Towards a global electricity market

by Simon HARDY

Recent years have shown an increase of CO_2 emissions, indicating that the strategies that have been set up in the last few decades to decarbonise our economies are failing. If solar and wind energies have to play a role in the energy transition, their deployment should be literally massified in the coming years before it becomes too late regarding climate change issues. As a possible solution to decarbonise the energy sector, one could imagine harvesting high quality renewable energy in remote locations where the potential is enormous such as in Greenland. This work stands within this context, and focuses on the evaluation of the potential benefits of harvesting energy from Greenland, assuming interconnections between North America, Greenland and Central Western Europe (CWE).

A sizing algorithm is proposed in order to optimise the installed capacity of wind farms as well as the HVDC links to repatriate energy to large load centres when Greenland is considered as a potential production hub. The Greenlandic region could be connected with Central Western Europe region and/or with North America. This interconnected model represents a hybrid model, because it contains subsystems whose market design is different. Indeed, the market design in the CWE region is zonal pricing and the market design in the region of the North America considered is nodal pricing. The main evaluation criterion is the total annual cost of the system.

A zonal pricing and a nodal pricing algorithms are run to determine the reference total cost of the CWE and North America regions when no interconnection is considered. From these reference scenarios, the possibility to install HVDC links, wind farms and/or storage units in Greenland are added to the system. The aim is to determine the total cost of the system when such installations are allowed. Simulations show that, under certain assumptions, an interconnection with the Greenland can lead to a decrease of the total annual cost up to 8%.

Another benefit of the Global Grid approach is highlighted via a CO_2 analysis. The objective of the optimisation problem is modified. The total CO_2 emissions replace the total cost of the system. The global CO_2 emissions are widely reduced thanks to the Global Grid approach for two main reasons : The CO_2 emissions of the wind farms in Greenland is negligible compared to the most polluting generators and the HVDC links allow to use less the most polluting units. The simulations show that when 50 GW of wind farms are installed in Greenland, the CO_2 emissions of the system are already reduced by 32%.

Finally, as there is also a wind potential in the European sea basins, the compromise between investing in Greenland and/or in European sea basins is studied. The optimisation problem is upgraded in order to allow the system to build offshore wind farms near the European continent. The installed capacities of the onshore wind farms near the European continent and the offshore wind farms in Greenland are optimised. The simulations show that there is interest to invest in European sea basins when the Levelized Cost of Energy of the project is below 61.54 €/MWh.