# Cigre SC B4 2009 Bergen Colloquium –
# Minutes from Closing Panel Discussion,
# **“Which role will HVDC technology have in the future?”**

Panel Chairman:
Bjarne Andersen SC B4 Chairman

Panel participants:

Utility side:
Håkon Borgen, Statnett
Jussi Jyrinsalo, Fingrid
Poul Damgaard, Energinet.dk
Sture Larsson, Svenska Kraftnät

Supplier side:
Gunnar Asplund, ABB
Hartmut Huang, Siemens
Norman McLeod, Areva T&D
Marc Jeroense, ABB
Gunnar Evenset, Nexans
Marco Marelli, Prysmian

Date: June 12, 2009
Location: Radisson SAS Hotel Bryggen Bergen, Norway

Minutes prepared with input from Matti Supponen

The Chairman had suggested that the following three topics be discussed:

- Integration of Offshore wind farms
- Meshed HVDC, can it be done reliably?
- Where Next for HVDC?

The panellists each gave a brief presentation (see attached presentations).

The Utility side focused mainly on the challenges that they face as the networks develop to accommodate an increasing amount of renewable power. They also emphasized the need for HVDC and Power Electronic solutions to work with very high reliability and availability, the need for higher ratings of VSC HVDC schemes, and the need for the power losses to be reduced.

The manufacturing side presented the existing technology and ratings available today. Generally, VSC HVDC converters and extruded cables are stated to be available for up to ±320kVdc with ratings approaching 1000MW. The LCC HVDC technology is available today at up to ±800kVdc, but the maximum rating of cables is today limited to 500kVdc. New VSC Technologies offer the prospect of significantly reduced converter losses, approaching the power loss of the LCC HVDC schemes. The VSC technology may gradually displace LCC HVDC schemes at ratings below 1000MW. The cable supply limitation for offshore applications is limited by manufacturing plant, e.g. the armouring lines, which is common to both the MI and the extruded technology, but the extruded technology makes extra capacity available for land cables, if armouring is not needed.

It was pointed out that one of the big differences between ac networks and HVDC schemes, is the fact that the ac network typically has N-1 or even N-2 redundancy, which has not yet been provided for HVDC schemes, unless bipolar schemes are considered to have N-1 redundancy, with their 50% remaining capacity in the event of a pole fault (however, HVDC schemes are often operated at their full rated capacity, which then means that true N-1 redundancy is not available).

Meshed HVDC schemes are generally considered to be feasible if the VSC HVDC technology is used. However, a number of issues need to be studied, in order to ensure that there would be no protection or control issues. Standards would also have to be agreed to prevent compatibility problems if equipment from different manufacturers were to be used in the same meshed system. Standard dc voltages become highly desirable. DC circuit breakers are another essential item for meshed HVDC networks, and because of the rapid rise in the infeed current in the event of a fault in the mesh, the present generation of dc breakers will not be fast enough, but power electronic alternatives could be used. B4 has recently commenced work on Meshed HVDC systems, and Gunnar Asplund is leading this work.

Following these brief presentations the floor was opened to additional questions and comments, and this discussion is captured in the following bullet points:

**1. Off-shore grid**

- Future grids have to be able to connect up to 5000 MW wind-farms, with individual wind farms having ratings of 500MW or more.
- Break even distance for DC is 40 – 100 km, and depend on the loads/generation/network connected at the offshore end. New ideas for AC: use of lower frequencies.
- Both LCC and VSC technologies are feasible, but VSC HVDC does seem to provide a simpler solution, with the integrated and independent PQ controllability. The fact that dc polarity reversal is not needed for a grid using VSC HVDC is also an advantage when comparing LCC HVDC and VSC HVDC.
- VSC losses need to go down to make the technology more competitive with LCC HVDC and AC connections.
- 500 kV dc cables (MI) are already available for off-shore grids. Cables can be connected in parallel to increase the rating.
- Off-shore grids need central control. Who should be the controller of a grid that covers many different jurisdictions?
- Who will plan offshore grids, vertically integrated companies or TSOs?
- How will N-1 will be implemented and managed?

**2. Meshed DC-grids**

- To build meshed grid a standardisation of voltages is needed and circuit breakers need to be developed.
- Longer outage times for cables due to a fault, compared to overhead lines is a problem, and need to be taken into account in the design of the grid.
- DC network will be built in multicontract environment.
- It is very difficult to get people to accept new lines, thus high capacities need to go through each corridor.

- Security requirements are high, thus even less cascading of faults will be allowed.  HVDC can prevent cascading of faults, but all possible failure mechanisms need to be studied.

**3. Next generation HVDC**

- 1000 kV dc and 10000 MW systems will be the next development for overhead lines, 2000 MW for cables.

- VSC losses will be reduced from 3% to 1% per converter station.

- MI cables could be developed for 1000 kV dc applications, extruded cables can be made developed for 600 kV dc.