Grid disturbances caused by electromobility -Results and analysis of field measurements

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Extensive measurement campaigns were carried out in several power grids in Switzerland to analyze the impact of the electromobility on the power quality. Different types of stations were investigated, including Type 2 (onboard charging), CCS (DC), CHAdeMO (DC) and a bus charging station. The results contain the analysis of current harmonic emissions, voltage harmonics, supraharmonics and voltage unbalance.

Introduction

Driven by the global task to reduce fossil fuel consumption, many countries are turning to electromobility. However, the charging infrastructure for electric vehicles is still underdeveloped in most places it will need to grow to meet demand in the coming years. The development of new electric vehicles and charging technologies has raised many questions related to their interaction with the grid.
The objective of this work was to determine possible impacts of charging stations on the distribution grid. The focus is on potential power quality disturbances that may occur in the system and should be considered in the design of the infrastructure. This was determined by taking measurements on charging stations in different areas of the Swiss power grid. Subsequently, these measurements were analyzed and evaluated using existing norms and guidelines to identify any particular behavior of the devices. The different behaviors were described in each measurement point with the special characteristics noticed and recommendations are presented as well as overview of the behavior.

Goals

The goal of the work was to provide a better understanding of the impact of EV-Charging stations on the power quality of the grid.

- Perform power quality measurements of EV-Charging stations in different scenarios and of different types of charging stations across Switzerland
- Analyze the effect on the grid and additional load produced by electromobility
- Analyze the emission of current harmonics and compensation effects on the transmission grid
- Analyze the effects of electromobility in voltage quality

Conclusions

The Type-2 charging stations which are the most widespread across Switzerland don't evidence important impact in voltage harmonics. The current harmonic emissions in most stations don't comply with the D-A-CH-CZ for the 15th component, but this harmonic doesn't violate any voltage limits of IEC-50160 in general. The harmonic currents increased when multiple stations were connected, but the currents are relatively small as well as their impact in voltage. If the existing guidelines are followed the impacts in voltage unbalance and flicker are minimal.

The fast-charging infrastructures are recommended to have a dedicated transformer due to the high harmonic currents. The correlation on these station between the voltage harmonics that are close to the limit values is very low, even in some cases compensation (decrease of existing harmonic voltage) was seen, for this reason no harmful effects on the voltage harmonics of the grid were identified.
The bus charging station has a big impact in high order harmonics as well as in the supraharmonic region in frequencies around 10 kHz. The current emissions have high values for low order harmonics such as 3rd,7th and 9th. The 3rd causes an increase in the voltage but for the 5th and 7th there were compensations.

The effects on the load situation are handled with exclusive transformers and control systems that regulate the charging power to ensure limits are not exceeded and charging times are optimized. When doing a full charging cycle using on-board chargers, it was noticed that the strategy to reduce the total power by reducing the number of phases connected at nominal current, reduces the harmonic production.
It was seen that location is one of the main factors for the harmonic current differences. The charging stations react to the harmonic voltages flowing in the grid and currents are produced. This makes it difficult to identify the source of the harmonic currents. Therefore, it is advised to perform power quality measurements in the sites on a regular basis to overview the interaction of the different elements and use harmonic mitigation filters if required.

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