MEDOW Academic Training Lecture

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Present:

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ESRs

Report by Gen Li on lecture:

DC grids as an option for future grids

By Associate Professor Dirk Van Hertem

The overall objectives of this lecture are to explain what are DC grids, why we think DC grids might be useful and prospective, introduces the components of a DC grid, how a DC grid operates, how is it built and other remaining issues.

From the view of history, the DC lost to the AC at the dawn of electricity (1885-1890s). AC won because of easy to transfer up to higher voltages and rotating field. But with the rapid and ongoing developments in electric power system, the DC is reviving and is changing the modern power industry.

The DC revived from the 90's as new markets (e.g. China and India) appeared, switching/acting component at first were mercury valves and later thyristors, transistor based components (IGBT) for HVDC started in the 90's, cable connections become more important and new applications such as offshore came out. Moreover, policy makers, environmental organizations, technology providers and energy companies drive the grid development. Also, the strong increasing penetration of smaller, variable energy sources has resulted in the close -to-the-limit utilization of existing grids, calling for upgrades for stability enhancement. The reapplication of DC grid is a good choice.

Comparing with AC, DC requires fewer cables for equal transmission, no reactive losses, no need for maintaining synchronism and power flow (injection) can be fully controlled. With these advantages, what researchers thinking are to use HVDC transmission system to transfer offshore wind energy to continent and build a supergrid in the short future. There are two technologies for HVDC, CSC/LCC technology and VSC technology, the later one is getting quite some renewed attention. Figure 1 is a typical VSC-HVDC system. All the details of each component were introduced in this lecture.

Nothing is perfect. There are some system issues with VSC-HVDC system including: the losses are relatively high (around 1% per converter), the protection in the AC network is not

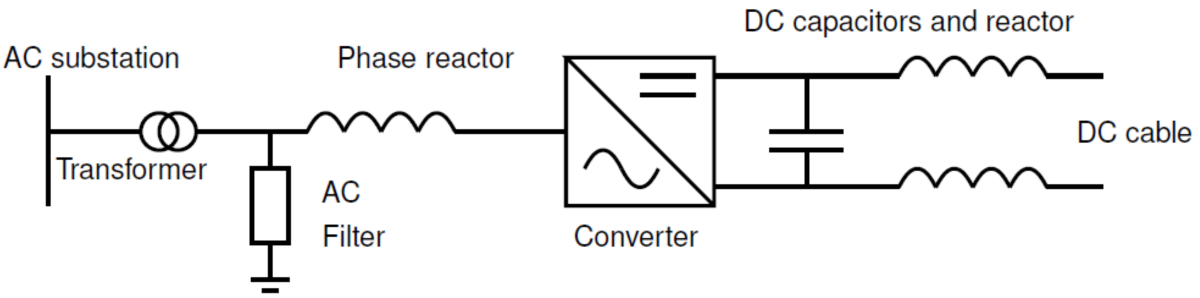

Figure 1: Main components of a typical VSC-HVDC system

trivial, dynamic model is still not fully available, new component which is not well know with the operators (no experience) and the ratings are limited.

A DC grid is increasingly seen as an option for the future grid or even a supergrid. A popular definition of a supergrid is: an overlay grid connecting different generation and load centres over larger distances. It serves as a backbone, connecting different regions and sources, adds reliability and security of supply to the system. Although many proposals for a supergrid have been envisaged, there are still many problems for the development of the future grid.

The grid development (technical problems), protection, operation and control, regulatory and acceptance for this concept are the main concerns. An alternative is stretching the use of the current infrastructures, making optimal use of existing right-of-way, using know technology such as utilizing new AC lines where possible, point-to-point HVDC, flexible generation, and smart grids. A new supergird must compete with traditional concepts. Figure 2 and 3 show the possible topologies of DC grids and point-to-point connections of VSC-HVDC systems respectively.

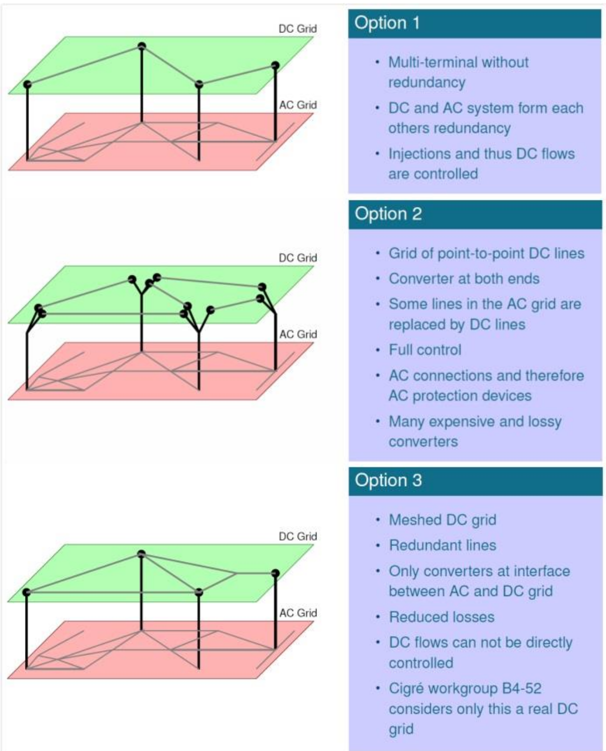

Figure 2: There options for DC grids

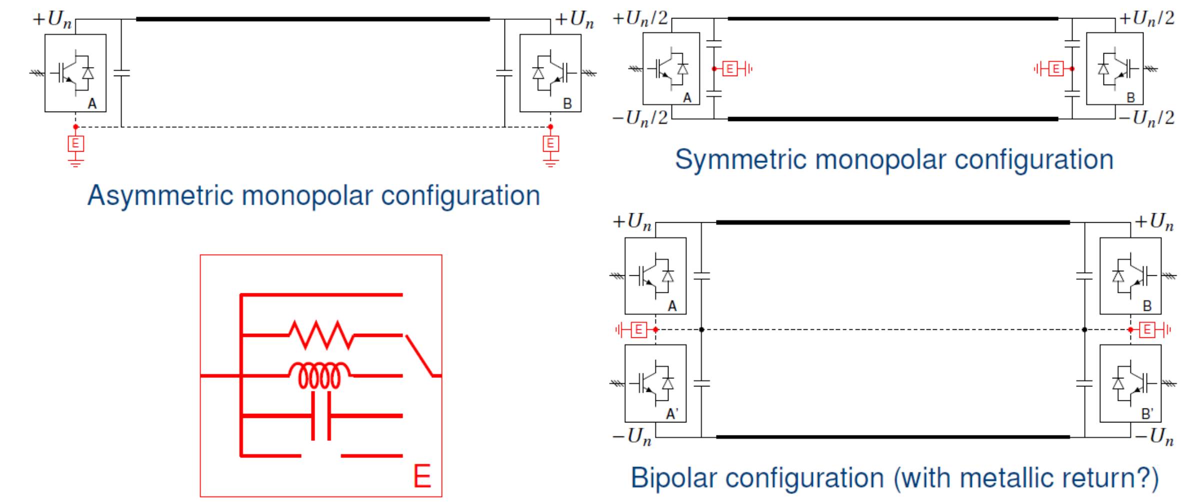

Figure 3: Converter station topologies for point-to-point VSC-HVDC system

One main concern of DC grid is the relay protection system. The fault current has no zero crossing point, the rising rate is high and steady-state value is high as well. For the point-to-point topologies, the protection can be achieved by breaking AC side breaker. But it is not possible for large DC grids. Moreover, there is no adequate DC breaker commercially available. The time constraints of DC system are very stringent, the interruption of current should not be too large and the converters should be protected. The problems of protection coordination: whether selectivity is possible within time constraints and the backup protection are unsolved currently. DC breakers need to interrupt high currents, withstand high voltages and operate in a few milliseconds. Events on the DC system will propagate to the AC system and vice versa.

An overlay grid is not built overnight. All investment decisions taken will effect future investments. Transmission investments are linked to generation investments. Whether the grid should be built overrating to accommodate further generation and each project has given lead times. All these problems should be considered seriously.

The potential benefits of a supergrid include: the access to remote energy sources, higher penetration of renewable energy sources by improved balancing, the improved grid security and the reduced congestion in the system. The costs of building a supergrid are very expensive, most of the investment is for HVDC terminals and cables. At the same time, there are other possible resources besides renewables (generation mix). It is also possible to use radial HVDC links to shore (is meshed cheaper?). AC system upgrades might be sufficient for many years. Is it interesting from an economic point of view to install a supergrid? Each independent investment needs to be economically feasible. Costs and benefits need to be allocated correctly. Risks/uncertainties come at a cost as well.

Conclusions:

- ✓ Energy policy is moving towards new grid developments, pushed forward by the additional requirements on security of supply, sustainability and economics.

- ✓ HVDC has received much attendence recently, especially cables.
- ✓ The DC grid is seen as a solution.
- ✓ However, several issues remain (technical, economical and regulatory).
- ✓ How the grid will look like and how it will be protected are specifically important when considering the potential of the future grid.

This lecture gives me an overview of the VSC-HVDC system and DC grids. The unsolved technical problems mentioned in the lecture are very interesting topics for my future research. The next phase is for me to study on these problems.