Interfacing Vehicle Charging Systems with User and Grid Requirements

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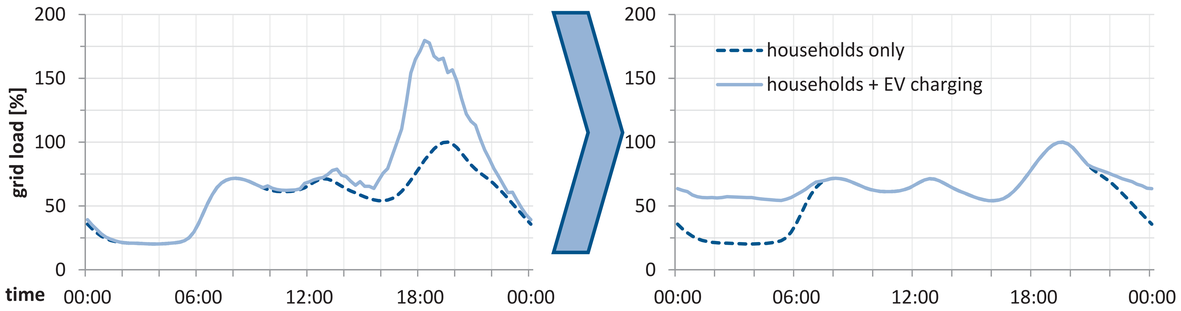
Abstract — The rising number of electrically powered vehicles (EV) challenges the distribution grid. Analyses revealed that the uncoordinated, simultaneous charging of vehicle batteries results in heavy load, especially in the afternoon and evening hours. This load leads to further increase of the already existing load peaks and thus to an even greater strain on the distribution grid. There are high costs resulting from the necessary expansion of network infrastructure. These effects can be counteracted by a system for coordinated vehicle charging.

Goal: Avoiding grid load peaks by smart charging schedules



Uncoordinated charging of 116 EVs in 200 households leads to high load peaks. The goal is to avoid those peaks by the use of a coordinated charging system. This system uses information about the grid and from the users to create an optimized charging schedule.

System description

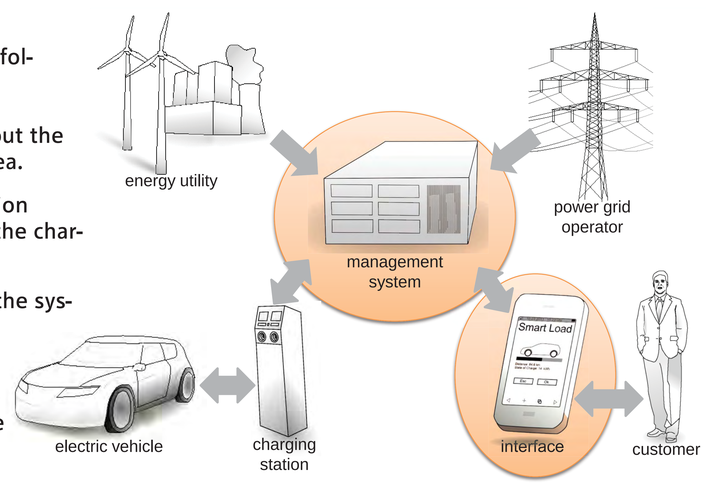
The vehicle charging system consists of the following elements:

(1) **Energy utility** providing information about the current energy consumption in a specific area.

(2) **Power grid operator** providing information about the grid load of specific areas where the charging stations are located.

(3) **Electric vehicles** (EV) being charged by the system.

(4) **Customers** connecting their EVs to the charging system and wanting their EV's batteries to be charged until a specific deadline to reach a specific distance.



(5) **Charging stations** where EVs are charged. They are also acting as information gateways between the management system and the EV.

(6) **Interfaces** which allow the customer to communicate with a central management system, to place their charging wishes and to retrieve information about the EVs (charging) status.

(7) Central **management system** aggregating information from all four stakeholders [(1) to (4)], scheduling the charging of EV's batteries (pro-active) and reacting to unforeseen events like over- or undervoltage (re-active).

Interface

The interface is a crucial element of the charging system. It enables the customer to communicate with the coordinating management system. This communication is essential for proper charging scheduling and load shifting. Interfaces can be placed both at the charging station and inside the EV, as well as on a mobile device. The latter turned out to be an easy to implement and cheap solution. So interface prototypes were developed for Android and iOS devices.

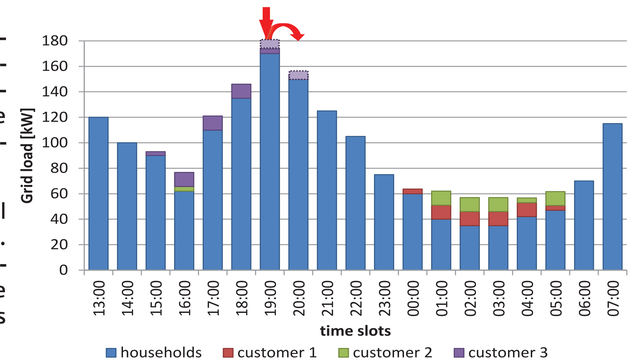
Charging system

The central management system fulfills two main tasks:

- Pro-active scheduling of EV charge to flatten the load profile and avoid load peaks
- Re-active stabilization of the voltage level by load shifting or load reduction

These tasks can be managed by the central system controlling the charging stations depending on information given by the customer (distance, deadline), the EV (state of charge), the energy utility (load information), and the power grid operator (voltage level).

The pictures to the right show a short practical example of three customers charging their EVs. The charging system creates a charging schedule like the one depicted in the middle where all customer deadlines are met and load valleys are going to be filled (pro-actively).



Due to unforeseen voltage drop at 19:40 the charging power is reduced and the load is shifted to the 20:00 time slot by the system (re-actively).