UTILISATION OF THE DISTRIBUTION GRID WITH A LARGE PENETRATION OF ELECTRIC VEHICLES.

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Electric vehicles have received a lot of attention lately and are expected to boom in the near future. In the power grid industry this raises concern on whether the grid is dimensioned to handle the power peaks related to charging. Using data from the one million customers connected to E.ONs distribution grid it was possible to analyse how electric vehicles will impact the grid owners, both in terms of network loading and profit.

In recent years there has been an exponential growth of electric vehicles in Sweden. By the end of 2017 there will be roughly 48000 electric vehicles driving on the streets (see figure 1). Future forecasts have estimated that by the year of 2030, it is likely that at least 20% of all cars will be electric. This means that the power grid will be one of the main distributors of energy to vehicles in the future, instead of traditional gasoline companies. With this in mind, grid owners are worried that the future charging of electric vehicles will stress the grid in a way that could lead to overloading of transformers and therefore large investments for grid owners.

The study started to collect all available data from E.ONs one million customers. Preferable, hourly measurements from all of E.ONs customers were needed. It turned out that hourly measurments could only be found for 13,000 of E.ONs customers and therefore a mathematical statistics method called regression was used.
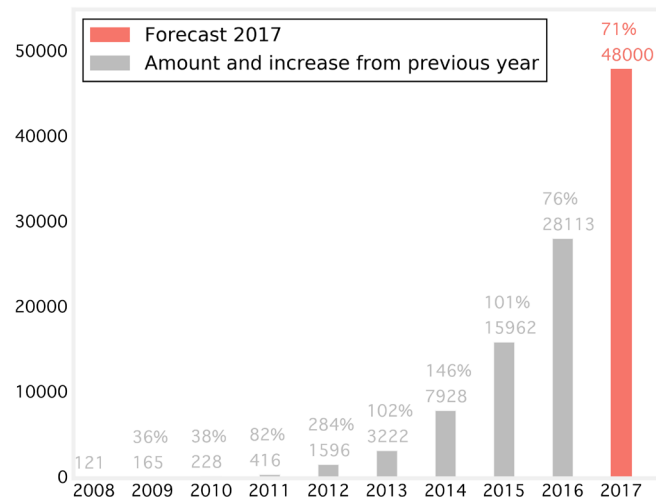

Figure 1: Accumulated increase of EVs per year. Source: PowerCircle (2016)

With the estimated consumption for all customers, future scenarios of electric vehicle penetration and charging behaviour could be modelled and then added. This made it possible to calculate the impact on the distribution grid and also what the expected profit or loss would be for grid owners. The future penetration of electric vehicles was chosen as 20% of all cars being electric by the year 2030 as a base case and a high case with 40%.

The results showed that most of the transformers in the distribution grid today are loaded less than 60% of its rated capacity and therefore have margin for the power peaks developed by electric vehicles. When simulating one of the substations in a power system program to calculate voltages and currents it also became clear that other technical aspects, for example cables, have sufficient margin for higher power peaks.

When a future scenario with a high percentage of cars being electric was investigated, 4.9% of all the transformers in the distribution grid were in risk of needing an upgrade. Although some investments have to be made for these overloaded transformers, they are still almost negligible in the context and the revenue is far greater than the cost. The results from the network loading can be seen in figure 2. The utilisation factor is the maximum power peak that occurred during the year, divided by the transformer rating. In summary, the results state that the distribution grid is prepared for electric vehicles.

Our financial analysis of the situation clearly showed that grid owners would most likely profit from a large-scale introduction of electric vehicles. The revenue from customers who have to purchase more electricity (and as a consequence, upgrade their fuse installed) will be higher then the cost.

The cost for the grid owners is mainly due to the fee that distribution grid owners have to pay to the sub-transmission grid. The low investment cost depends on the long lifespan of a transformer, which is up to 40 years.

In conclusion grid owners may not have to be concerned about the development of electric vehicles. On the contrary, they should welcome it. With that said, the energy market is changing from traditional electricity production to renewables, which will surely have an impact on the usage of electric vehicles.
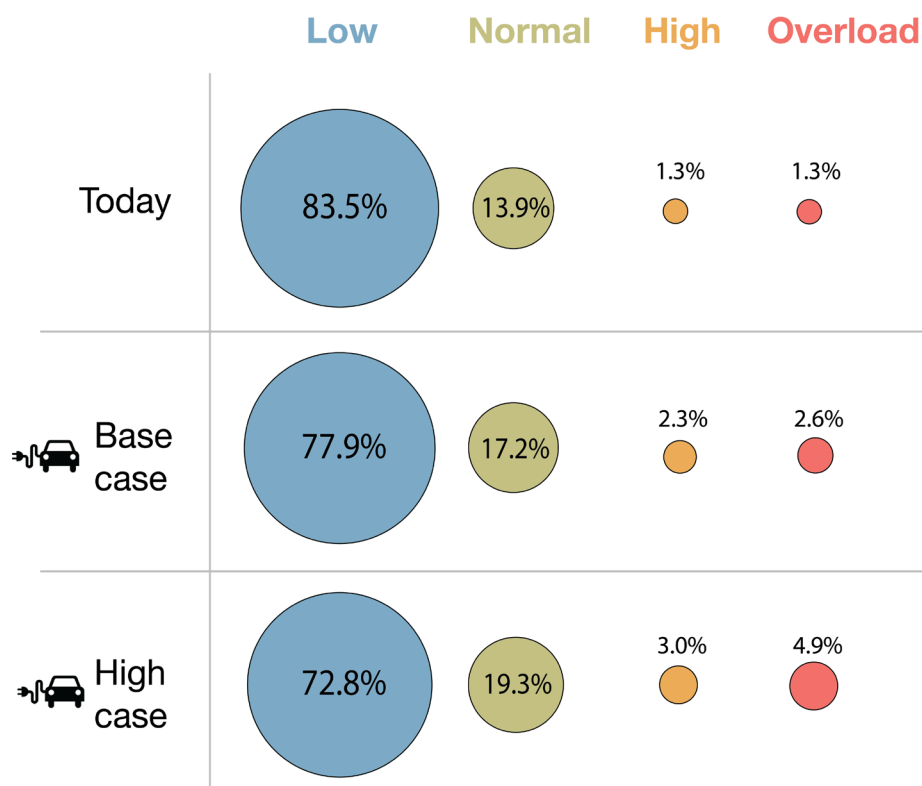

Figure 2: Utilisation factor for the substations in the distribution grid. The areas of the circles are proportional to their respective percentage. Where low =0-59%, medium = 60-89%, high = 90-100% and overload =>100%. To clarify, for example 83.5 % of all transformers had a low utalisation factor today as seen i the blue circle at the upper left corner.