

The fight against climate change is the great challenge of the 21st century. To achieve this, Europe has decided to reduce its use of primary fossil fuels. In addition, it is increasingly turning to renewable energies, which seems to be indispensable to the future energy mix. Alongside these technologies is nuclear power, which had a heyday in the 1970s. However, this major source of decarbonised energy is very controversial. Belgium, a Western European country, is following the German trend away from nuclear power. It is planning to shut down some of its reactors from 6 [GW] of nuclear power to 2 [GW]. This loss of power is planned to be temporarily replaced by the construction of Combined Cycle Gas Turbines (CCGTs) until sufficient renewable energy is installed. On the other hand, many new projects around nuclear energy are emerging, including Small Modular Reactors (SMRs). These are very similar to conventional reactors but claim to have certain advantages, including higher flexibility.

This thesis studies the relevance of nuclear energy (under conventional or SMR form) in the Belgian energy mix. The tool used to carry out this study is EnergyScope Typical Days (ESTD), an energy system modelling tool based on cost optimisation. First, the case of the conventional NPPs is studied. Then the alternative solution of SMRs is studied as well.

The results show that the installation of nuclear power under either form is favouring the energy transition. The latter suggests putting a lot of nuclear, around 42 [GW] coupled with 10 [GW] of Wind Turbines (WT). It is obvious that the installation of this nuclear capacity in Belgium is not feasible. However, results from a Global Sensitivity Analysis (GSA) show that on average, ESTD recommends 12 [GW] of nuclear power. This is more than double the current Belgian nuclear fleet. Moreover, the annual cost of the energy mix decreases when nuclear is increasingly present. All in all, nuclear seems to be a viable ecological and economical way to reach carbon neutrality by mid-century.