

# VSC-HVDC Solution

An advanced solution  
to make grid interconnection more flexible



The VSC-HVDC technology is the most advanced direct current transmission solution with voltage-sourced converter (VSC). Compared with LCC-HVDC technology, VSC-HVDC can regulate active power as well as reactive power independently. With the advantages of flexible control, small footprint, reactive power support to grid and easy to realize multi-terminal system, VSC-HVDC is the best solution for grid interconnection, city centre in-feed, renewable energy evacuation and power from shore.

## 1. Application

### I. Grid interconnection / Energy market:

- Suitable for both stiff and weak grid
- Increase power quality and system stability
- Fast capacity control to prevent frequency oscillation
- Bi-directional power flow to achieve a flexible energy market.
- Black start function to shorten restoration time in blackout situation.
- Available for multi-terminal systems

### II. City centre in-feed:

- Decrease rights-of-ways and cost of lines or cables
- Reducing the space of converter station by around 40% compared to LCC-HVDC.

### III. Power Supply to Islands:

- No transmission length limitation.
- Better power quality and stability of the Island's grid.

### IV. Decoupling of urban grid:

- Connecting AC power grids without increasing the short circuit capacity.
- BTB or short distance transmission lines can be designed base on real situation.

### V. Off shore wind farm:

- Regulation of system voltage and frequency.
- No transmission length limitation.
- The converter station of off-shore is conveniently operated by control centre on on-shore, eliminating operators in off shore platform.
- Simplified platform construction due to compact and lightweight

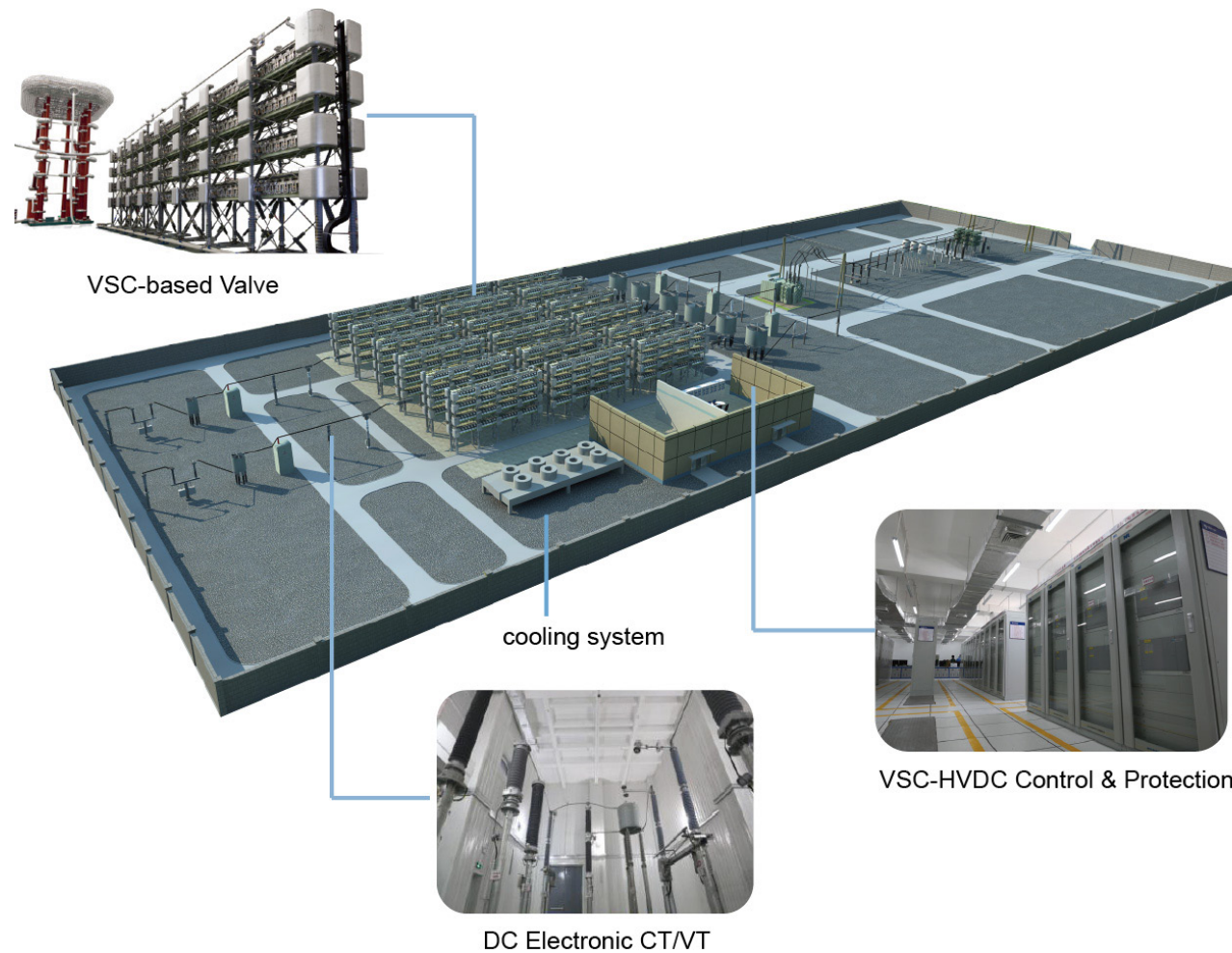




## 2. System Structure

NR Electric's VSC-HVDC consists of

- VSC-based Valve
- Control & Protection System
- DC Electronic CT/VT
- Cooling System
- Other primary equipment for AC and DC yard



## 3. A true all-in-one package service to maximize your benefits

### 3.1 Vast Experiences of System Analysis and Design

NR Electric focuses on electric power system solution for decades and is the top expert in the field of FACTS and HVDC. NR has got various advanced across field system study ability, including stability control analysis, FACTS application, AC-DC grid analysis etc. As to HVDC system, NR is competent for system design, equipment model selection, insulation analysis, operation mode, system simulation etc.

### 3.2 In-house manufacturing

NR Electric produces IGBT valve and valve cooling system, DC breaker, control and protection system, electronic measurement system in its own world class manufacturing campuses with whole process quality control.

### IGBT valve

NR's advanced IGBT valve has advantages to clients, like low loss, small footprint, easy maintenance, and etc.

NR has IGBT valve production capacity up to  $\pm 535\text{kV}/3000\text{MW}$ , and got type tests witnessed by DNV-GL for its state of the art  $\pm 535\text{kV}/3000\text{MW}$  IGBT valve in April 2017.



IGBT valve

### DC breaker

DC breaker is key equipment for multi-terminal VSC-HVDC or VSC-HVDC grid that becomes more and more popular. DC breaker helps multi-terminal VSC-HVDC or VSC-HVDC grid to achieve fast and selective fault clearance.

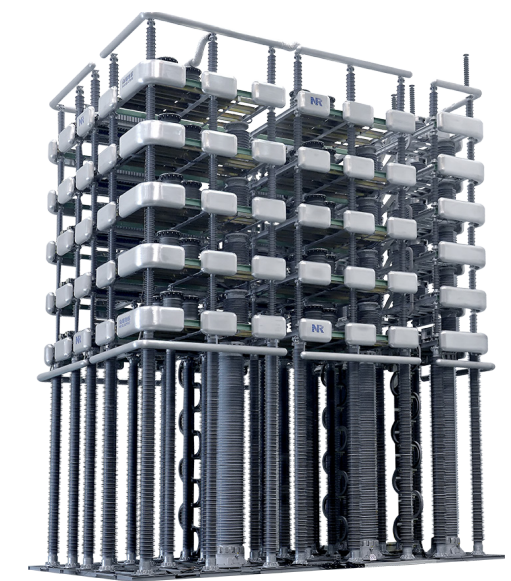
NR's DC breaker applies advanced hybrid topology, composed of three branches, namely main load branch, breaker branch and MOV dissipation branch.

Based on NR's unique design, the DC breaker has features of reliability, compact structure, fast re-close and double breaking capability.

NR also got verification of type tests of 535kV DC circuit breaker by DNV-GL.

Table 1. Parameter of DC breaker

Items	Values
Rated Voltage	535KV
Rated Current	3KA
Breaking Current	25KA
Breaking Time	$\leq 3\text{ms}$



535kV DC breaker

### Control and protection system

NR's hierarchical, full redundant HVDC control and protection system has successfully applied in 22 LCC-HVDC and 4 VSC-HVDC, including world first 5-terminal Zhoushan VSC-HVDC project. All of them have a good running record.

### Electronic measurement system

High speed electronic measurement system is mandatory in VSC-HVDC link due to low overcurrent tolerance ability of IGBT, consequently, fast overcurrent protection based on high speed electronic measurement system is essential.

NR has vast experience of electronic measurement system for both LCC-HVDC and VSC-HVDC. NR can provide electronic measurement system with Sampling frequency up to 50kHz.



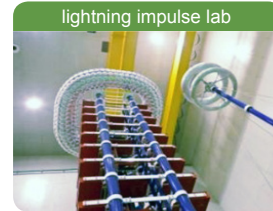
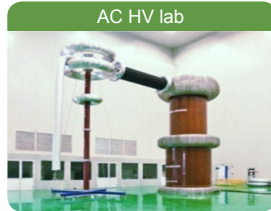
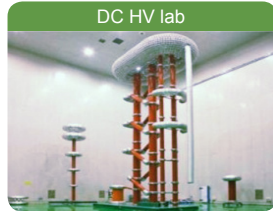
Electronic CT of Zhoushan 5-terminal VSC-HVDC project



### 3.3 Comprehensive testing facilities

#### VSC-HVDC synthetic test platform

36kV/2000A back to back test platform is mainly applied for functional test, including full-load and overload test with IGBT valve, VBC(Valve Base Control), control and protection; It also could simulate DC faults and AC faults. These tests are fully compliance with IEC62501. This platform can test 192 sub-modules of IGBT valve at one time.



#### Insulation Test

NR's high voltage insulation test facilities can implement up to 1650kV AC,  $\pm 2400$ kV DC and 4800kV lightning surge test.

#### Digital Model Simulation Test

NR has both RTDS and RT-LAB which can be applied for control and protection system test.

### 3.4 Project execution

NR has successfully executed projects in more than 90 countries world-wide. NR's professional project management team is the great guarantee for smooth project implement. NR has 130+ senior project managers certified by PMI who have vast experience in international project execution.

## 4. Reference Projects

NR VSC-HVDC has been successfully put into service since 2011.

- Two-terminal Nan Hui project has been in operation since 2011. It connects an offshore wind farm to Shanghai with a rating of  $\pm 30$ kV and 18MW.
- The Nan Ao project uses a three-terminal VSC-HVDC solution to supply power to islands from mainland, with a rating of  $\pm 160$ kV and 200MW, 100MW and 50MW valves.
- Zhou Shan, the world first five-terminal VSC-HVDC power transmission project in the world. The VSC-HVDC is utilized to interconnect 5 islands with mainland grid and evacuate wind power with  $\pm 200$ kV DC submarine cables. For this project, NR Electric developed the five-terminal coordination control scheme.

