The Path towards HVDC Grids

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The widespread interest in incorporating large amounts of renewable energy into the AC transmission grid, principally from wind and solar generation, has revealed shortcomings in the existing infrastructure. In Europe the major wind resources are in the North West in locations that are remote from the major load centres. The existing grid infrastructure in these areas is relatively weak and unable to carry the power potentially produced by the wind power plants. A similar situation exists in the South of Europe and North Africa, where there is the potential for large amounts of solar power generation, but lacking transmission systems for bringing the power to the market. In the USA there is abundant wind power generation capability in the Mid-West and solar power in the South – West, but again these sites are remote from the major load centres. Bottlenecks in the AC grids will restrict the power flows from remote generation sites to the load centres.

One solution becoming increasingly credible because of technological developments and the difficulties in persuading the public to allow the building of new overhead lines, is to overlay the existing AC grid with a DC grid that can transport the power over long distances effectively and efficiently. In Europe there are proposals to integrate off-shore wind power generation into the AC grid using an HVDC grid. Germany's path to a new energy policy, has as one of the key elements a new power superhighway involving the latest HVDC technology. Solar power generation in North Africa could be transported to Europe via HVDC links, and another proposal is for a Mediterranean Ring using AC and DC grids linking the nations which border the sea. In the US a submarine interconnector from New Jersey to Maryland and Delaware, which will also connect to multiple off-shore wind farms is proposed. In China multi-terminal HVDC Schemes are being designed, and HVDC Grids are being considered.

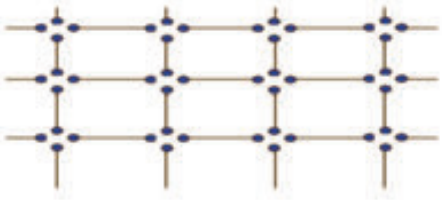

Figure 1a: multiple point to point HVDC schemes.

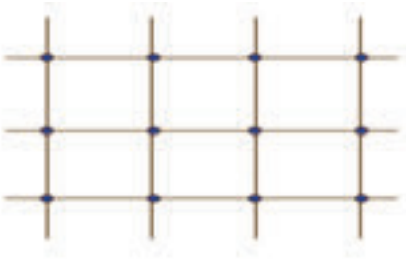

Figure 1b: HVDC Grid

HVDC Grids are likely to require converter stations with larger ratings (dc voltage and power) than is presently available, and therefore they will be more expensive. However, the development and design of higher rating is not considered to be an insurmountable problem. Similarly, higher voltage DC cables are also likely to be required for HVDC Grids, but no doubt these can be provided, if the market for such cables can be seen to exist.

Current Cigre activities towards HVDC Grids is proceeding well, but there is still a large amount of work to be done, before planners can use the guidelines to start to develop the functional specification for equipment to be connected to specific HVDC Grids. It should be remembered that AC Grids have been developing for more than 100 years, and the creation of HVDC Grids will be a major task, which will take tens of years.

In the author's opinion the real question is not if, but rather how and when the design and building of a HVDC Grid will start.

In reality, the activity will most likely start by building larger and larger multi-terminal systems. Some of these may include special equipment margins in an attempt to facilitate connection to a future HVDC Grid. However, without prior planning, e.g. taking into account the larger direct voltage range and equipment stresses (e.g. surge arrester energy duties) that are likely to be experienced when operating in a HVDC grid, operational constraints such as reduced active and/or reactive power ranges for some converter stations may have to be imposed. The provision of fast DC circuit breakers may reduce some of the equipment stresses, since injection of energy into the fault can be quickly curtailed.

The main issues delaying the implementation of a HVDC grid are in the author's opinion the following:

- There is still a lot of work to be done to define the stresses to which equipment in the HVDC grid will be exposed. This work need to be done by the organisation which will develop and design the future HVDC Grid.
- There is still a lot of work to be done to ensure that equipment from different manufacturers can be connected to the HVDC Grid without extensive investigations and tests. This will result from work done by Cigre and Standards institutions.
- The magnitude of the investment which will be needed whilst economies are only slowly emerging from a recession.
- Regulatory regimes which focus on short term cost & efficiency but which fail to properly incentivise long term strategic development needs.
- Uncertainty resulting from energy policies which are often relatively short term.
- Political issues associated with an HVDC Grid potentially covering many different countries, which may have different energy policies and security concerns.

The equipment in an HVDC Grid need to be designed taking into account the conditions and requirements that would apply within the HVDC Grid. There will of course, at least initially, be some additional cost associated with the design of the equipment for the duties in the HVDC Grid, i.e. a new point to point scheme designed to be capable of incorporation in a HVDC Grid, would cost more than a simple point to point scheme. Therefore, developers of new point to point schemes need to either have a business case for future proofing the scheme, or to receive a subsidy covering the additional costs, otherwise the simplest and lowest cost solution is likely to be specified.

It is hoped that the work done and in progress within CIGRE on HVDC grids will help clarify the issues associated with their design and implementation, and will enable Developers of HVDC schemes, Network Operators and Governments looking for solutions to the transmission of vast amounts of intermittent renewable energy to make the right decisions.

HVDC Grids are feasible, but much work is still needed, before they can become tomorrow's economic solution.

For further information, a longer Paper: "HVDC Grids - Overview of CIGRE Activities and Personal Views", by Dr Bjarne R Andersen, Chairman SC B4 is available on www.e-cigre.org, refence ELT_275_2 ■