The Federal Governments of Germany and the European Union have passed numerous laws that enforce a further integration of renewable energy sources. The distribution networks which can be found throughout Europe, are designed to match the conventional electrical power supply. Most decentralized energy systems are connected to the low voltage grid. As a consequence of political decisions on a national level, the low voltage grid must technically cope with ongoing large-scale changes on a local level. To facilitate the assessment of resultant challenges, a load capability analysis of electrical distribution grids in the context of decentralized energy systems is helpful. Thus, the present-day and future conditions of the grid can be analyzed and the absorptive capacity of different network topologies for diverse energy systems can be estimated. As a result, future research projects may find ways to overcome those challenges and to develop new concepts that ensure the grid stability on a long term.

For a significant study, a great spectrum of network topologies, building developments, forecasting horizons and technologies were investigated. Because the precise differentiation of variable scenarios was of equal importance, a methodology was developed, based on a broad collection of existing written studies. It helps to explore the topic from different perspectives. First, a survey for the examination of the building development, building density and the grid structure of residential areas was undertaken. The most important parameters in terms of grid structure and housing, were derived from this survey. Additionally five classifications of varying network topologies were made. Furthermore, statistically generated load profiles of an electrical heat pump, an electric vehicle and photovoltaics were available. Moreover, two performance indicators were developed to display critical grid conditions in an adequate manner.

The resulting information as well as typical networks developed by Kerber, OpenStreetMap-data and data from the pyCity library were used to form a grid model. It consists of 20 algorithms – one for each step in the methodology and for each type of grid topology. Every algorithm contains its own configurations. They allow an extensive load capability analysis with a static power flow calculation. The simulation results shed light on the absorptive capacity of the modelled network for the integration of decentralized energy systems.

With the obtained insights, the conclusion can be drawn that further integration of decentralized energy systems will lead to overloads in the future distribution grid. If the political goals are being pursued, it could be shown that by 2030 the rural grids would become unstable if the integration level of decentralized energy systems is at 40 %. Heat pumps severely endanger the grid stability in winter, and photovoltaics show equal effects in summer, if the integration level is very high. A mixture of these two technologies in one household result in major surcharges of the low voltage grid throughout the whole year. Alongside the described risks, new chances can result from the integration of mixing technologies such as heat pump and photovoltaics. Compensating and grid stabilizing procedures could be proven as steps toward a solution. Even though they don’t solve the problem completely, they can minimize negative effects. With the load capability analysis critical fields could be detected and emphasized where grid stabilizing measures are most needed.