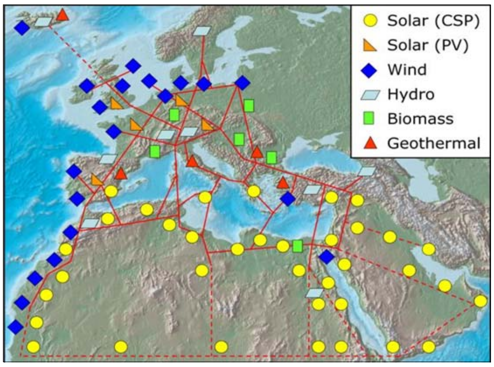
Challenges in future dc transmission systems

Introduction

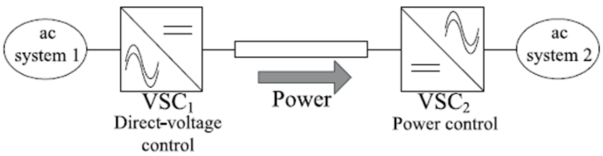
HVDC grids are proposed to interconnect renewable resources located far away from consumption centres and to integrate electricity markets over large geographical areas. However, future HVDC grids do not only bring benefits, such as transfer of large amounts of power over long distances but also challenges. For instance, an HVDC grid is a system composed of complex elements such as cables and Overhead Transmission Lines (OHL) that have resonance characteristics, and whose time constants are in the same order as of the converters connected to the grid. The interaction between these two can lead to undesirable behavior, thus, investigations are needed in order to guarantee a safe connection of the different components within an HVDC grid.

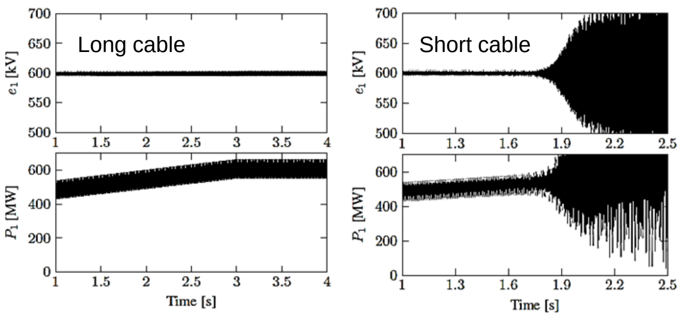


Source: http://www.desertec.org/

Example of dynamic issues in HVDC

A simulation has been performed in a point to point HVDC system. The simulation consisted of increasing the power transfer between in the direction shown in the below figure, for two different cable lengths, 50 and 100 km.



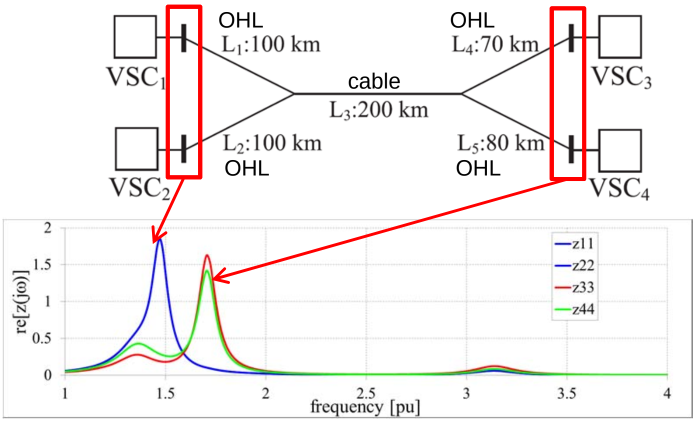


The results presented above show that for the same simulation the cable with the shortest length ends in an unstable scenario. This instability is in the form of oscillations whose oscillation frequency coincides with the cable oscillation frequency.

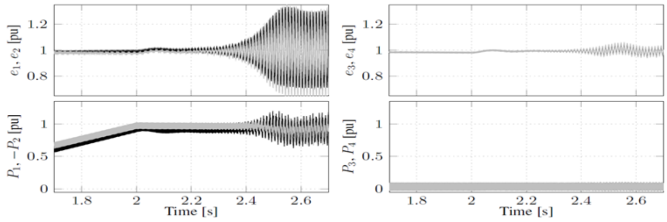
Thus, the question is, what is the relationship between the cable dynamics and the converter that causes the system instability?

Study in a multi-terminal HVDC system

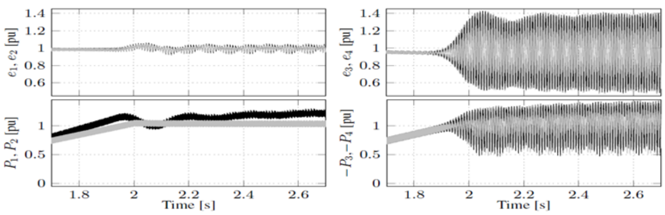
The four-terminal system in the below figure is studied. It is a 300 kV system and the dc network is composed of cables and OHL. The converters rated powers are 600 MW.



The figure shows the resonance peaks at the points where the converters are conected. Two different resonance phenomena can be observed. Simulations are performed such that VSC_1 and VSC_2 exchange 1 pu power while VSC_3 and VSC_4 powers are set to zero. The results presented below show that oscillations are more pronounced at nodes 1 and 2, as intuitively expected by looking at the resonance plots.



The control system is changed in VSC_1 and VSC_2 such that instabilities originated at nodes 1 and 2 are mitigated. Another simulation is now performed where VSC_1 and VSC_2 supply 1 pu power each to VSC_3 and VSC_4. The results below show that now the oscillations are more pronounced at nodes 3 and 4.



Conclusions

The studies have shown that there is a risk of instability in future HVDC grids and they depend on the resonance characteristics of the dc grid. This is critical in an HVDC system where the configurations are expected to change due to outages, planned or unplanned. Thus, measures taken to avoid instability in one scenario can be ineffective if the dc network configuration changes.

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