Regionalization of four storylines for the decarbonization of the European power system including flexibilities

Topic (3) Integrated grids of the future
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Motivation (max. 100 Wörter)

The EU Green Deal and the consequently increased reduction targets of greenhouse gas emissions intend to accelerate the transformation of the European energy system towards more renewable energy sources (RES). Especially in Germany, a significant increase in home photovoltaic (PV) systems with integrated battery storage can be observed in recent years [1]. The spatial distribution of RES and flexibilities is of great importance for the integration into the existing and future grid. This paper investigates this allocation planning of RES, demand, and flexibilities in Europe, considering four different storylines developed in the Kopernikus project ENSURE[2].

Methodology (max. 200 Wörter)

We investigate the spatial distribution of the four future energy storylines (A-D). Where storyline A describes a reference scenario based on the german grid development plan. Storyline B entails the most ambitious emission reductions. Storyline C considers an enhanced European interconnection whereas Storyline D focuses on a decentral approach to decarbonization [2].
Our aim is to break down the storylines, defining the national pathways towards a carbon neutral power system, into spatial and temporal highly resolved demand and renewable generation profiles using the approach described in [3]. For the planning and operation of the future power grid the knowledge of these inputs plays a crucial role.
In addition to the existing allocation planning for RES and demand, we allocate different flexibilities. These include household and industrial heat pumps, home battery storage, and battery electric vehicles. The heat pumps of households and battery electric vehicles are allocated using distributions and projections of future population, whereas the industrial heat pumps are distributed using heat grids and industrial heat demands. Besides of regionalizing the flexibilities our aim is to model their simultaneously optimized decentral dispatch on distribution grid level. With a focus on photovoltaic battery energy storage systems (PV-BESS) we first allocate the residential battery energy storage systems based on the regional development of solar rooftop capacities and the residential demand. Afterwards, we run a stochastic dynamic programming approach to maximize the self-consumption of all households with PV-BESS, aggregated at buses of the distribution grid, considering the uncertainty of the PV and demand forecast.

Results and Conclusion (max. 200 Wörter)

The storylines describe distinct targets of the diverse RES capacities, flexibilities, and demand, representing possible future energy system developments. The data basis we use consists of the distribution grid data derived from Open Street Map data. They contain the European high voltage substations, including their geographical information.
Considering the results of the regionalization, we can observe different outcomes depending on the storyline. In storylines B, C, and D, there is an increased electricity demand in the heating and mobility sector. We use the resulting generation capacities and electricity demand in a market simulation to investigate the impact on the energy balance for each storyline. In storyline D, the demand cannot be met at all times resulting in load shedding of approximately 0.03% in Germany. In the other storylines, the demand can always be met. However, at certain hours, the conventional power plants are working close to their limits, and transmission capacities between market areas are almost fully exploited. We can also observe the positive effects of the battery storage system on the energy system due to the shifting of PV energy. Figure 1 shows exemplarily the results of the regionalization of storyline A in 2030. For better illustration only the central European area is shown.

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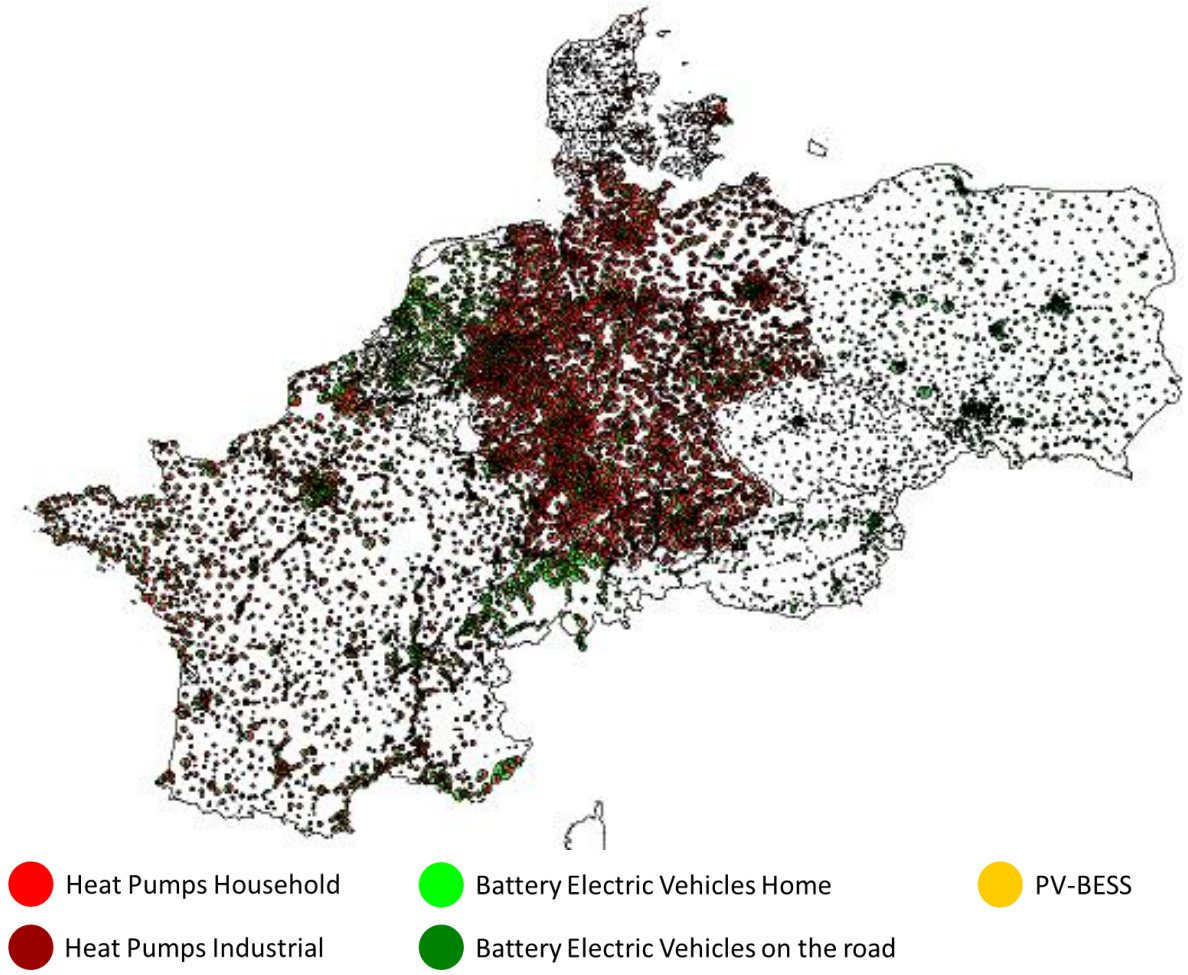

Figure 1: Regionalization of Storyline A – Energy consumption by flexibilities in central Europe in 2030

Literature

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