CIGRE Study Committee B4

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP (1)

WG* N° B4. 72	**Name of Convener :** Ting An (China) **E-mail address**: anting@sgri.sgcc.com.cn	
Technical Issues # 3		**Strategic Directions # 1**
Title of the Group: DC grid benchmark models for system studies		

Scope, deliverables and proposed time schedule of the Group :

Background :

A high voltage direct current (HVDC) grid is a power transmission system which consists of multiple HVDC terminals interconnected through DC lines. The advantages of a DC grid are increasing system flexibility and reliability and providing redundancy at a lower cost by sharing resources, resulting in lower power losses. With the development and availability of DC circuit breakers, DC/DC converters, DC cables and other relevant technologies, HVDC grids have become possible. HVDC Grids are considered to be the most effective and promising technical solutions for the connection of renewable onshore and offshore wind generation, remote energy resources, ocean power supply, sharing of energy storage including hydro plant, as well as interconnection of AC systems perhaps even on a global scale. Thus, the development of HVDC grids has become an important direction for the future development of smart grids.

Working Group B4-57 of CIGRE proposed the CIGRE B4 DC grid test system in 2014, and this was published in Technical Brochure 604. The test system is a VSC based DC grid test system with 3 VSC-DC systems, i.e. a 2-terminal HVDC link, a 4-terminal HVDC radial system and a 5-terminal HVDC meshed grid. The test system has 11 AC/DC VSC converters, 2 DC/DC converters and 2 DC voltage levels (±400kV and ±200kV). The main purpose of the test system is to provide a common basis for all CIGRE SC B4 WGs that work on the research of DC grids.

As the CIGRE B4 DC grid test system is designed mainly for offshore wind farm collection and integration, it is difficult to use it for studies of other DC grid applications, such as collection, integration and transmissions of onshore renewable power generation over long distance, LCC-HVDC grids, LCC-VSC hybrid HVDC grids, AC system interconnections via DC grids, etc. Therefore, researchers around the world are undertaking HVDC grids related R&D work with their own models which use different configurations and data, and the research results, even for the same study scenario, could be different and cannot be compared directly and shared effectively, as they are not obtained on the same basis.

Nowadays the funding support for large research projects tends to be provided by large organizations, such as the European Commission, Engineering and Physical Sciences Research Council (EPSRC), UK Energy Research Centre, Natural Environment Research Council, Chinese Government, State Grid Corporation of China (SGCC), State Grid Research Institute (SGRI) etc. It is also common that the large projects are undertaken by various organizations under collaboration nationally or internationally.

Therefore, it is essential and necessary to establish additional HVDC grid benchmark models to provide unified study platforms and common references for the researchers to undertake HVDC grid system studies for different research purposes. These models can be used for the relative researchers from different countries and different organizations to save their time and effort to develop their own models, to share and compare their research results directly and effectively, and to help for formulating the standards of DC grid equipment and operating standards of the DC grids.

In order to provide common study platforms to meet the most different HVDC grid study purposes and needs, seven (one large, two middle and four small) HVDC grid test models have been established by SGRI, with the large and one of the middle models being formed by the 4 small models. These models were designed to cover most HVDC grid applications including collection, integration and transmissions of onshore/offshore renewable power generation over long distance, LCC-HVDC grids, LCC-VSC hybrid HVDC grids, AC system interconnections for different types of studies with appropriate and applicable sizes.

The large model includes 22 AC/DC converters, 5 DC/DC converters and 5 DC voltage levels and is designed mainly for electromechanical transient studies due to its large size. The small models are intended for electromagnetic transient studies, whereas the middle ones can be used for both electromagnetic and electromechanical transient studies. These models have been used for the collaborative projects between SGRI and various organizations nationally and internationally, and positive feedbacks have been obtained.

As the models described above were designed based on the distribution of China's renewable energy, existing features and future development trends of power systems in China, they would have certain limitations in respect of international applicability. The purpose of the proposed SC B4 Working Group is to start from the SGRI test models described above and the CIGRE B4 DC grid test system and develop a new set of HVDC grid benchmark models covering most applications of DC grids for the benefit of researchers in the community.

Scope :

The objective of this Working Group is to establish HVDC grid benchmark models to cover most different HVDC grid applications for different types of studies, based on the output of B4-52, B4-57, B4-58 and B4-59, and the test models mentioned above. Both VSC and LCC HVDC grids will be considered, and the possibility and limitations for a LCC HVDC grid will be addressed.

The following specific activities will be undertaken by the working group:

1. Global survey and summary of the possible applications of HVDC grids and the possible grid configurations for the applications.
2. Literature research of the most common DC grid models used by researchers for different types of studies and for different DC grid applications.
3. Development of benchmark models suitable for different types of studies and for different DC grid applications based on the output of Items1&2 above, the test models and the CIGRE B4 DC grid test system. The output of B4-57, B4-58 and B4-59 on control functions and protection strategies will be applied for the models accordingly. The models will be verified by various modeling studies.
4. The out comings of Items 1 and 2, the design principles, logics and verifications of the models will be summarized and included in the Technical Brochure.

Deliverables: Technical brochure with summary in Electra, material for tutorial

Time Schedule : start : January 2016 **Final report** : September 2018

Other SCs/ Target Groups concerned by the work:
SC B1 and C4 are welcome to delegate one or more liaison members.
Target Groups: Transmission companies, Manufacturers, Consultants, Academia

Comments from Chairmen of SCs concerned : B4 will invite SC B1 and C4 to participate

Approval by Technical Committee Chairman : M. Waldron

Date : 11/11/2015

Table 1: Technical Issues of the TC project "Network of the Future" (cf. Electra 256 June 2011)

1	Active Distribution Networks resulting in bidirectional flows within distribution level and to the upstream network.
2	The application of advanced metering and resulting massive need for exchange of information.
3	The growth in the application of HVDC and power electronics at all voltage levels and its impact on power quality, system control, and system security, and standardisation.
4	The need for the development and massive installation of energy storage systems, and the impact this can have on the power system development and operation.
5	New concepts for system operation and control to take account of active customer interactions and different generation types.
6	New concepts for protection to respond to the developing grid and different characteristics of generation.
7	New concepts in planning to take into account increasing environmental constraints, and new technology solutions for active and reactive power flow control.
8	New tools for system technical performance assessment, because of new Customer, Generator and Network characteristics.
9	Increase of right of way capacity and use of overhead, underground and subsea infrastructure, and its consequence on the technical performance and reliability of the network.
10	An increasing need for keeping Stakeholders aware of the technical and commercial consequences and keeping them engaged during the development of the network of the future.

Table 2: Strategic directions of the TC (cf. Electra 249 April 2010)

1	The electrical power system of the future
2	Making the best use of the existing system
3	Focus on the environment and sustainability
4	Preparation of material readable for non technical audience