ASSESSMENT OF REGIONAL PEER-TO-PEER ELECTRICITY TRADING

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Overview

The impact of local electricity markets (LEMs) and peer-to-peer electricity trading (P2P-ET) have been widely discussed and assessed as options to help reduce the carbon footprint of energy systems. The potential positive impact that these concepts can provide on electricity bills makes them attractive to end customers, specifically to household end-users [1, 2]. However, regulatory aspects or policies to incentivize, or even make their implementation possible are not yet there. Political directives consider renewable energy communities (RECs) as an important support instrument to reach climate neutrality for the future energy system [3]. Moreover, expiring policy mechanisms, such as feed-in electricity tariff schemes, make LEMs a promising concept to ensure reliable energy supply, at an accessible cost. As their name states, LEMs are restricted to a local geographical area, usually defined under the same distribution network. Meaning that the power distribution situates in the low or medium-voltage lines. Therefore, this paper evaluates the possible impacts that P2P-ET may have on the residential sector in a regional geographical resolution considering the data of the German state of Baden-Wuerttemberg with an approximated area of 35,000 km^2, a population of 11 million and 70 TWh of consumed electricity in the year 2019.

Methods

To represent the power system of the aforementioned German state, a process of data collection, such as, hourly electrical load time series, installed energy generation capacity (conventional and renewable energy carriers) and capacity factors is performed. Secondly, the collected data was disaggregated for the residential sector, cleaned and processed utilizing the python-based library of pandas. After the data preparation process, the data will be fed into the PyPSA [4] energy system modelling tool and will be used to build a network in which the P2P-ET can be simulated (see figure 1). Using the built-in linear optimal power flow function, an optimization model adding a CO_2 emission constraint allows the quantitative evaluation of different scenarios considering the impact of P2P-ET and the dissemination of flexibility measures (e.g. battery storage systems) in the network.

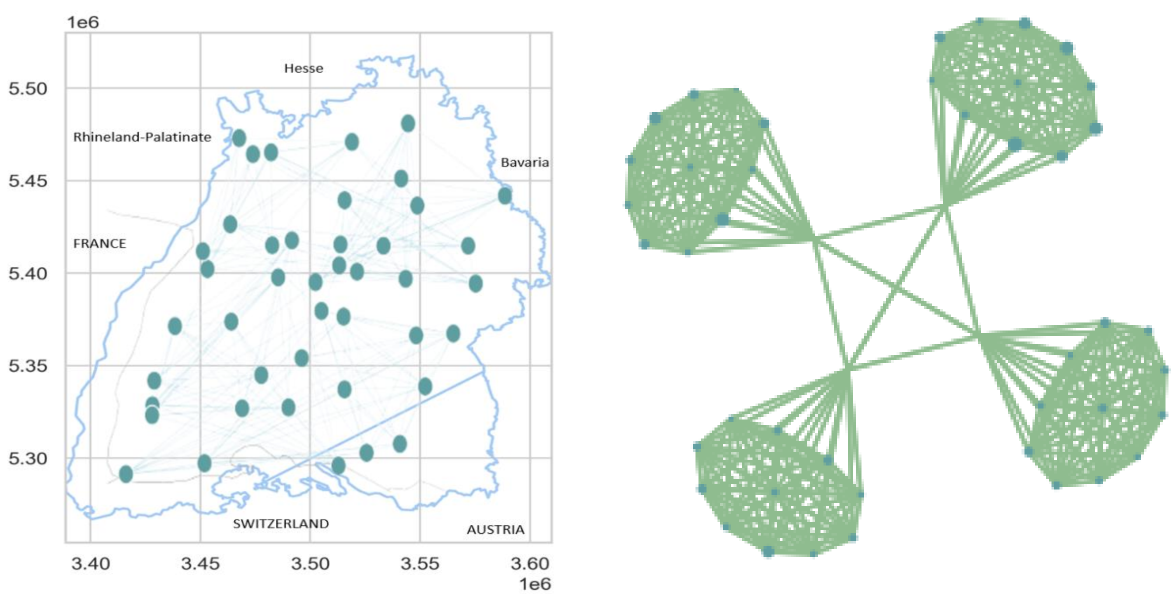

Figure 1: PyPSA generated networks. Geo-referenced P2P network (left) and simplified P2P network (right).

Results

The interaction of electricity flow between different communities can be evaluated from the previous results of the model. Calculations of locational marginal prices can be as well assessed from the optimized model. Impacts of P2P-ET in the system can be observed, such as a reduction of carbon footprint (see figure 2), optimisation of the power flow and reduction of the electricity price.

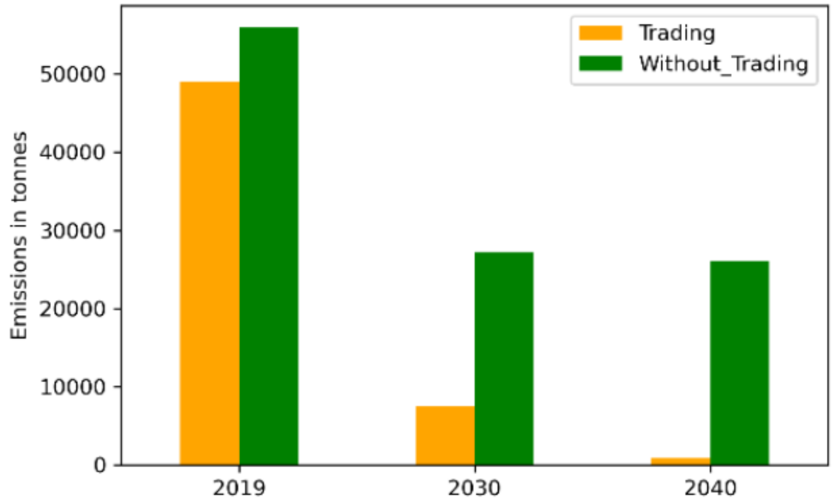

Figure 2: Reduction in CO_2 emissions with and without P2P trading

Early results show as well that the consumption from renewable generated energy is optimized as the implementation of P2P-ET takes place. Moreover, the outcomes of community battery storage can be quantified once the model performs the optimisation of the network.

Conclusions

A model capable of simulating a power system network with and without P2P trading is successfully implemented. This allows modelling reference scenarios for the year 2019 and for future energy scenarios considering the dissemination of P2P-ET in a transregional energy system. It is concluded that P2P-ET has a positive impact on the energy system, since in the future energy scenario of 2040, climate neutrality is almost achieved by the sole integration of P2P. Additionally, the locational marginal price when P2P trading was present is significantly reduced compared to reference scenarios without P2P, especially for regions in which the renewable generation potential is higher. Lower energy prices are directly correlated to the summer season due to higher shares of solar-generated electricity present in the system. Moreover, P2P-ET shows an optimized utilization factor on the installed capacity of battery storage systems.

References

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