Modeling spatial and temporal charging demands for electric vehicles for scenarios with an increasing share of renewable energies

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The electrification of the transport sector together with an increasing share of renewable energies has the potential to reduce CO$_2$ emissions significantly. This transformation requires the roll-out of charging infrastructure, which, as a new and rapidly growing electrical consumer, has an impact on the power grid. For grid planning and dimensioning purposes, it is crucial to assess this impact as accurately as possible. Consequently, the possibility to simulate potential spatial distributions of charging points and their ramp-up is of central importance. We present an approach using socio-economic data such as population size, income levels and age to estimate where electric mobility will be concentrated, especially during the transition phase.

Suitable socio-economic data for Germany is only available for the current population and, in terms of spatial resolution, at the level of streets. Thus, both spatial disaggregation and temporal extrapolation within a demographic model are necessary for more detailed scenario predictions. In our proposed approach, a fuzzy-string comparison method and geographical mapping are used to allocate the socio-economic data to buildings (LOD1). A prediction on demographic changes taking into account recent municipal developments in Germany has been implemented. Age-specific changes at the community level are disaggregated on the household level and merged with socio-economic data. Combined with framework scenarios, we use these criteria based on socio-economic factors to develop spatially disaggregated scenarios. The framework scenarios take into account an increased penetration of renewable energies and a developed TCO approach for the ramp-up of electric mobility.

Predicting future distributions of domestic charging points with such a level of detail in terms of the ramp-up model and spatial resolution is highly beneficial for grid analysis and planning purposes. Typically, distribution grid studies that assess necessary grid investments rely on various simplified assumptions. A more detailed analysis of when and where the power flow at certain building connection points is likely to increase allows for more precise analyses of possible grid congestions. This also makes more efficient grid reinforcement and expansion planning possible, especially in urban areas, where infrastructure changes are expensive and time-consuming.
Another important aspect for demand-driven grid planning is the temporal modeling of charging processes. We use individual driving profiles based on surveys to create charging profiles for different consumer types. We combine them with a holistic model of the energy system including power plant scheduling as well as other (future) local producers and consumers such as photovoltaics and heat pumps. It allows us to consider correlations and simultaneities in their behavior and additionally enables us to explore various flexibility options and their influence on the electricity market and the grid.