NR's Innovation in VSC - HVDC

The National HVDC Center, UK : 27-06-2019

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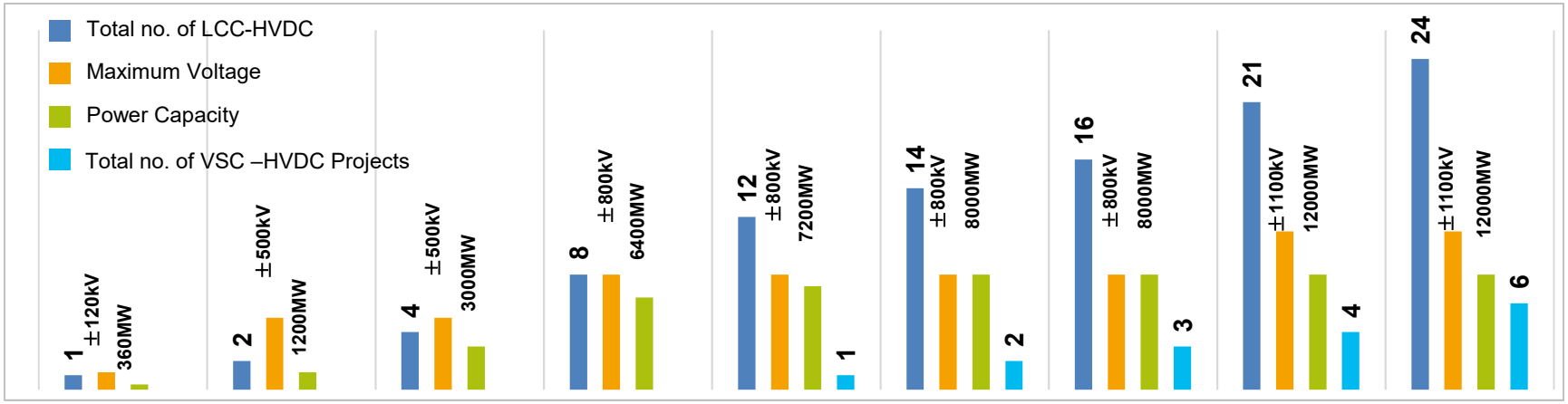
Agenda

- **NR's Milestones in HVDC (LCC & VSC)**
- Zhoushan Project : World's First 5-T VSC-HVDC (±200kVDC/400MW)
- Zhangbei 4-T DC Grid Project (±500kVDC/2*3GW/2*1.5GW)
- Wudongde 3-T Hybrid HVDC Project (± 800kVDC/8GW/5GW/3GW)
- Summary

NR's Milestones in HVDC (LCC & VSC)



VSC R&D

First VSC (30kV/18MW)

3-T VSC (160kV/200MW)

5-T VSC (200kV/400MW)

4-T DC Grid & 3-T Hybrid HVDC (500kV/3GW & 800kV/5GW)

C&P of LCC

UHVDC

7200MW UHVDC

8000MW UHVDC

±1100kV 12000MW

±1100kV 12000MW

2000 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018

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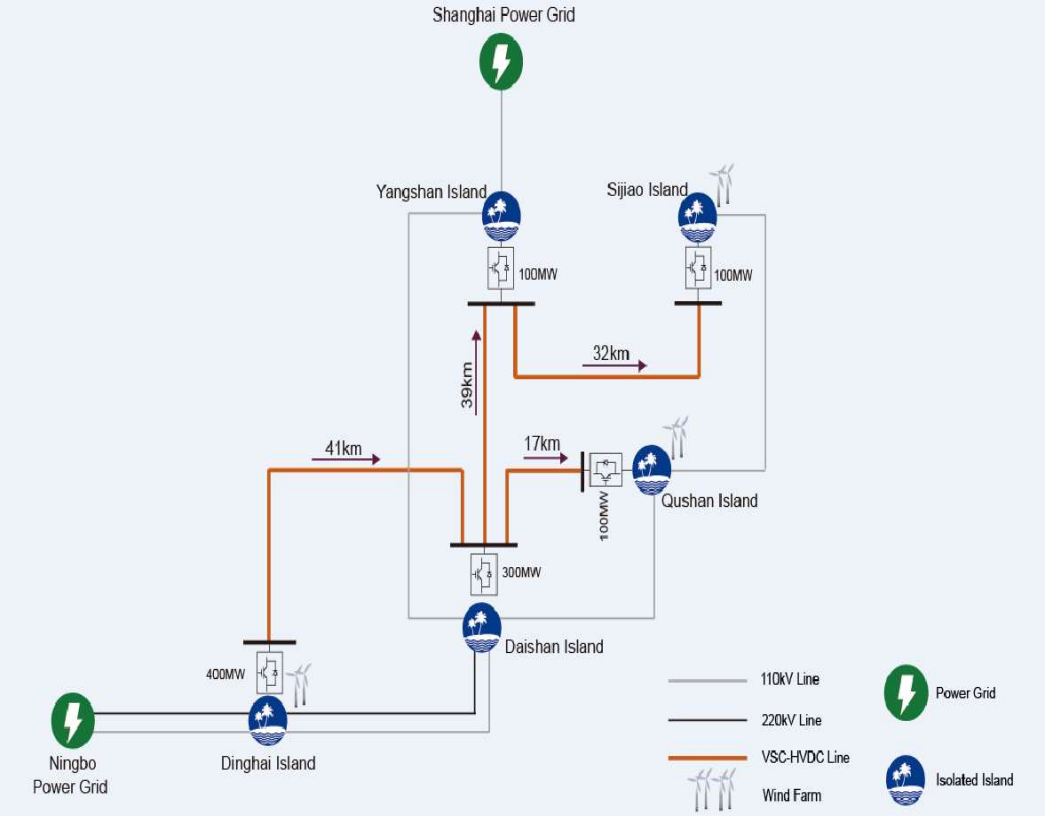
Zhoushan: World's First 5-T VSC-HVDC (±200kVDC/400MW)

- In 2013 the total installed generation capacity and peak load demand in Zhoushan islands were 765.3 MW and 818 MW respectively.
- The estimated power demand will rise up to 4775 MW by 2030.
- So the island region is suffering from power instability and failure problems due to high load demand
- Weak power inter-connection system.
- Operating successfully since 2014



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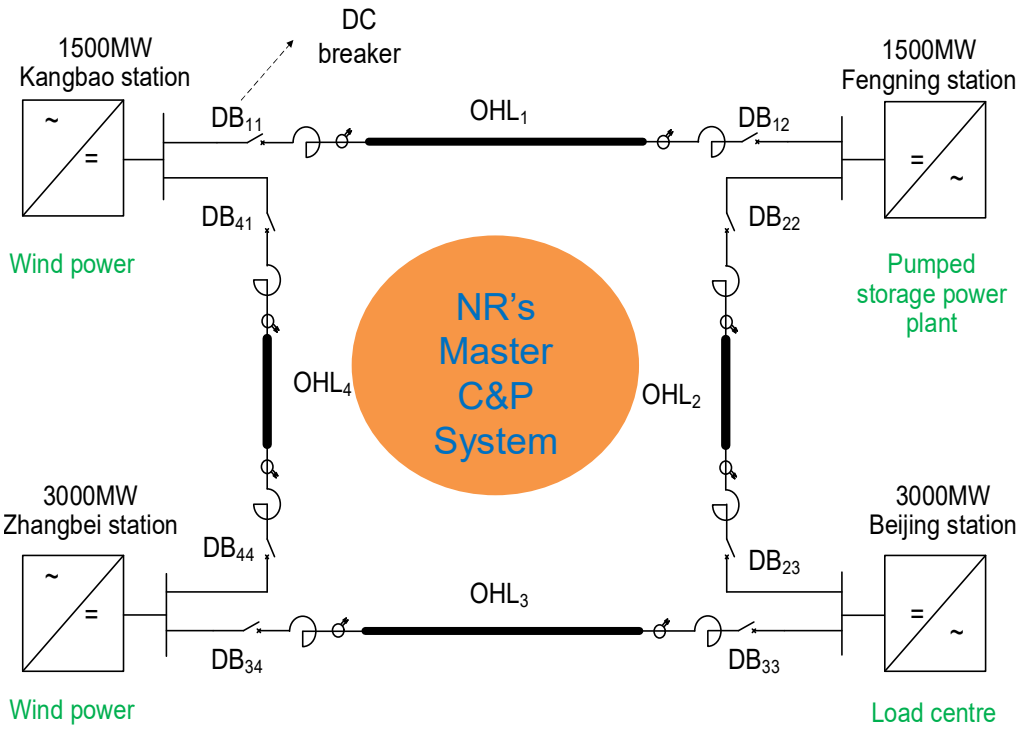
Zhangbei DC Grid Project : Why DC Grid ?

- Phase1: Four VSCs are under construction
- Phase2: Three more VSCs will be built

- Will be operational by end this year 2019

- **Objectives:**
  - Integration of large renewable sources
  - Balance different types of renewables sources
  - Foundation for future DC grid extension
- **Challenges**
  - Large capacity of converters
  - DC Fault Management
  - Managing complex C&P system for multi-terminal DC grid

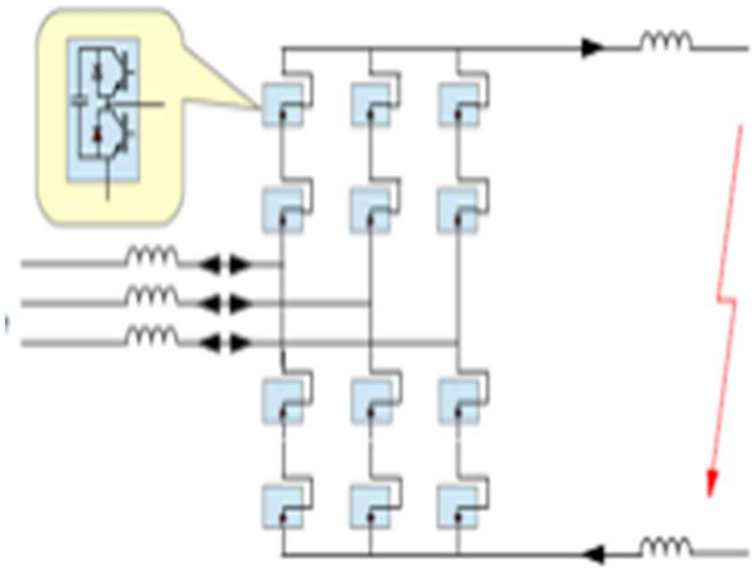
Zhanbei DC Grid Project : NR's Contribution



NR's Scope

- 8 out of 16 HVDC CB (50%)
- One 500kV/3GW Converter Station
- C&P System for all four stations
- Coordinate Control System for the DC Grid
- High Speed DC measurement systems

DC Grid : DC Fault Management



- The current will be fed into the short-circuit point from the AC side continuously due to the diodes of sub-modules.
- Threatening the safety of the diode devices due to be exposed to the high level fault current.
- If the fault were to be cleared by opening the AC breaker, then it will lead to the system outage.
- Alternatively use HVDC circuit breaker
- But the challenge for DC breaker is : Ultra high DC fault current and di/dt without any zero-crossing point

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**

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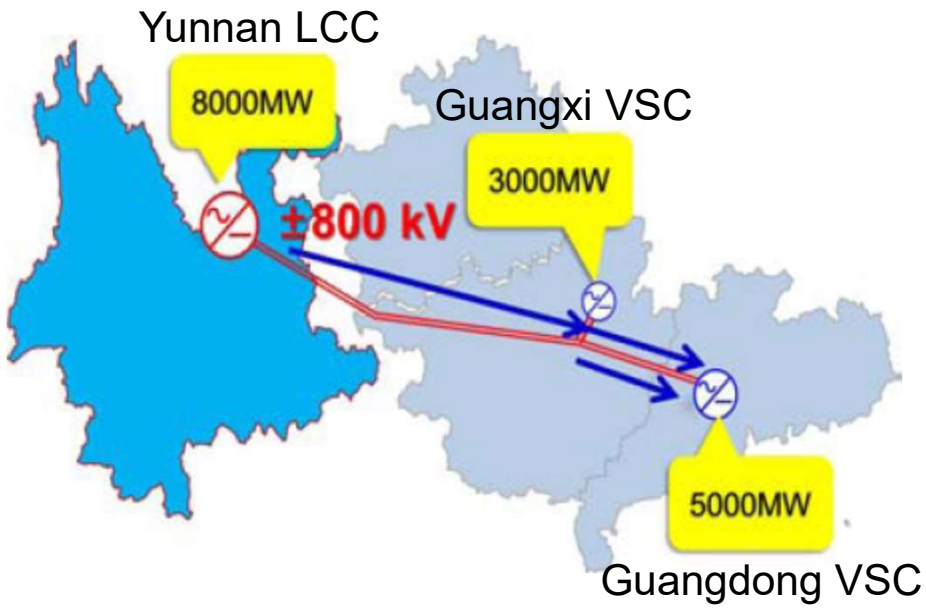
Wudongde Hybrid 3-T HVDC Project (±800kV/8000MW)

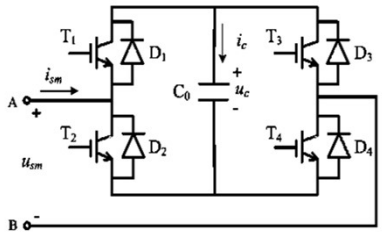


Technical Data	
AC Voltage Level	500kV
AC Frequency	50Hz
DC Voltage Level	±800kV
Power Rating	8000MW/Yunnan station 5000MW/Guangdong station 3000MW/Guangxi station
OHL Length	Yun-Guangxi 932km Guangxi-Guangdong 557km
Converter	Bipolar with MMC

Source: B4-120, CIGRE 2018

Challenges & Solution for Hybrid HVDC

- **Challenges**
  - System operation at reduced DC voltage
  - Fast DC faults clearance and switch on/off converters
  - Reduced cost and power losses of converter



Full-bridge Sub-module

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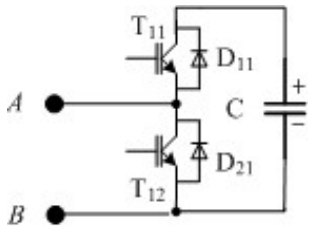

Half-bridge Sub-module

- **Solutions**
  - New hybrid type converters using full bridge and half-bridge modules.
  - The converters have inherent DC fault blocking & clearing capability
  - Capable of operating at reduced DC voltage level
  - Topology also helps in reducing cost and power losses

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Summary

VSC-HVDC:

- VSC-HVDC is playing vital role in the modern grid system & several projects are in commercial operation
- Two development trends of VSC-HVDC are : **DC grid** and **high voltage bulk power transmission**
- **DC grid** will able to overcome all the technical barriers and gain considerable momentum.
- **In bulk power long distance transmission**; VSC is rapidly catching up with the LCC solution not only in terms of technical functionalities but also decreasing cost.

Hybrid HVDC:

- This could be the solution to resolve the multi in-feed LCC inverters commutation failure which will be demonstrated by Wudongde Hybrid 3-T project.

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Thank you

Version 2017