DECARBONISATION STRATEGIES IN ENERGY SYSTEMS MODELLING: BIOCHAR AS A CARBON CAPTURE TECHNOLOGY

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Overview

The new IPCC (Intergovernmental Panel on Climate Change) report from March 2023 has highlighted that negative emissions technologies are essential to meet the global climate goals by 2050 [1]. This means that not only greenhouse gas emissions need to be reduced but also actively carbon dioxide needs to be removed from the atmosphere. There are several options to reduce CO_2 from the atmosphere, from reforestation to Direct Air Carbon Capture and many other technologies [2]. This study focuses on the introduction of pyrolysis in the energy system and the changes that occur in it. Pyrolysis technology is particularly interesting from a systems analysis perspective because, in addition to providing negative emissions, it also provides other outputs like electricity or heat, allowing the technology's interaction with other power plants to be analysed. In this study, the energy system costs and the changings of the energy system in Germany are analysed comparing it with a reference scenario without pyrolysis. Results indicate that pyrolysis can decrease the costs of the energy system by allowing conventional power plants to operate while compensating for their emissions.

Method

Pyrolysis technology has been implemented in the open-source model PyPSA-Eur [3]. The model focuses on a pyrolysis plant that is configurated to produce biochar and electricity. The electricity output will be used to cover the load while biochar is considered for the model as a carrier which has negative emissions, which means that can sequestrate CO_2 from other conventional generators. The evaluation of the impact of this new technology is carried out by measuring the impact of different “Scenario with pyrolysis” with respect to a “Reference” case. The “reference” scenario is defined as an energy system model with the same characteristics but without the pyrolysis technology. The input values from the pyrolysis plants are the costs and the biomass potential, as the results will represent future scenarios, a range of values representing more optimistic and pessimistic predictions is used for the analysis. To optimize the pyrolysis process for this particular configuration, extensive research has been conducted on various biomass types. After careful analysis, the most suitable biomass types have been selected. The selection process also took into consideration the biomass potentials and their availability in the future. Regarding the costs, pyrolysis is an emerging technology that started in Europe in 2013 [4], for this reason the collection and prediction of costs is hard. However, different cost values have been collected from literature, research projects and companies.

Results

Different runs are done using a range of values of the input values for the pyrolysis technology: costs and biomass potential. The results show that depending on the costs and biomass available for pyrolysis, different capacities will be installed. If enough pyrolysis capacity is installed, pyrolysis is able to compensate the emission of certain conventional power plants and the energy system will still achieve the goal of zero emissions. Moreover, the cost of this network configuration is cheaper than the “reference” scenario, without pyrolysis. In addition, it is also stated that the need of long-term storage, like hydrogen, can decrease depending on pyrolysis deployment. Figure 1 shows the unit commitment of a week in February. The first plot shows the unit commitment of a network with pyrolysis, while the second one is the unit commitment for a network without pyrolysis, in both systems the CO_2 emissions are zero. It can be observed, that in the scenario where pyrolysis is running, conventional power plants, in particular, CCGT and OCGT generate electricity during times when renewable generation was not enough to cover the demand, this way, less hydrogen is needed and the total costs of the network are cheaper. The biochar product can compensate for the CO_2 emissions generated by these power plants.

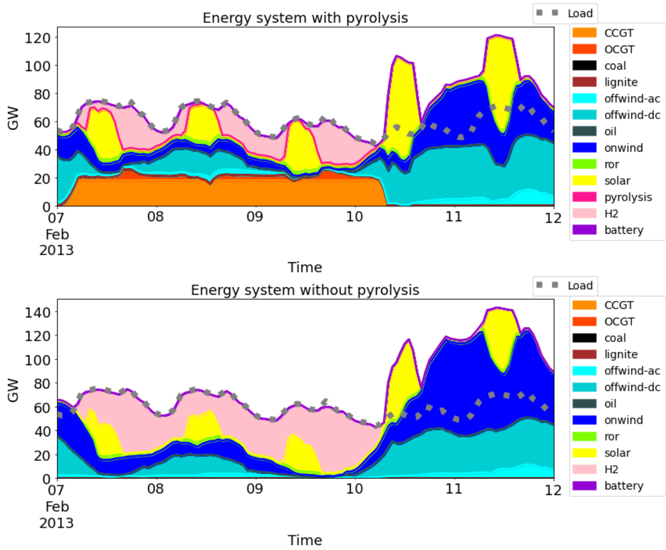

Figure 1: Unit commitment for one week in February, the top plot shows the energy system with pyrolysis, while the bottom plot is the energy system without pyrolysis, both achieving zero emissions.

Conclusions

With respect to the introduction of pyrolysis in the energy system, the model shows that by the introduction of this new technology, the total costs of the energy system can decrease and the CO_2 emission goal of having zero emission can be achieved. Pyrolysis will be used to compensate the emissions of some conventional power plants depending on the capacity installed, because these emissions will be compensated by biochar. In addition, the need of hydrogen in the energy system can also decrease, and the total costs of the energy systems will be lower. This study wants to prove that negative emission technologies can accelerate the path to achieving zero emissions in the energy system by reducing costs and enabling faster progress towards the next goal of getting negative emissions.

References

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