Electromobility Stress Test – Evaluating the Effects of Increasing Electromobility Integration into Distribution Grids

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In Germany, the trend towards electromobility is gaining pace: In July 2006, the German government issued an incentive promoting the acquisition of at least 300,000 new electric vehicles (EVs) in order to achieve a significant reduction of pollution.

German distribution system operators are now facing the questions of how their grids will be affected by an increasing penetration of EV charging infrastructure in the future, and if the installed equipment, such as cables and transformers, will have to be adapted to the changing requirements. Power demand for EV charging is expected to increase gradually, but considering that the expected equipment lifetime is 40 years, investment decisions are already relevant today and need to be addressed in grid planning.

Against this background, Netze Duisburg GmbH, the municipality of Duisburg, has collaborated with Siemens PTI to perform an electromobility stress test of their 110 kV distribution grid, as well as of the connected substations and 10 kV grid. The goal of the stress test is to evaluate when and where the distribution grid performance will be affected by the integration of EV charging infrastructure and to determine which measures need to be taken in order to ensure a stable and reliable power supply.

The first step of an electromobility stress test is to determine the expected load types (e.g. private, public, commuters) and connection points, i.e. charging stations, in the system. Based on the current conditions, the expected load demand for fully electrified traffic can be derived. The development curve is estimated according to the latest market forecasts and/or the regulatory framework. In this particular project, the target values of the German National Development Plan were scaled down to the local grid and distributed over the considered time frame.

As a next step, the charging capacity at the different charging points is defined. On this basis, the grid is modeled with all required future charging points with a grid simulation and analysis software. In an existing grid, the current gas station locations, for instance, can be selected as future fast charging points. All fast charging points are then allocated to the substations nearby. All other charging points (private, public, commuters) are positioned according to the available grid data, such as type of station, peak load, radius of the local grid and number of households in the local grid.

The resulting future grid model shows which grid areas will be taking the highest loads for each of the charging capacity levels (Figures 1 and 2). A simulation over time shows the load development at an increasing penetration of e-car charging points, including the specific load increase at each of the substations and the loading of all cables.
In this particular project, the results of the simulation showed that for the Duisburg distribution grid, the total load increase on substation level is expected to be around 90 percent. The average substation utilization will increase from 61 percent to 117 percent, whereas some substations will be higher utilized than others. In consequence, Siemens PTI's recommendation was to consider the higher rated power during re-investment in transformers at particularly affected substations (Figure 3).

Siemens PTI's electromobility stress test delivered a detailed forecast of the impact of integration of electromobility on Duisburg’s distribution grid. With the delivered grid model, the calculations can easily be repeated with changing conditions at regular intervals. Based on the results, Netze Duisburg GmbH can make well-founded decisions for future investments into the grid considering the increasing electrification of traffic. This will enable them to maintain a secure and reliable power supply in the future and avoid stranded investments.