ANALYSIS OF A PV POWERED CHARGING STATION FOR ELECTRIC VEHICLES

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Abstract

The future developments in the automotive industry with electric drives with power from rechargeable batteries require a network of charging stations and loading facilities. In the last few years 1562 (as of 2012-01) charging stations have been built in Germany. This figure will considerably increase in the near future.

Photovoltaic (PV) systems are a considerable energy source for electricity in Germany; especially in Bavaria. That is why E.ON Bayern, the largest local grid operator in Bavaria, has started studies together with Munich University of Applied Sciences to feed these charging stations with electricity coming from PV systems nearby.

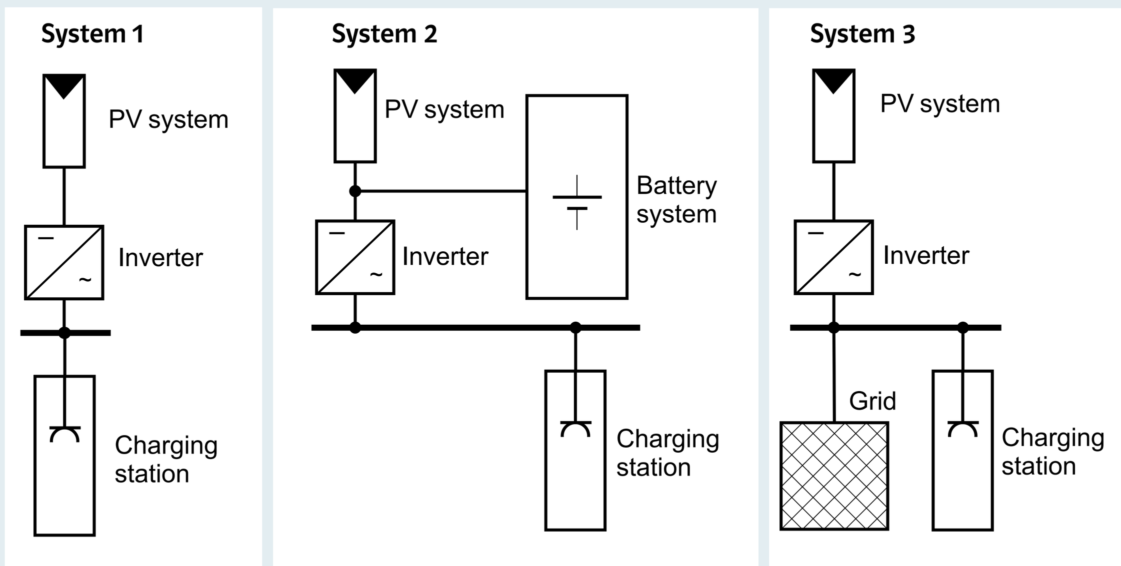

Fig. 1: Three types of systems have been investigated – the standalone system (left), the system with a buffer battery (middle) and the system with grid connection (right).

1 Overview

In figure 1 three types of charging stations are shown, as they are considered and investigated in this paper. All systems are designed for charging the batteries of e-bikes i.e. bicycles with a lithium ion battery of approximately 10 Ah and 26 V. The difference to other investigations is that system 1 and 2 are not connected to the grid. The grid connected system is designed without a buffer battery.

- System 1: Charging station powered purely by a PV system. It is a standalone system without any grid connection.
- System 2: Charging station powered by a PV system with battery backup, without grid connection.
- System 3: Charging station powered by a PV system with parallel grid connection.

2 Investigation of charging systems

2.1 System 1: Standalone system in Germany

The simplest system that has been investigated is a standalone system without buffer battery and without grid connection. Fig. 2 shows the results of the simulations with the software INSEL. For these simulations, meteorological data from a not very sunny week in July have been applied, based on hourly mean values. Using this type of charging system, batteries can only be charged during daytime, when there is at least some (direct or diffuse) irradiation.

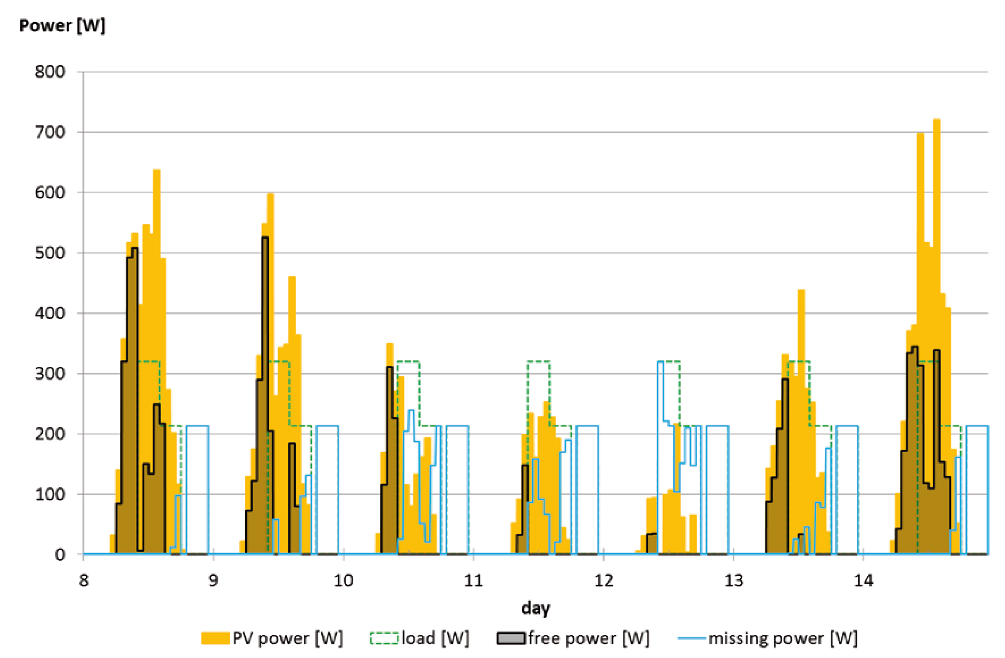

Fig. 2: Behavior of the load and the missing power are shown for some days in July in Nuremberg.

Summarizing this system cannot reach a good utilization ratio in Germany because of the strong addiction to the global radiation. In summer the most PV energy is produced but because of the bigger load in this time the same energy is missing, like in the wintertime.

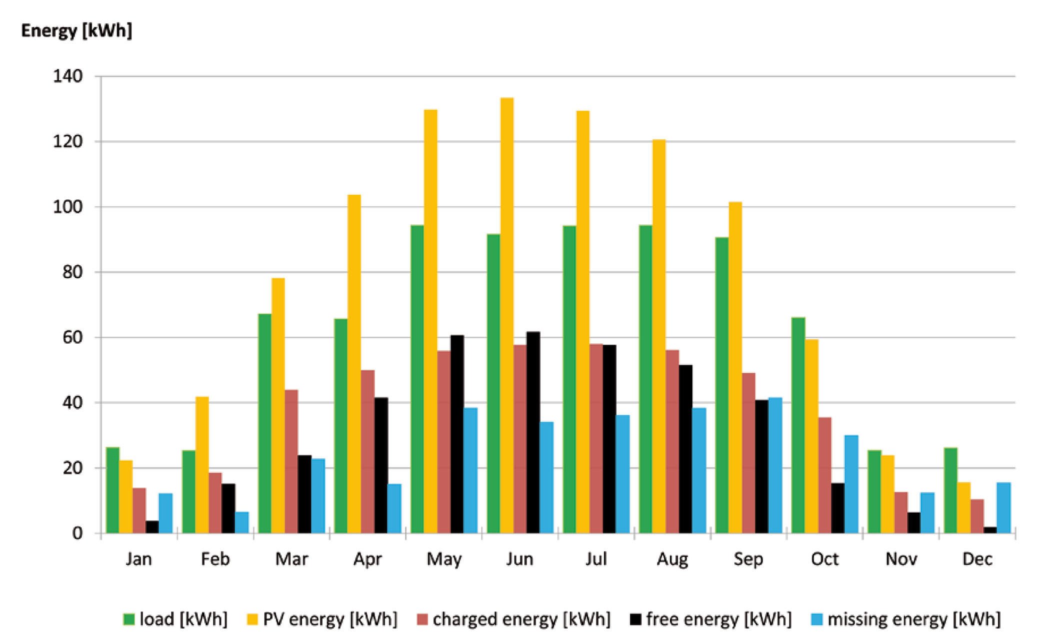

Fig. 3: Annual overview of the shown energies. Results for one year in Nuremberg.

2.2 System 2: Charging system with buffer battery in Germany

At the opposite of system 1 the second system has a buffer battery to store the power, which could not charged into electric vehicles. With this requirement, charging is possible even without sunshine. A higher utilization follows. Fig. 4 shows the result of the simulation for the same time span with the same meteorological data as in system 1. There is much less time when the load cannot be covered. This effect occurs although load is assumed in the night. There is only missing power in the shaded timespan.

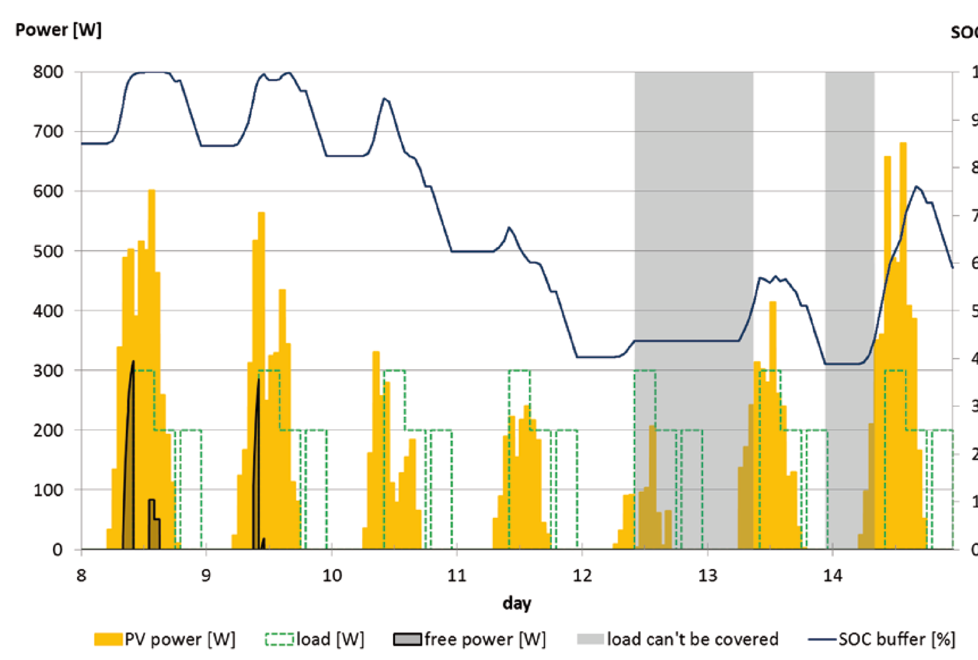

Fig. 4: Behavior of the load, the SOC and the time, the load cannot be satisfied are shown for some days in July in Nuremberg.

There is a little difference between the produced energy of the PV modules in system 1 and 2, caused by the fact, that in system 2 the system voltage is addicted to the voltage of the buffer battery. This voltage depends on the SOC. This system has a much better availability than system 1.

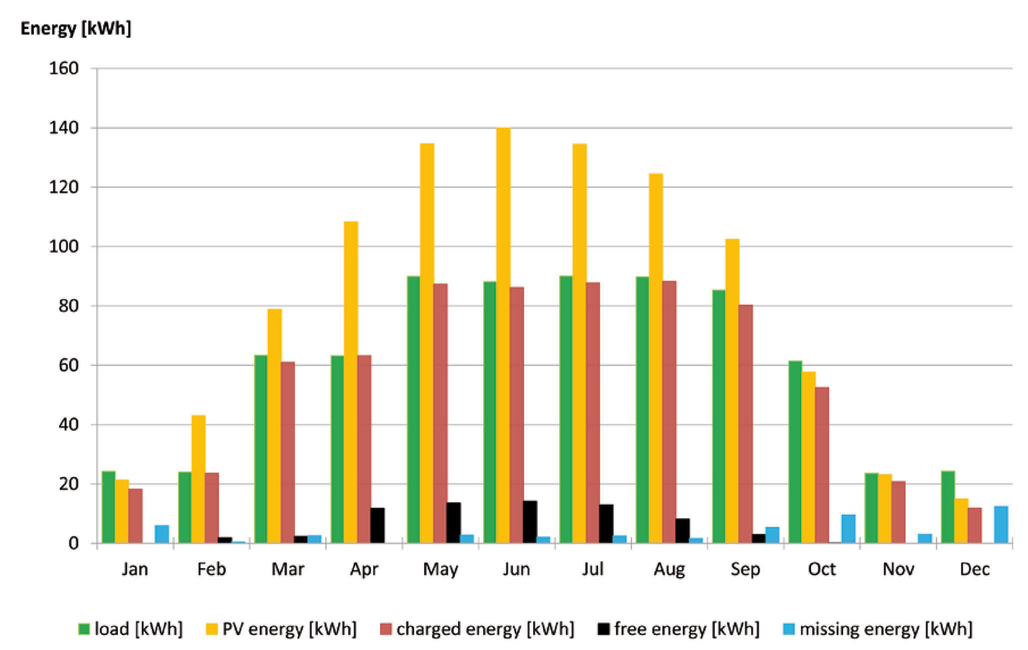

Fig. 5: Annual overview of the shown energies. Results for one year in Nuremberg.

2.3 System 3: Charging system, connected to the grid in Germany

Theoretical investigation and practical measurements were made for system 3. In this system the PV power plant is connected to the grid. This system is built in Sengenthal (Germany). Measurements were made during a charge of an e-bike. For the following simulation, the same timespan was used as in system 1 and 2. With a grid connection there is no energy unused. What cannot be used for the load is being feed into the grid. If the load is higher than the PV power, the difference has to be balanced by the grid. In the other systems, this power is called the missing power.

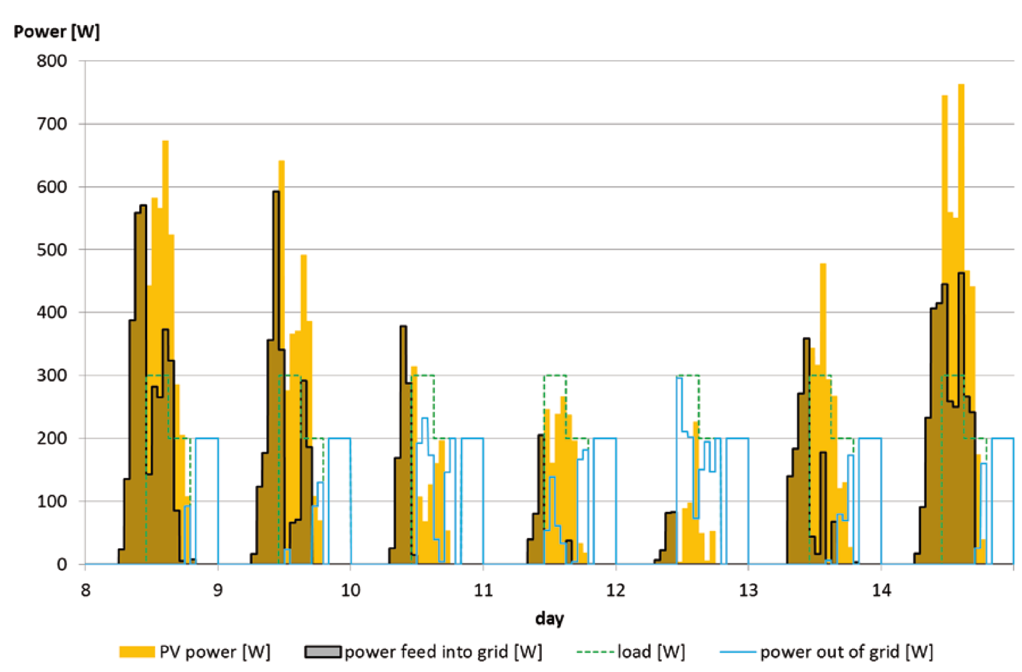

Fig. 6: Behavior of the power, fed into the grid, the load and the power out of the grid are shown for some days in July in Nuremberg.

There is although a little difference between the produced energy of the PV modules from system 3 to the others, caused by the fact, that in system 3 Maximum Power Point Tracking (MPPT) is applied. The charged energy is the same as the load, because there is no missing energy.

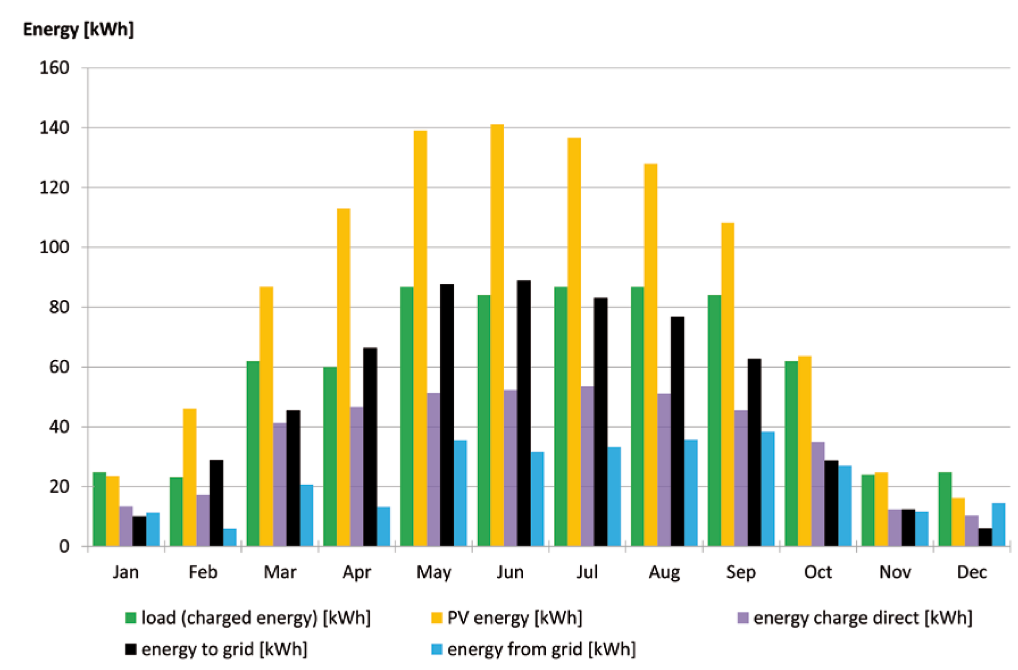

Fig. 7: Annual overview of the shown energies. Results for one year in Nuremberg.

3 Conclusions

Finally, it can be concluded, that the standalone systems 1 and 2 are not able to compete economically this time. However, this statement is not applicable for the system with grid connection (system 3). In Germany it could be different, if the owner and operator receives an Renewable Energy Sources Act (EEG) benefit for the PV power plant. High costs for battery systems and a low utilization time for these systems are responsible for high costs (Fig. 8). It should also be considered that the overall availability is not given. In system 1 an electric vehicle can only be charged when there is enough irradiation. Because of this fact, this system makes only sense for e-bikes. System 2 has an availability of 95 percent. It is although better to use it for e-bikes and not for e-cars. System 3 is the easiest to handle.

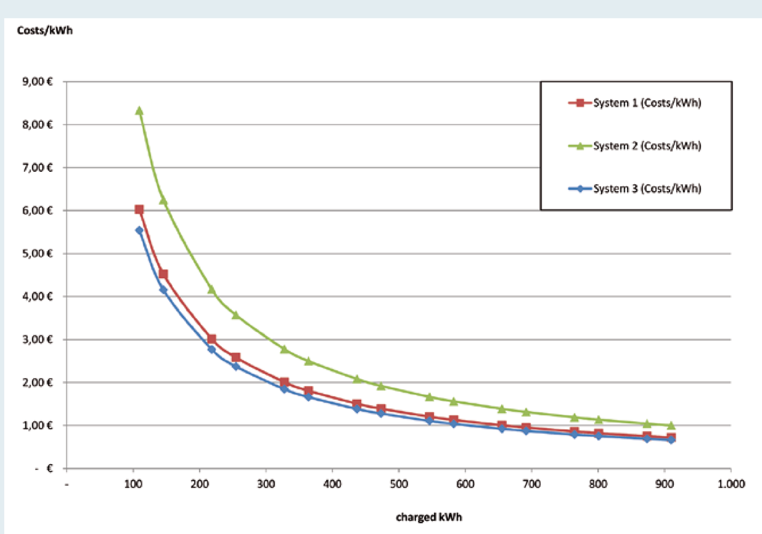

Fig. 8: Comparison of the electricity production costs of all three systems, depending on the number of charged kWh.

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