Renewables and electrification in Europe
A critical analysis

Electrification through the joint deployment of renewables on a European scale corresponds to a no-regrets decarbonisation strategy.

To combat climate change, European states are planning a drastic increase in their electricity consumption to replace fossil fuels with low-carbon electricity sources. These sources, which will mainly be solar and wind, have seen their integration constraints greatly reduced in the scientific literature, notably with sharply declining storage requirements. Furthermore, this thesis shows how the difficulties that may arise with the deployment of variable renewable energies can be greatly mitigated by developing a joint strategy at continental European level.

The development of solar and wind power is the subject of much discussion, sometimes controversial, in Europe. Although their development, still relatively modest today, is the subject of a fairly broad consensus in the short term, there are many debates surrounding the possibility of having a significant share of electricity from these sources in Europe. Their intermittent nature and winter periods with little wind are constraints that need to be properly assessed before concluding on the relevance of variable renewable energies.

One of the first objectives of this thesis was to assess the major trends in the scientific literature concerning European energy transition scenarios, since the early 2010s. Two very interesting conclusions can be drawn from this analysis. Firstly, the scenarios did not anticipate the drastic fall in the cost of solar and batteries. Secondly, storage requirements were greatly overestimated in the literature of the early 2010s, notably due to less-than-robust assumptions about costs, interconnection possibilities and grid flexibilities in the models. The emergence of batteries, made possible by their falling cost and strong synergy with solar energy, will make it possible to meet a large proportion of storage needs. Furthermore, this analysis leads to the conclusion that seasonal storage needs, with hydrogen, are only necessary once the proportion of renewable energy in total consumption reaches very high levels (over 80%). To sum up, the development of renewable energies on European territory seems to be much less constrained today.

However, this lower constraint implies being able to significantly increase the interconnections between the countries, so as to benefit from the different wind and sun regimes on the European continent. In the model that I created in the thesis, I show to what extent this development of interconnections, with the aim of pooling production between neighboring countries, makes it possible to fight against winter periods of low solar and wind production. The various analyzes disqualifying the possibility of massive development of renewables under the pretext of these winter periods, without taking into account this possibility of benefiting from different deposits, are found to be erroneous. On the other hand, this greater level of interconnection between states means that countries are more dependent on their neighbors. This greater dependence must, however, be weighed against the very significant gain in independence from hydrocarbon-producing countries that the electrification of the energy mix brings.

Finally, to manage a power grid dominated by renewable energies, a certain level of flexibility is required. Certain energy-intensive industrial sectors offer considerable potential for flexibility once they have been electrified. Strangely, this phenomenon is little studied in the literature. In this thesis, I evaluate the level of flexibility in the steel, ammonia and methanol sectors on a European scale. It turns out that these amounts are considerable, and opens the door to further research to develop more complex models, enabling a wider scope of sectors to be assessed.