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HVDC GRIDS FOR OFFSHORE AND ONSHORE TRANSMISSION

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SUMMARY

The objective with this paper is to describe that existing point-to-point building blocks of HVDC systems can be expanded to multi-terminal HVDC schemes with three or more converters connected in a system for bringing offshore wind into shore and further into the onshore transmission system. Benefits of the expansion of an offshore grid into the onshore grid to reach critical load centers are faster load flow and balancing as well as less cost compared to several point-to-point connections as well as losses.

Recent developments of voltage source converters (VSC) have increased power ratings to 1 200 megawatts per cable pair and reduced losses to one per cent per converter. Advancements in breakers technologies have provided attractive solutions for HVDC breakers that meet response time in the ms-range to enable grids with several protection zones.

This paper is a short overview of statements and figures given in the corresponding poster presentation. A more complete description of VSC-HVDC and HVDC Grids is available in the references.

HVDC GRIDS WITH VOLTAGE SOURCE CONVERTERS

The first voltage source converter (VSC) HVDC Grids are now in planning in Europe. Recent point-to-point connections have been awarded as HVDC Grids Ready. These links are now under construction.

HVDC Grid Enablers

ABB:s VSC technology, namely HVDC Light™, has evolved in power rating and voltage since it was commercially introduced in 1997. Main progress items are shown in Figure 1 and summarized below [1]:

- Reduce Losses
- Increase converter and cable capacity
- Maintain compactness, functionality, availability & reliability

In the present fourth generation of VSC a cascaded two-level (CTL) converter design has been introduced to reduce conversion losses and need for AC filters as depicted in Figure 2. HVDC is the only long distance sub sea transmission technology at high power; this combined with VSC reactive power compensation functionality, swift cable laying procedures for plastic cables and the recent gains in conversion efficiency and power increase makes it very attractive for offshore wind and onshore applications.

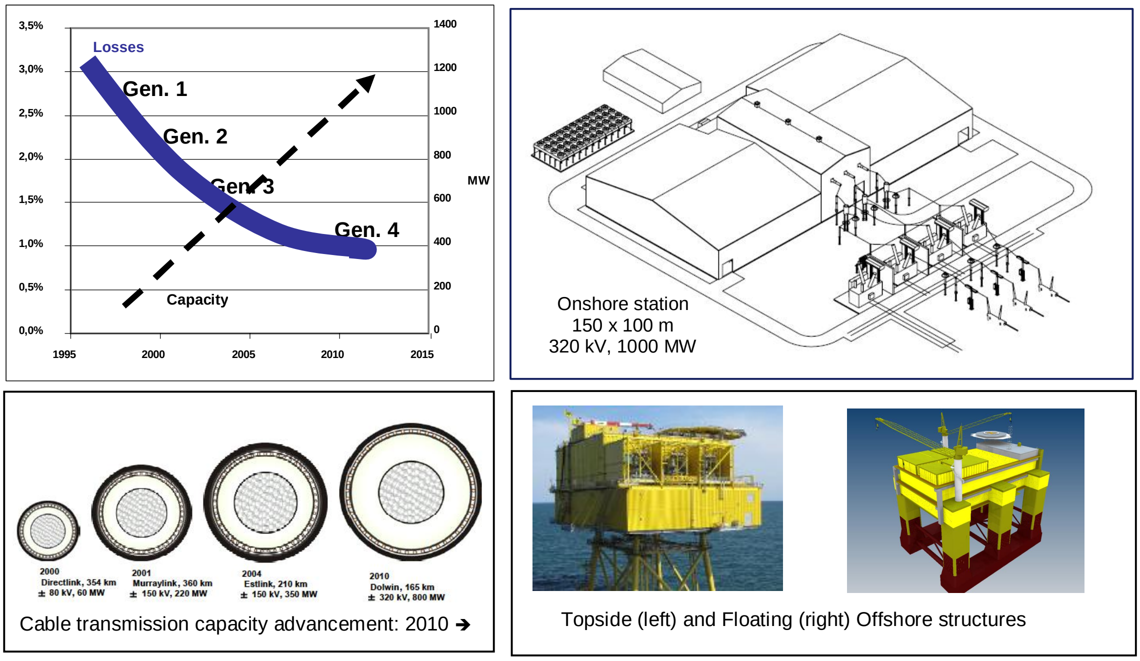

Figure 1. Reduction of losses and power increase (upper left). Compact onshore station (upper right). Cable transmission capacity from 60 MW 2000 to 800 MW 2010 (lower left). Two solutions for offshore converter station (lower right); one with jacket and topside and the second with a gravity based structure.

HVDC Light™ Cascaded Two-Level Converter

With the cascaded two-level converter cell the AC voltage is gradually build up one cell by another. Hereby switching losses are reduced and need for filter is significantly reduced [2].

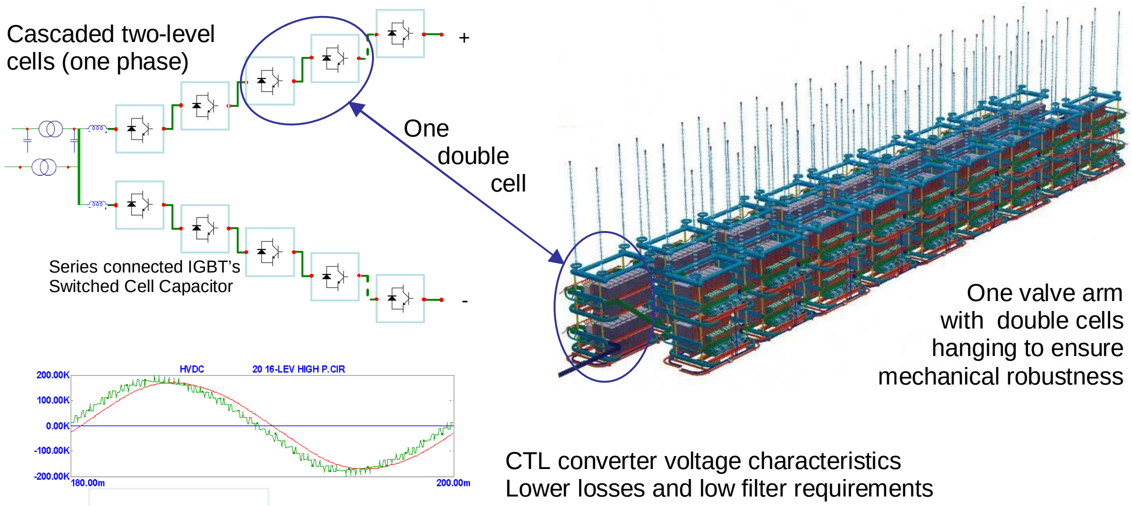

Figure 2. Valve arms with cascaded two-level cells (upper left). Upper right as simplified line diagram, upper right 3D resemble of the mechanical design. Lower left graph show voltage characteristics.

HVDC GRIDS

Regional HVDC grid with optimized voltage level

Regional HVDC Grids or Multiterminal HVDC transmission systems are characterized by

- One protection zone for DC earth faults
- Temporary loss of the HVDC system has limited impact on the AC network
- Fast restart of the faultless part
- HVDC breakers are not needed
- Normally radial or star network
- Limited power rating

These are generally smaller systems, but could still cover very large geographic areas similar to existing point-to-point connections that are stretched over 2000 km in length.

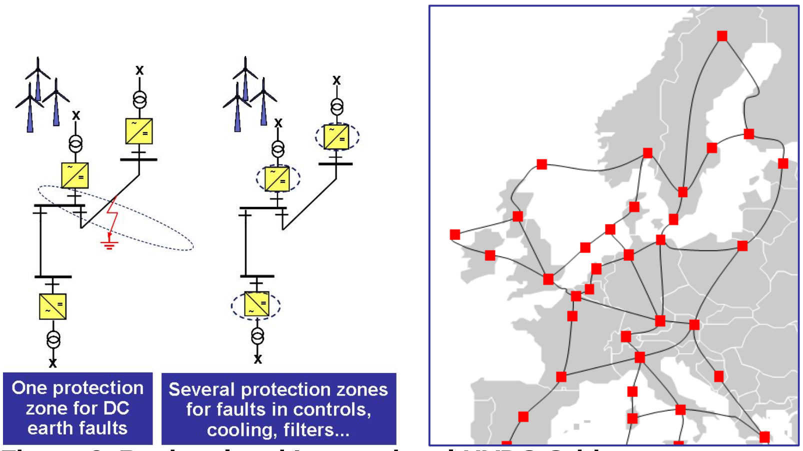

Figure 3. Regional and Interregional HVDC Grids

Interregional HVDC grids

Interregional HVDC transmission systems, cf. Figure 3, are characterized by

- Several protection zones for DC earth faults
- Harmonized voltage level
- High power rating
- New technology needed, such as:
    - HVDC grid breakers
    - Grid Power flow control
- Long-term development, such as:
    - HV DC/DC converters for connection of regional systems

Hybrid DC Breaker

The recently proposed concept for Hybrid DC Breaker, depicted in Figure 4, is well suited for HVDC Grids [3]. The main breaker based on power electronic valves can interrupt the full load short circuit current. However to reduce the on-load losses to very low levels a bypass path which carry the load during normal operation. When a fault is indicated the current path is transferred to the main breaker modules.

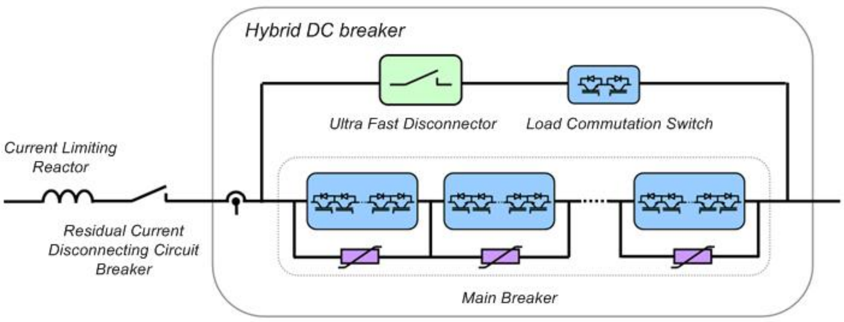

Figure 4. A Hybrid DC breaker

Hybrid DC Breaker Characteristics

- Fast — Breaking times of less than 2 ms
- Powerful — Current breaking capability of 16 kA
- Efficient — Transfer losses are less than 0.01%
- Modular — Easily adapted to actual voltage & current ratings
- Reliable — Protective current limitation, functional check in service
- Proven — Power electronic design similar to converter technology

BENEFITS WITH HVDC GRIDS

By building a HVDC grid or Multiterminal HVDC transmission system several benefits can be acknowledged [4].

- Decrease the number of converters compared to a combination of several HVDC point-to-point links
    - Lower overall investment cost
    - Decrease AC-DC conversion losses
- Increased flexibility for handling of power imbalances and energy trading
- Connect large intermittent power resources with large-scale energy storage over large distances for better overall utilization

For offshore installation over medium or long distances, HVDC is the only rational technology.

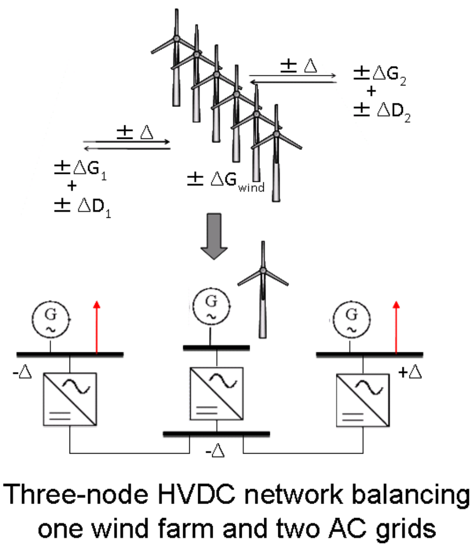

Figure 5. Transmission capacity matching peak wind production can be utilized for energy trading or power balancing when wind generation is lower

REFERENCES

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