TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Demand Coverage of Electric Vehicles through Self Consumption of Photovoltaic Energy

Purpose of Realtime Balancing

Electric vehicles consume energy out of the battery storage during driving. Charging the batteries can ideally take place during parking times. Mostly the parking duration surpasses the charging duration, as well as the fact, that the storages have not to be charged completely for every new journey. This enables the consideration to charge the vehicles´ batteries at times of a surplus of fluctuating renewable energy supply. The power system draws benefits from local power balancing like

- reducing transportation losses and
- reducing voltage deviation in the grid.

Definition of Characteristic Values

Some indices are essential for the discussion of balancing of photovoltaic and e-mobility, which are coherently used to literature [Kathan, Stifter].

$$Total\ Coverage\ (TC) = \frac{\sum PV\ generation}{\sum electric\ load}$$

$$Self\ Coverage\ (SC) = \frac{\sum matched\ load}{\sum electric\ load}$$

$$Direct\ Use\ (DU) = \frac{\sum matched\ load}{\sum PV\ generation}$$

While TC exclude the concurrency between the profiles, SC and DU take the realtime situation into account.

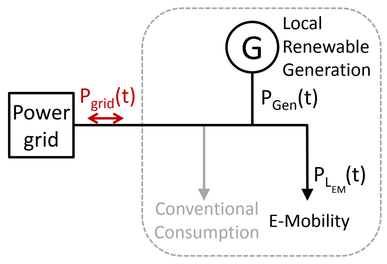

Fig. 1: Local balancing of renewables and charging demand of BEV

Charging Profiles

Preceded analysis of the user behaviour of conventional cars and electric vehicle simulation deliver the basis for charging profiles. Even if all parking spaces would be equiped with charging infrastructure, only two of them would be of energetic relevance at common power level.

- Places „Home“ and „Work“ enable charging of approx. 80 % of the energy.
- All other places together reach only the remaining 20 % and do not justify the investment.

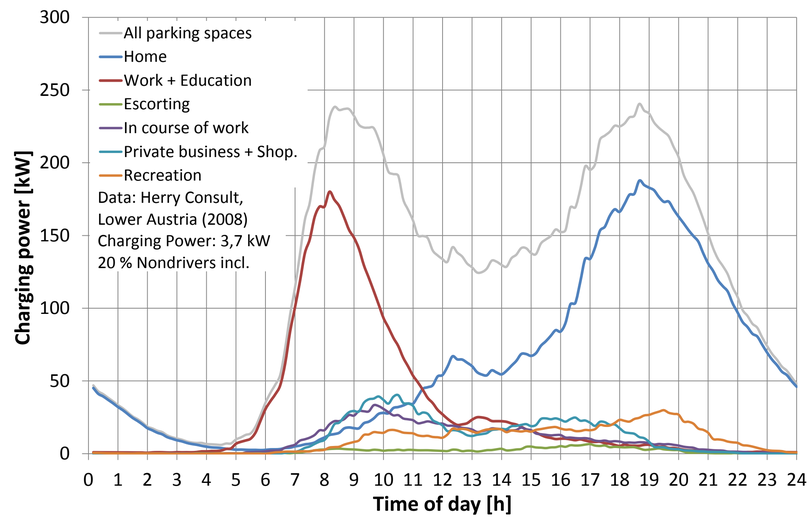

Fig. 2: Load profile at different parking spaces (Scenario „charging everywhere“), 400 BEV

Methodology of Power Control Algorithms

For the balancing of photovoltaic power and charging demand of electric vehicles, two concepts were developed:

- **PV-Synchronous-Charging**
  The charging profile follows the irradiation of the sun until the charging demand is satisfied.
- **PV-Offset-Charging**
  First the PV supply up to a chosen offset value is delivered to the grid. Exceeding this level, PV is merely used for charging electric vehicles. This limits the grid feed-in values of PV significantly.

The charging demand during nights is shifted to the next day, if a certain amount is not exceeded (e.g. 10 % per car). Otherwise night charging is performed.

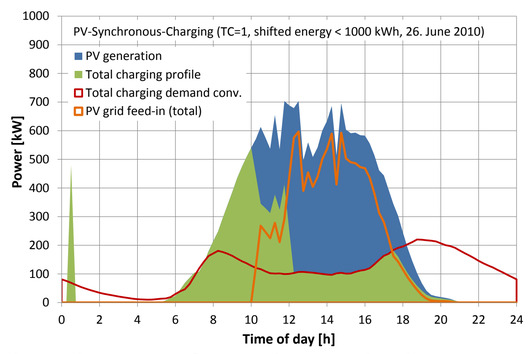

Fig. 3: Time course of PV-Synchronous-Charging

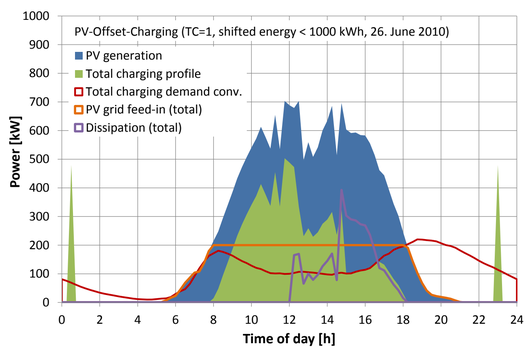

Fig. 4: Time course of PV-Offset-Charging

Power and Energy Consideration

Both concepts show different duration curves in half year analysis. PV-Synchronous-Charging leads to rather high rates for grid feed-in power for shorter time (orange line). PV-Offset-Charging reaches a long time of grid feed-in values up to the adjusted offset value (orange dotted line). All generation higher than this level is used merely for charging, unless a small amount of PV supply which has to be dissipated due to the lack of demand in a few time steps.

Considering the characteristic values, it can be demonstrated, that PV-S-Charging can reach up to 61 % direct use of PV generation by charging electric vehicles, compared to 39 % direct use with PV-O-Charging.

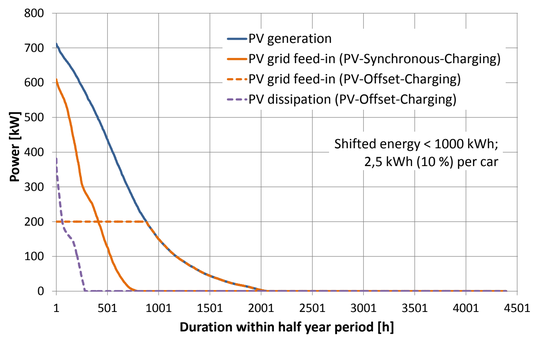

Fig. 5: Duration curve of both concepts (PV-S-C, PV-O-C)

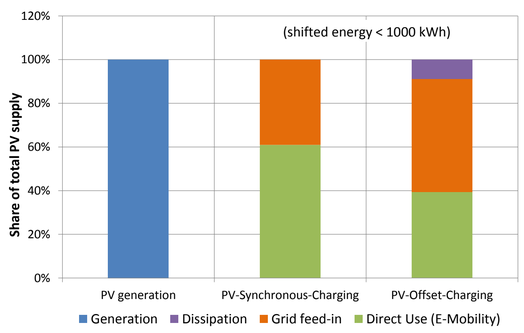

Fig. 6: Direct use and grid feed-in share in both concepts (TC=1, therefore DU equals SC)

Dependence of Location of Photovoltaic Facilities

The values of self coverage and direct use are depending on plenty of parameters like the total coverage, the level of shifted energy for the next day, as well as the placement of PV facilities. In order to reach high values for SC and DU, it is neccessary to install PV at both places of residence and work, as shown in the figure below. Taking just one location into account, the results for self coverage and direct use will be destinctly lower.

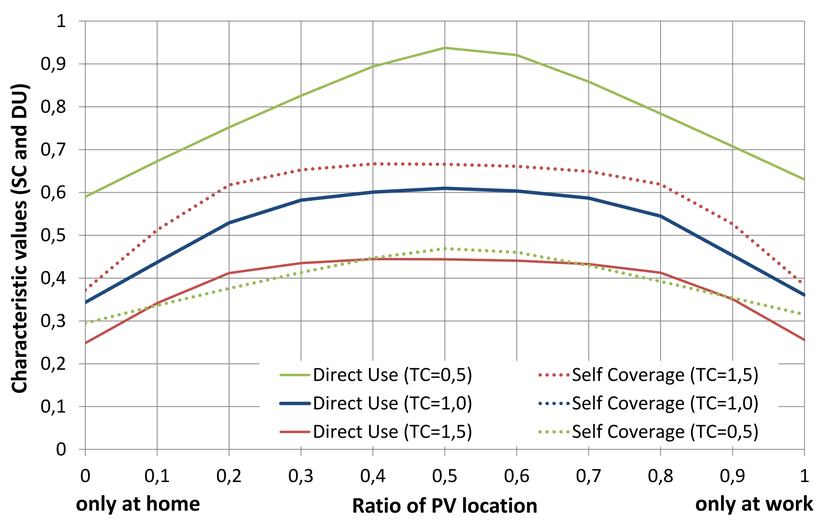

Fig. 7: Characteristic values (DU, SC) for PV-Synchronous-Charging

Conclusions

- For charging of electric vehicles during parking times, in general only places of residence and work are energetic reasonable at common power level.
- At a total coverage of 100 % over the whole period, values higher than 60 % for self coverage and direct use can be obtained. Varying the total coverage, either self coverage or direct use can be increased.
- Therefore photovoltaic facilities have to be installed at places of presence during day time of the vehicles, especially a combination of places of residence and work.

Project Details of Smart Electric Mobility

This poster is a result of the project “Smart Electric Mobility - Storage of Electric Car Batteries for Mobility Use and Grid Stability”. Focus is set to the interoperation of user behaviour, battery characteristics and power system integration to treat the upcoming chances and challenges of e-mobility and renewables.

Three scientific partners are forming the project team: Vienna University of Technology (ESEA), Austrian Institute of Technology (EDT), University of Natural Ressources and Applied Life Sciences (IVe). This project is funded by the Austrian Climate and Energy Fund within the programme „Neue Energien 2020“.

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