

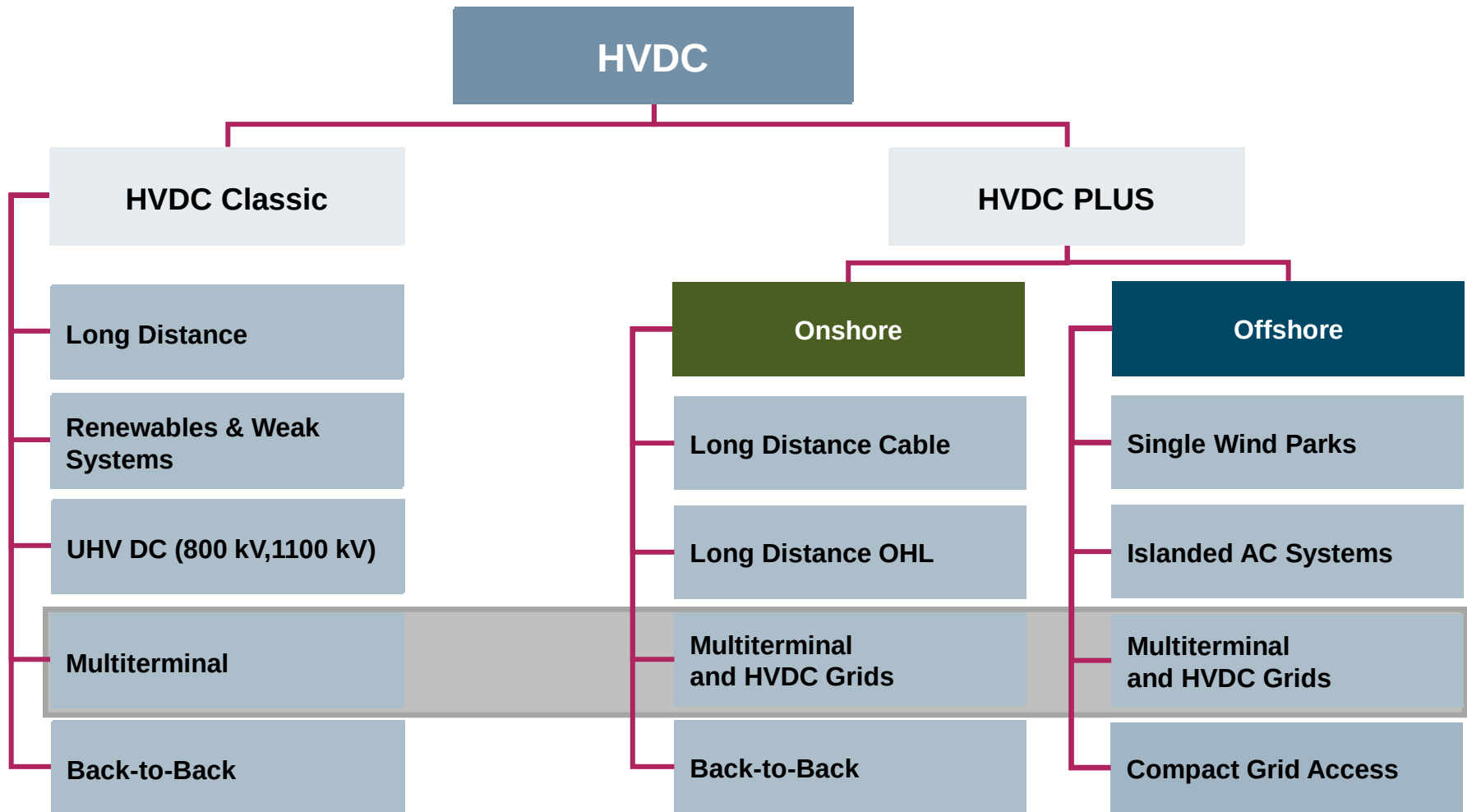
PROMOTioN

A manufacturers view on meshed HVDC grids
17.11.2016 Hamburg

Content



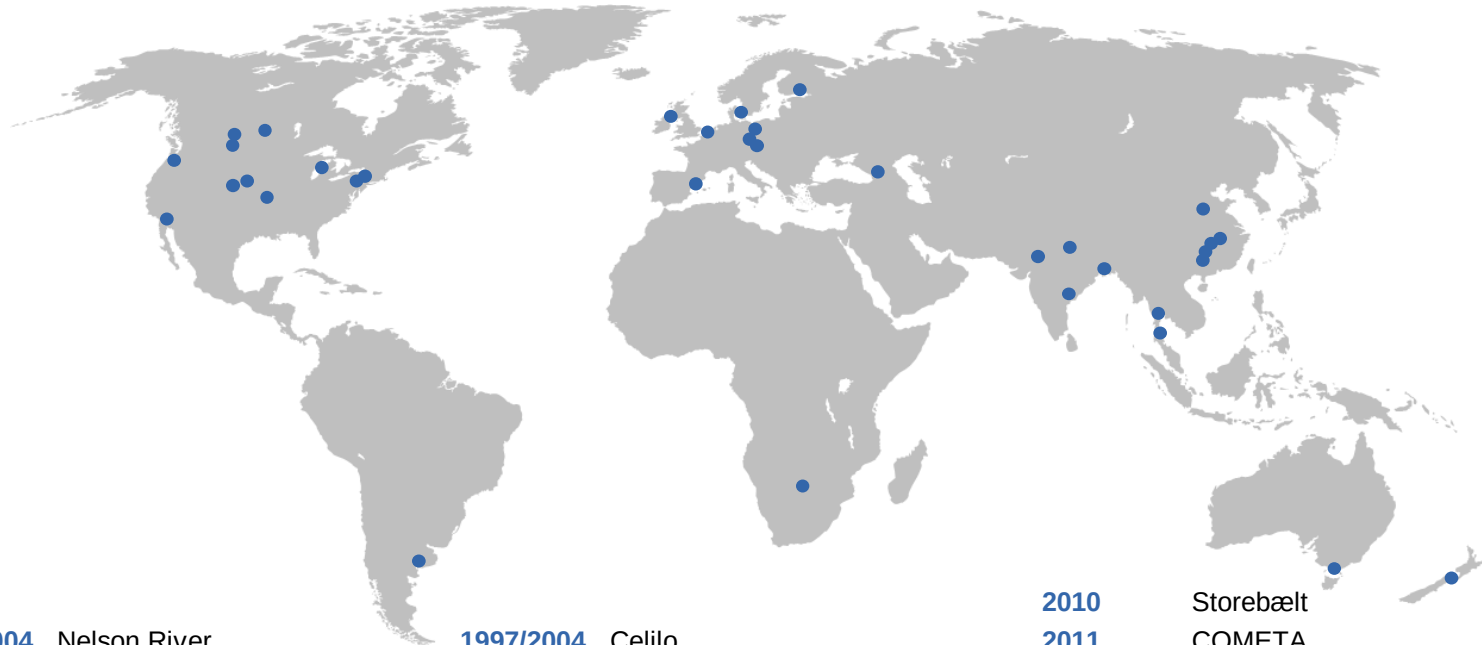
- Siemens HVDC Products and Solutions
- HVDC systems worldwide by Siemens
- Future HVDC Grid Development
- Full Bridge MMC based Protection Concept
- R&D Challenges Protection Concept
- Offshore AC Grid Development
- Hybrid AC/DC Development – One step further



HVDC Classic – Made by Siemens

Projects worldwide

SIEMENS



1977/2004 Nelson River
1975/1998 Cahora Bassa
1981 Acaray
1983 Dürnrohr
1984 Poste Châteauguay
1987 Virginia Smith
1989 Gezhouba-Nan Qiao
1993 Etzenricht
1993 Wien Südost
1995 Welsh
1995 Sylmar East

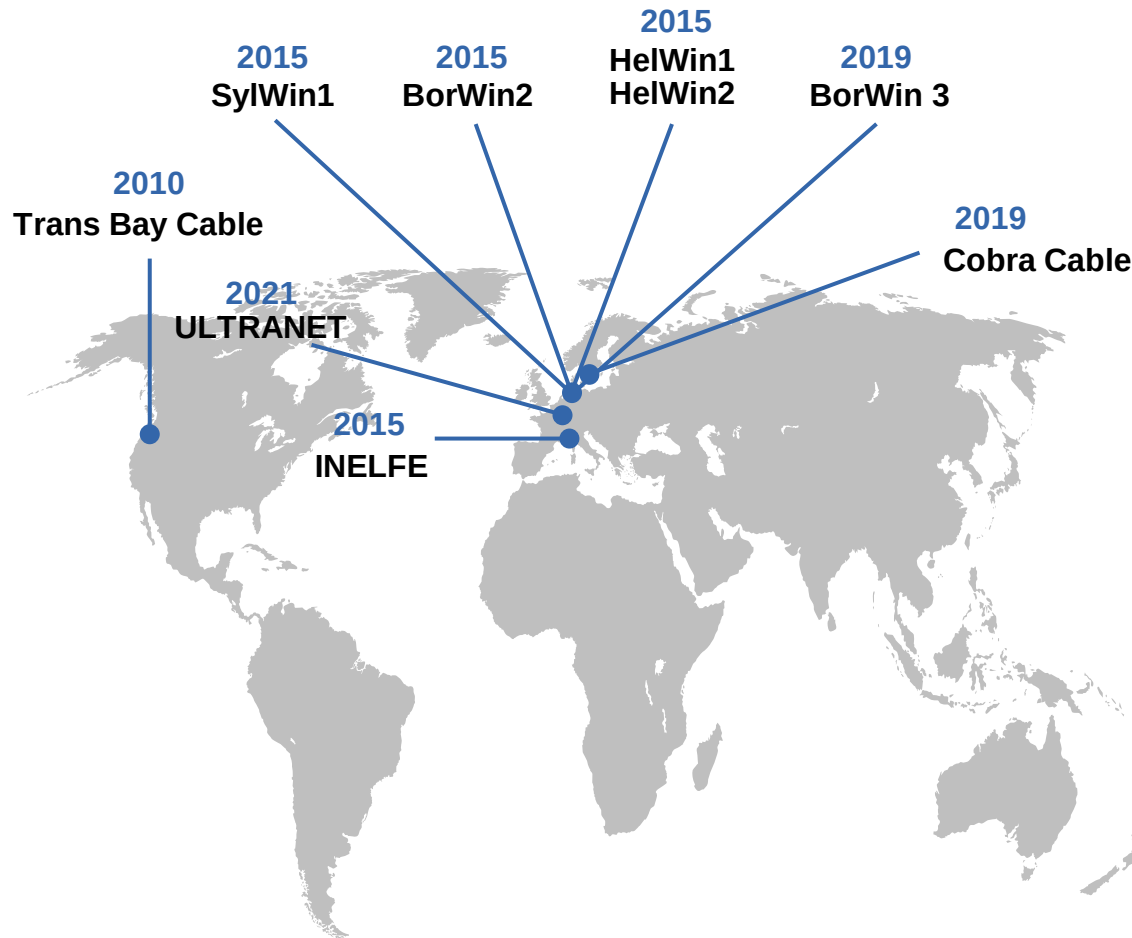
1997/2004 Celilo
2000 Tianshengqiao-Guangzhou
2001 Moyle
2001 Thailand-Malaysia
2003/2007 East-South Interconnector
2004 Guizhou-Guangdong
2005 Lamar
2006 Basslink
2007 Neptune
2008 Guizhou-Guangdong II
2010 Ballia-Bhiwadi

2010 Storebælt
2011 COMETA
2011 BritNed
2011 Adani
2013 Inter Island Connector Pole 3
2013 Hudson
2013 Black Sea Transmission
2013 BtB Bangladesh
2013 Xiluodu-Guangdong
2014 East DC Link Project
2014 Western Alberta Transmission Link
2014 EstLink 2

HVDC – Made by Siemens

HVDC PLUS References

SIEMENS



HVDC Grid Development - A scenario for a step by step evolution

► First stage

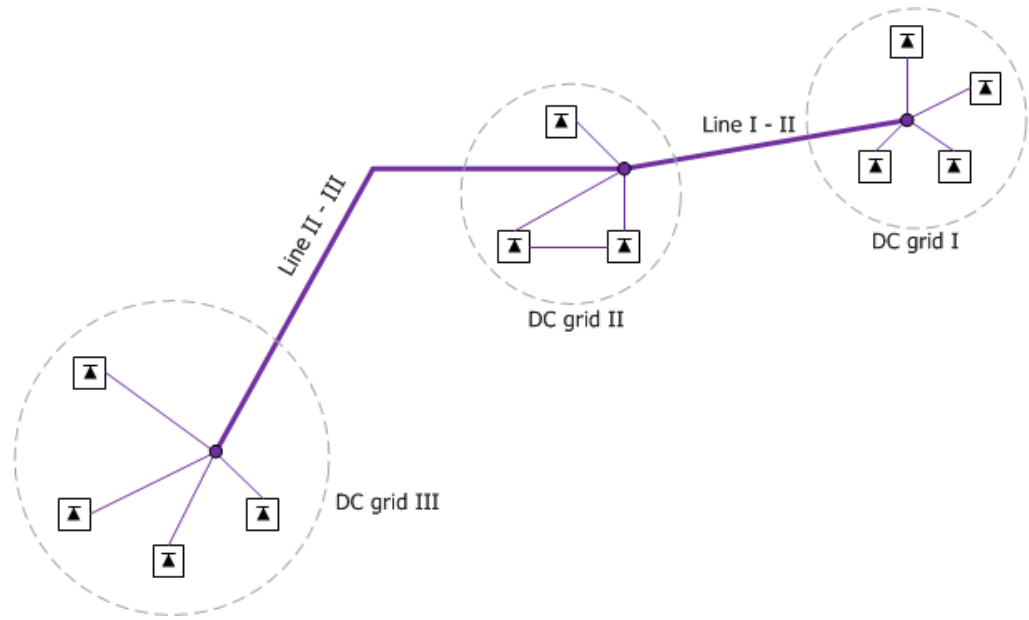
HVDC grids connecting a small number of converter stations are established.

- Full Bridge MMC in combination with fast disconnectors provide reliable and cost efficient selective fault clearing and fast recovery

► Subsequent stage

The small HVDC Grids become interconnected

- Full Bridge MMC provides increased DC voltage control range as needed for longer transmission distances
- Selectivity between sub grids may need additional fast switching devices, like fault current limiters or DC Breaker

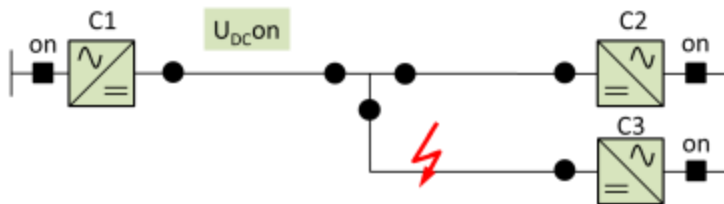


The expected step by step growth of HVDC Grids requires standardisation of HVDC Grid design and operating principles.

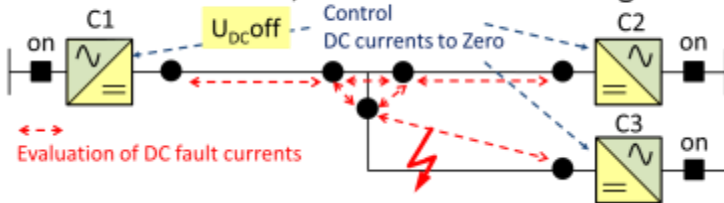
First stage DC Grid Development - Full Bridge MMC based Protection Concept

Fault isolation sequence

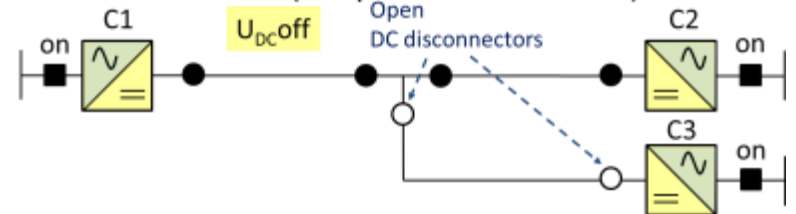
1. Fault event



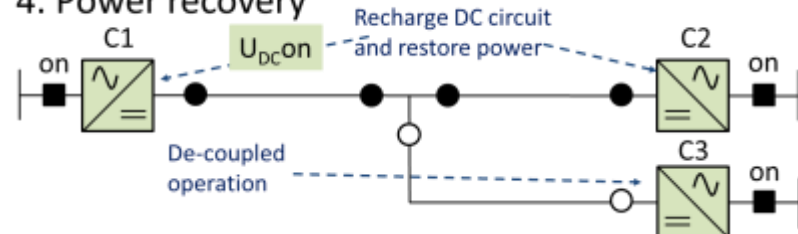
2. Fault localisation, fault current breaking



3. Fault isolation (for permanent faults)



4. Power recovery



With the full bridge's ability to extinguish DC fault currents fast DC disconnectors are sufficient to isolate faulty parts of the system

HVDC Grid Development - R&D Challenges

Main issues for all DC protection concepts:

DC fault clearing and system recovery are key challenges for the design of reliable HVDC Grids

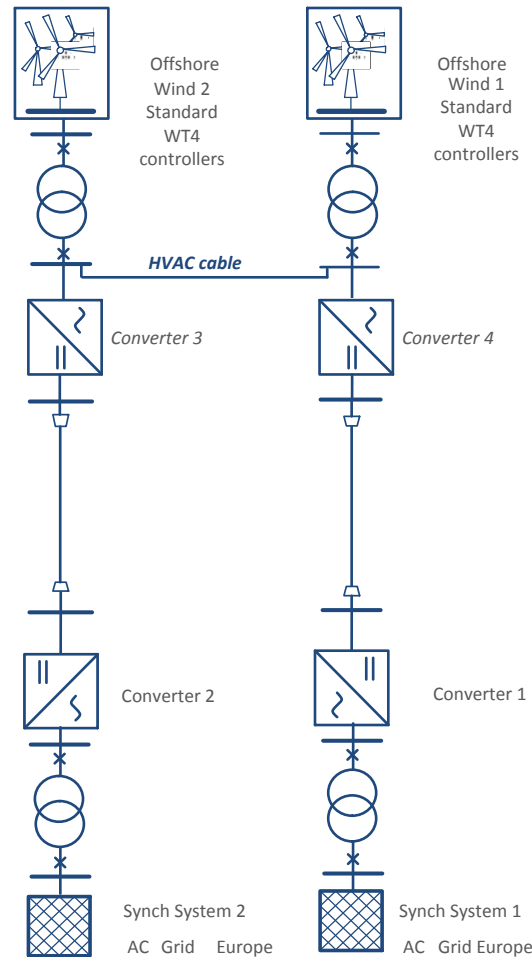
→ Possible solutions include electronic DC Breakers, Hybrid DC Breakers in combination with large reactors, Full Bridge VSC in combination with ultrafast switches

Fault handling has 4 components, all are needed and are related to one another:

1)	Fault detection and localization	▶ algorithms distinguishing normal transients from faults ▶ protection relays/functions ▶ methods identifying the fault location w/o communication (if possible)
2)	Fault current interruption	▶ highly reliable solutions minimizing interference with AC systems or the other DC pole ▶ backup systems
3)	Fault isolation	▶ ultra-fast switches
4)	System recovery	▶ fast and reliable recovery of remaining system ▶ high repetition capability

Workable solutions need alignment of system aspects and switchgear capabilities
DC Breakers can only provide fault current interruption and fault isolation functionality

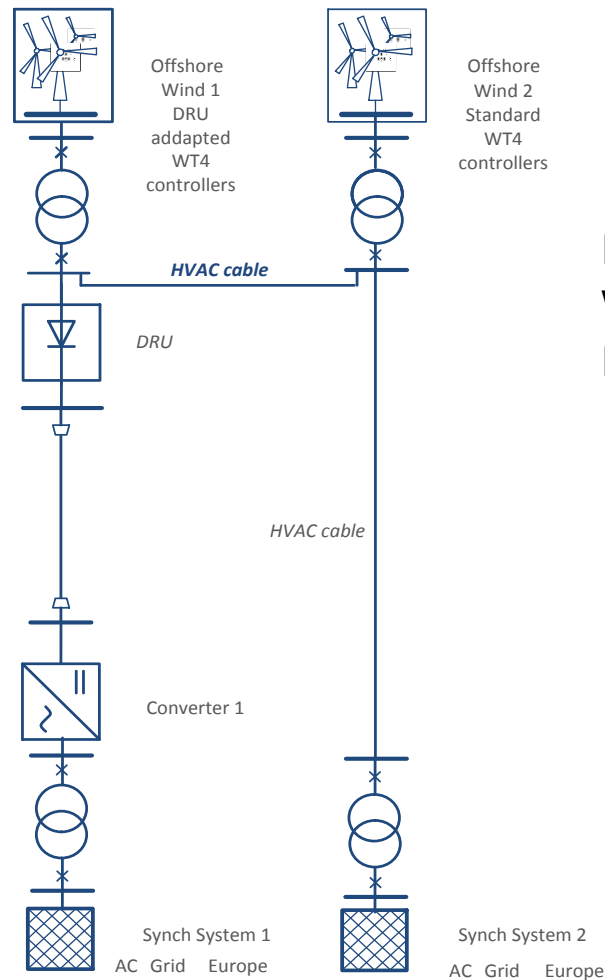
Offshore AC Grid Development – Solution 1



AC Interconnection of two
P2P-HVDC Systems

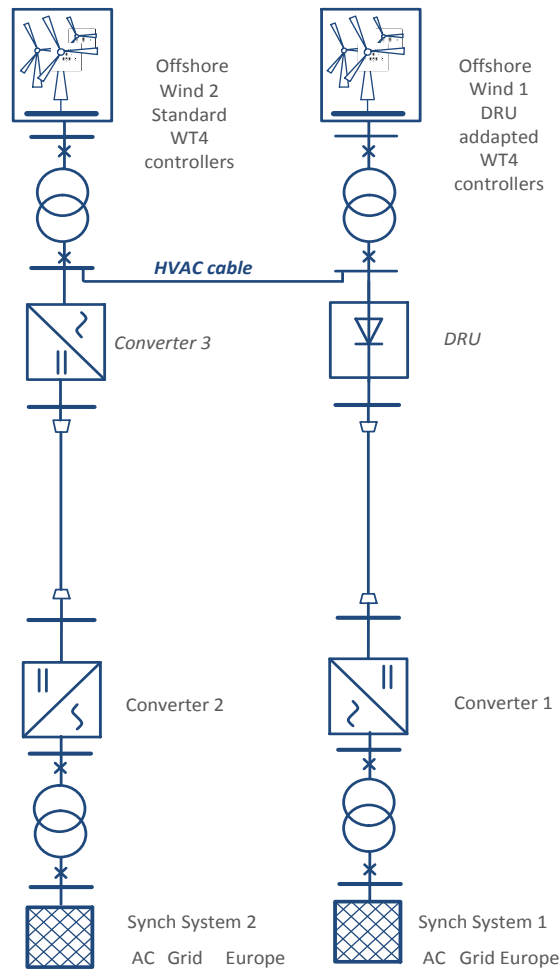
Offshore AC Grid Development – Solution 2

SIEMENS



Enhancement of AC connected
Windpark with Diode Rectifier
DC Transmission

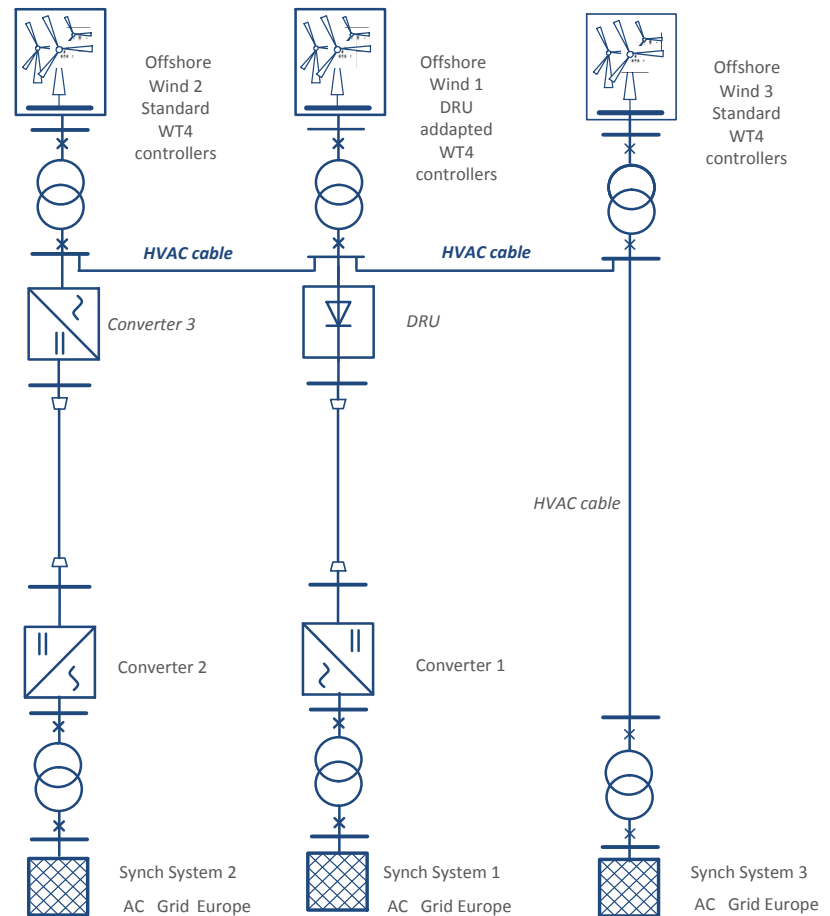
Offshore AC Grid Development – Solution 3



AC Interconnecting of a P2P-HVDC System and Diode Rectifier DC Transmission

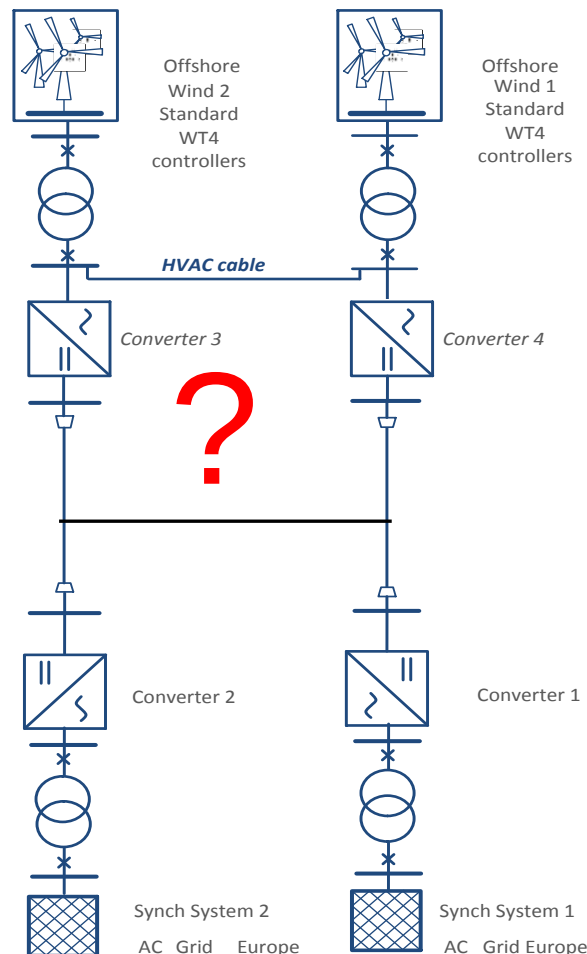
Offshore AC Grid Development – Possible Outcome

Combination of different AC-solutions merging into a mixed grid.



Hybrid AC/DC Development – One step further

How will different AC- and
DC-interconnecting
technologies fit into the
grid of the Future?



Question cannot be fully
answered today –
requirements and
interfaces of the single
solutions have to be
worked out first!

Thank you very much for your attention!

Questions ?