European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)	International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2011

Electric vehicles and their effects in low-voltage grids

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Abstract. Currently the requirements to be met by the low-voltage grid are increasing. In addition to the growth of the distributed power supply the starting e-mobility is the main cause for this change. This paper contains the simulation of different low-voltage grids with a high number of connected electric vehicles. One of the results is that the utilization of the distribution transformer is the limiting criterion for a high number of electric vehicles in urban low-voltage grids. The comparison between a urban and a rural grid shows that the voltage drop is the limiting criterion in rural low-voltage grids. A solution to charge a high number of electric vehicles is a controlled charging system which makes it possible to charge all vehicles at night.

Key words

Electric Vehicles, Simulation Low-voltage Grids, Power Flow Simulation, Energy Management, Smart Grids

1. Introduction

At the end of the 19th century the first electric vehicles driven in the streets reached a distance of less than 20 km. This was the major drawback and after the electric starter was developed conventional vehicles boomed. However, at the end of the 20th century electric vehicles are again in the focus of research. This is caused by the development of the Li-Ion-Battery as well as the increased awareness of environmental aspects.

One topic of actual research is the connection of electric vehicles to the grid. One possibility is to exchange the battery and charge it at some main station like a petrol station. This option requires a connection to the medium-voltage grid and allows to power a high number of electric vehicles. The second possibility is decentralized charging in the low-voltage grids. This is a big challenge, due to the fact that low-voltage grids were not dimensioned for this high power flow. This paper describes the effects of charging a high number of electric vehicles in different low-voltage grids.

2. Electric Vehicles in Germany

In 2009 the German government published the national planning for electric vehicles. Among other things this directive includes the aim to have one million electric vehicles in 2020 and five million electric vehicles 2030 in Germany [1].

These aims are not legal requirements but merely a vision. It depends on many factors whether these goals can be achieved or even exceeded. In addition to the costs of a nationwide charging infrastructure system, range extension, durability and acceptance in the population will be challenges.

The use of electric vehicles is currently tested in some pilot projects. First experiences have been gathered with the electric vehicle as well as with the battery charge. These are some practical approaches to combine the two major industrial sectors of energy supply and automobile industry but also to raise people's awareness of the issue. Unfortunately, financial assistance for the purchase of electric vehicles which is common in France is not envisaged by the federal government in Germany at the moment.

Research reveals that the average daily car route is around 40 km [2]. If an electric vehicle needs 20 kWh / 100 km, it needs 8 kWh every day. This means an electricity consumption of approx. 2 TWh / year for one million electric vehicles which corresponds to only 0.3 % of the total electricity consumption in Germany in 2007. (600 TWh) [3].

A more relevant aspect is the connection and the charging. It seems possible, that every electric vehicle can be charged with a power of 20 kW. Due the most protections of low-voltage sockets in the households, it is only practicably to charge with less than 10 kW. One million electric vehicles require 10 MW. The worst case would be, if every electric vehicle would charge its batteries at