Above witnessed and verified type tests with mentioned main test parameters passed in accordance with NR Electric 535kV HVDC Circuit Breaker product standard which is based on SGCC Zhangbei pilot ±535kV HVDC gird project HVDC CB technical specification and draft Chinese national standard GB. Detailed test conditions and results are described in the next part of this report.

WITNESSED AND VERIFIED BY Dr. Yanny Fu, DNV GL Netherlands B.V.

DATE AND SIGNATURE Arnhem, 28 March 2017

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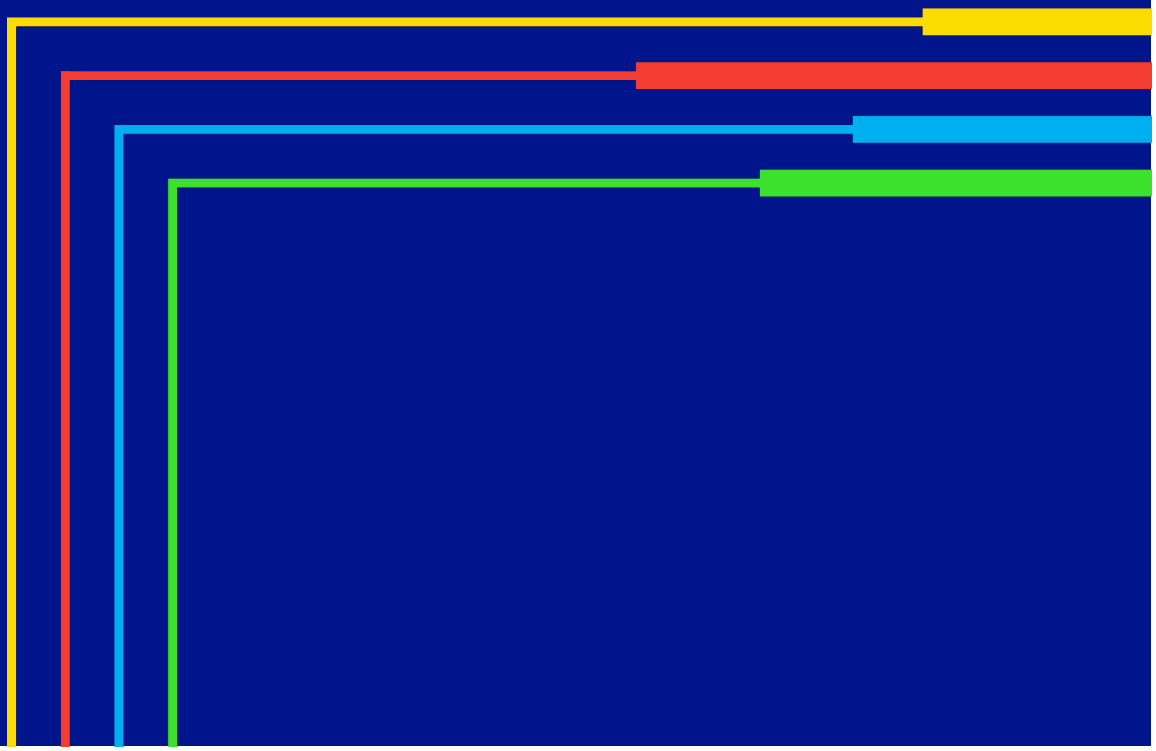
- Dielectric Type test
- Operational Type test

- Anti-seismic Test

Figure 9: 500kV HVDC Breaker Type Test

Lion-Link HVDC Project NGV



Multi-Purpose Interconnectors / OHAs

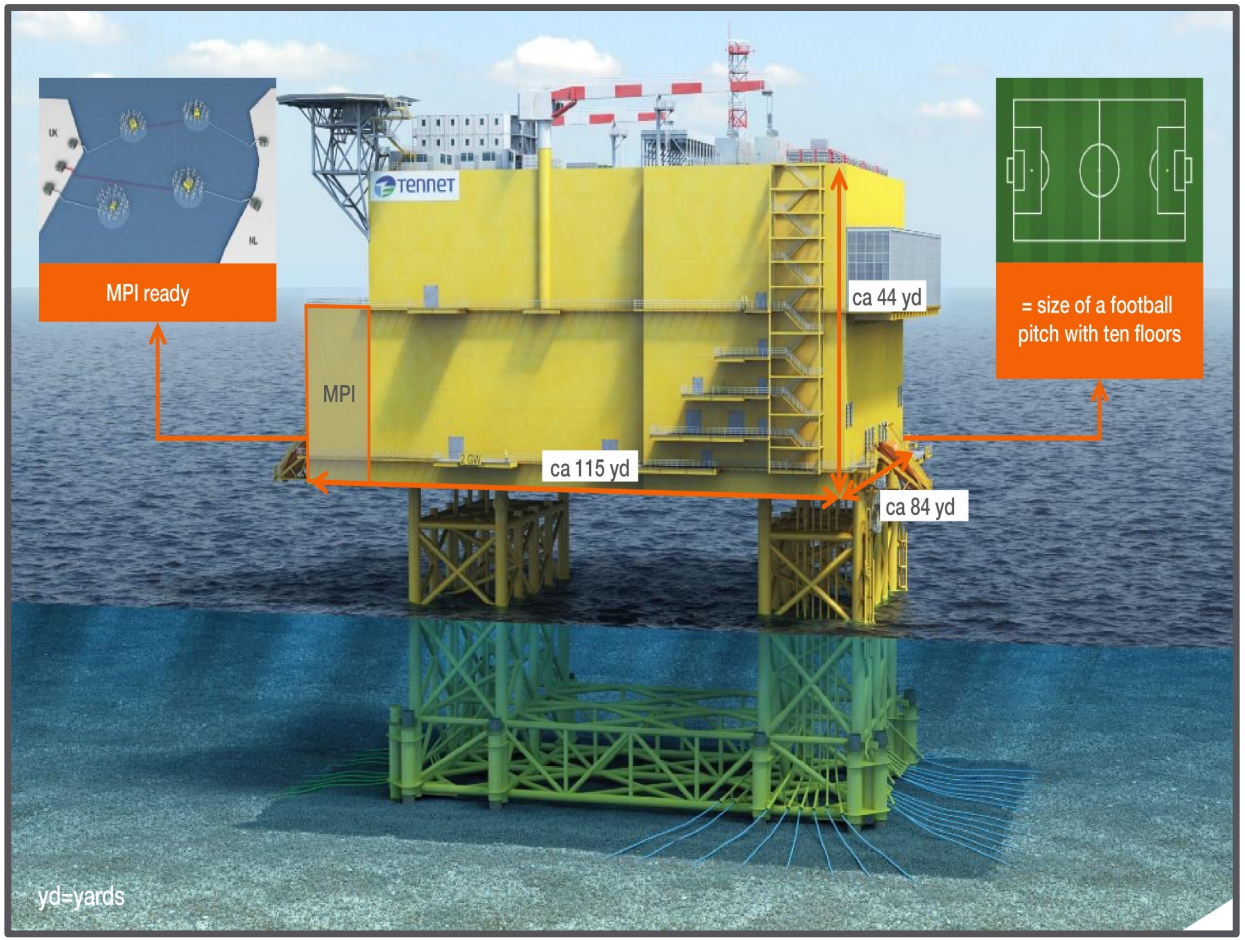


Figure 10: 500kV HVDC Breaker operating principle

- Interconnector connecting offshore wind to different countries.
- Switchgear maybe installed on a point-to-point interconnector to make it MPI ready for future connection.
- Offshore converter platform owner will provision space for third party connection later.
- Power can be exchanged in any direction between countries whether wind is available or not.

Questions?