WORKING GROUP FORM

Study Committee: **B4**

WG number: B4-60	**Name of Convener: Dr Norman Macleod, UK**

Title: Designing HVDC Grids for Optimal Reliability and Availability performance.

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.

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

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.

During the last 50 years the design of HVDC systems has evolved such that HVDC now provides a very Reliable and Available power transmission solution. However, when designing an HVDC Grid, which may become an integral part of the overall transmission infrastructure, the present performance may or may not be acceptable. It is likely that different performance criteria may be appropriate for different parts of the HVDC Grid, as ultimately it will be the overall power and energy supply security for the combined ac

network and HVDC Grid that will dictate the actual needs.

Scope

This WG will concentrate on the Reliability and Availability (R&A) of the HVDC Grid, and will look at how different design approaches for the HVDC Grid impact on the R&A performance. It will consider the capability of the converter stations to provide the relevant power interfaces between the HVDC Grid and the ac network. The concept of power path availability between different nodes in the combined AC/HVDC Grid will be elaborated upon. The use of earth/sea electrodes, and the potential limitations of earth current operation, will be considered. The WG is expected to lay the foundations for a future joint WG which will look at the R&A needs for the combined ac network(s) and HVDC Grid.

The proposed WG will develop the definitions of Reliability and Availability for HVDC Grids, e.g. considering the ability of different parts of the system to transport power between each part, as well as the capability of the converter stations to provide the relevant power interface between the HVDC Grid and the ac network. Issues to be considered will include mean time to failure, repair times, capacity loss etc. Reference will be made to the criteria developed for ac networks, as well as those developed for point to point HVDC systems. All components of the HVDC Grid will be considered, but unavailabilities in the AC system should be disregarded in this context..

The design of HVDC grids and the possible arrangements of VSC HVDC converter stations and switching (hub) stations can influence the development of a DC grid. Radial and meshed HVDC grids will require significantly different reliability and availability performance and these issues will be discussed.

Converter station and switching stations may not have the same topology and will be supplied by multiple vendors. The WG will look at the impact these differences may have on the R&A performance of the evolving HVDC Grid. This will include consideration of necessary strategic spares holdings and recommendations for further standardisation in respect of HVDC Grid components.

The WG will provide guidance in respect of the additional costs that may be incurred by adopting different reliability and availability criteria.

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 members can exchange information and request assistance from other WGs, as appropriate.

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 C1 and C2 are invited to provide liaison members for this WG. Target Groups: Transmission companies, Manufacturers, Consultants, Academia
Approval by Technical Committee Chairman: Klaus Fröhlich **Date** : 24/02/2011