JOINT WORKING GROUP FORM

Study Committee: B4

JWG number: B4/B5-59	**Name of Convener: Kees Koreman, NL**
Title: Control and Protection of HVDC Grids	

Terms of Reference

Background:

HVDC has been used mainly for point-to-point transmission with one sending and one receiving converter station. Although the connection of more than two HVDC into a multi-terminal HVDC configuration is feasible, there are only a few such schemes in service. The need for integration of large scale renewable generation, the electrification of oil- and gas-platforms from on shore grids, the integration of markets, has resulted in a demand for new transmission capacity and interconnectors. To meet this need consideration is being given to applications of more multi-terminal or meshed HVDC grids. The evolving Voltage Sourced HVDC (VSC HVDC) technology has made it easier to build such HVDC schemes.

In 2009 SC B4 initiated WG B4-52 “HVDC Grid Feasibility Study”, to investigate the feasibility of this concept. The WG has identified a number of issues that need to be studied to a greater level of details. Therefore, SC B4 is now proposing five additional WGs as follows:

B4-56: Guidelines for the preparation of “connection agreements” or “Grid Codes” for HVDC Grids

B4-57: Guide for the development of models for HVDC converters in a HVDC grid.

B4-58: Load flow control and direct voltage control in a meshed HVDC Grid.

B4-59: Protection of HVDC Grids. - **This ToR**

B4-60: Designing HVDC Grids for Optimal Reliability and Availability performance.

These WG will use the information developed by B4-52 as their starting point. Their focus will be on the HVDC grids, and not on the HVAC network to which they are connected. However, ac/dc interaction issues, such as the real power changes injected/extracted from the ac network during dynamic and fault conditions will be identified, where appropriate.

These WGs will consider HVDC Grid which are meshed, with some radial part, and possibly including sub-grids. The Grid may include balanced monopolar, monopolar and bipolar converters. A configuration and complexity similar to that of the proposed MEDGRID or Desertec HVDC Grids may be used.

The majority of the work will be based on the use of VSC HVDC, but each WG will also discuss the impact of the use of LCC HVDC. Further WGs focusing on the use of LCC HVDC within an HVDC Grid may be started at a later date, if necessary.

The output from these five WGs will also be of relevance to multi-terminal HVDC schemes being developed with the aim of allowing multiple converter station vendors.

In a HVDC Grid the fault currents during faults to ground are limited initially by the surge impedance of the lines and the reactance of the smoothing reactors and other reactors involved in the circuit, but this is very quickly followed by a period where the dc resistances will play the dominant part. With VSC HVDC the fault currents within the HVDC Grid can become very large, unless rapid action is taken to disconnect the faulty elements. Since the design of the elements in the HVDC Grid will depend on the prospective fault currents, it is necessary to identify the current levels at an early stage. Furthermore, it is essential that

only the faulted equipment or section of the grid is removed from service. It is also important to establish the consequences of failing to trip or remove a faulted section of the grid on the integrity of the overall system (equivalent to breaker fail philosophy in ac).

Scope

The objective of this WG is to provide guidelines for the control and protection system needed for a HVDC Grid, with the emphasis for this WG being on the protection of the HVDC Grid and the elements within it, and not on the Converter or ac side equipment. The primary objective of the control and protections system will be to ensure that the HVDC Grid undertakes its transmission role reliably and efficiently, and that the ac networks to which the HVDC Grid are connected are not impacted beyond the anticipated/planned level by faults. This will be achieved by rapid detection of faults and rapid identification of the exact faulty elements, and the provision of devices to quickly disconnect faulty elements, such that the remaining part of the system can quickly resume operation.

The proposed WG will consider the entire HVDC Grid protection system e.g. the measurement, fault detection and interruption devices. It will develop the requirements for the system in relation to:

- Availability and reliability including redundancy requirements,
- Speed,
- Selectivity,
- Maintainability,

All possible faults within the HVDC grid or affecting the ac grid, including dc line faults, “dc breaker” failures, and converter faults will be considered.

The proposed WG will look at the prospective fault currents and over-voltages that may occur within a HVDC Grid. The timing required for the detection and isolation of the faulty elements, and the consequences of delayed clearing, will be determined.

The WG will look at the pro’s and con’s of including passive elements in the dc grid to slow the rise in fault current and/or to slow and reduce the voltage sag in the healthy parts of the HVDC Grid..

The WG will look at methods available to reliably identify faulty elements within a HVDC Grid. The WG will consider different methods and approaches of limiting fault stresses and for the removal of faulty elements of the HVDC Grid.

The WG will draft a functional specification for detection devices and for devices within and external to the converter stations to achieve the disconnection of the faulty elements within the required time.

The WG will look at converter control and sequence strategies required to ensure timely restoration and recovery of the remaining HVDC Grid. The restoration and recovery time is likely to be critical to ensure satisfactory and robust operation of the overall ac and dc system.

The Telecommunication needs resulting from these strategies will be identified.

In addition to the above protections, the WG will look at all other protections for the HVDC Grid, including but not limited to the following:

- Direct Voltage unbalance
- Over-voltage and under-voltage protection

- Over-current protection
- Harmonic Protection

Interaction with other B4 WGs and with other SCs

Since the work in each HVDC Grid WG could impact on work in other parallel WGs it is proposed to take the following steps:

- A B4 Advisory Group will be set up to oversee, co-ordinate and advice the 5 WGs.
- Notes of meetings will be exchanged with the other WGs
- The draft WG documents will be made available to the other WGs
- A joint workshop between the WGs will be arranged during each SC B4 meeting, where WG members can exchange information and request assistance from other WGs, as appropriate.

It is proposed to invite SC B3 and SC A3 representatives to a workshop during the 2012 meeting in Paris, where the protection and fault clearance device requirements will be discussed.

Other SC's are invited to nominate experts with knowledge in this area to contribute to this WG, and their contribution will be acknowledged in the TB in the usual way, with the mention of their name and the SC to which they belong.

Deliverables and time schedule:

Technical Brochure, Tutorial, Electra Paper

WG start 2011. Completion end 2013.

Other SCs/ Target Groups concerned by the work:
SC A3 and B3 are invited to provide liaison members.
Target Groups:Transmission companies, Manufacturers, Consultants, Academia

Approval by Technical Committee Chairman: Klaus Fröhlich

Date : 24/02/2011