PhotoVoltaic EV Charge Station

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***Abstract* — The Electric Vehicles (EV) realize the clean and environment friendly traffic. It is true if the EV-s is fuelled by renewable based electricity. One viable energy source is the small and medium scale PV systems. This paper investigates the different PV – EV charger combinations. The concentrated load generated by the EV chargers can overload the existing network or huge developments are necessary. We found that the daytime garage of the officers and employees a possible place where to charge the cars during the work time. If we do not want to cause an extra load we have to synchronize the load to the actual PV generation. An appropriate rule based charger control can schedule the charge service of the suddenly arrived mass of consumers. In Óbuda University we made several developments for the investigation of the charging process.**

Keywords: EV, charger, power system, PV cells

I. INTRODUCTION

Nowadays a hot topic is the EV development. We are dealing with an energetic aspect, with the supply of the EV charger. The charge and the refuelling of the batteries is a hot topic of the electric cars. There are different underway solutions. High Frequency Wireless Power Transmission is possible between the steel belt of the car wheels and electrodes buried beneath the road surface. [11] [12]

The PhotoVoltaic (PV) system can generate enough electricity for the car, but the production schedule differs from the load schedule (day long "sinusoidal" production vs. ad-hoc some hours long charging sessions).

The new way of the environment consciousness is the usage of the Electric Vehicles, and the renewable electricity generation. Of course, the PV generated electricity is a good fuel source of the environment friendly traffic.

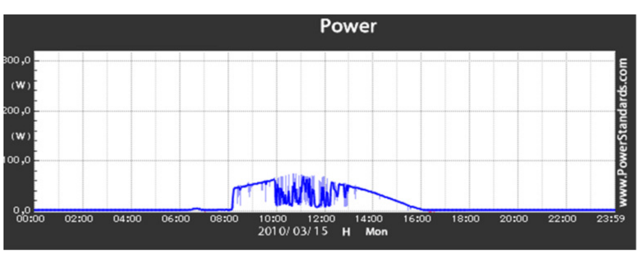

Fig.1. Daily production of a PV system

Figures 1 and 2 show a typical daily and weekly PV generation characteristics.

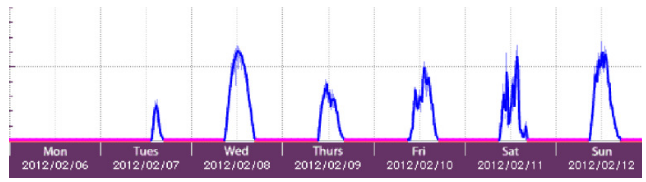

Fig.2. Weekly production of a PV system

On the other side the EV-s can be charged

- by fast charger during a short stop meanwhile the travelling
- by change of the battery
- by normal charger at home at night and
- during the work time in the garage of the office.

In Fig. 3. one can see the records of the usage of a public but non fast charger. I shows that the arrivals are not scheduled, the load differs (depends on the type of the car, the charger, the actual charge level of the battery, etc.)

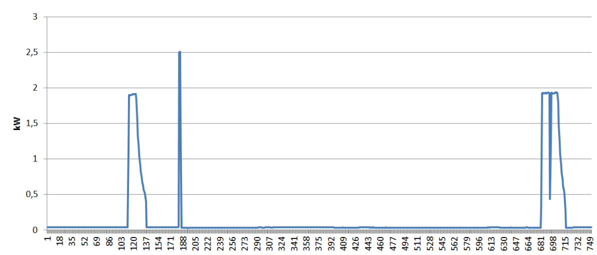

Fig.3. Load of public charge station 17-19. Oct. 2012

Fig. 4 and 5. show the individual charging process, where we have a constant current/power part and a decreasing hyperbolic curve part. It was measured by students of Óbuda University.

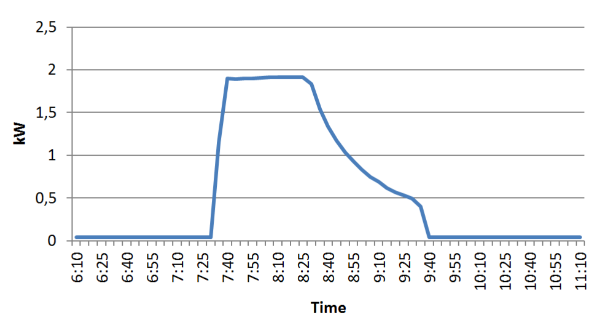

Fig. 4. Individual charging process

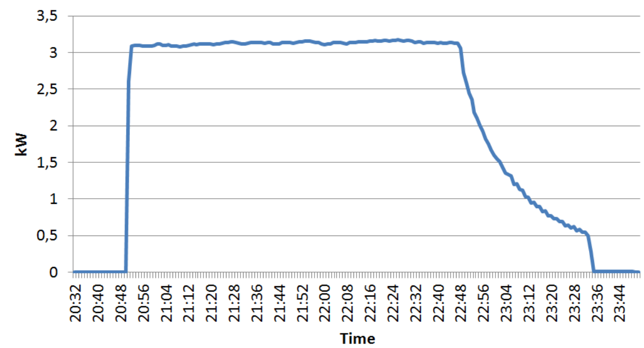

Fig. 5. Charge at home charger

II. PV CHARGER SOLUTIONS

There are more options how to combine the PV source with the EV batteries.

A. *Thin film PV painted on car chassie*

Another solution is the light resistive paintings on the car surface. The thin film technology PhotoVoltaic solutions are cheap and can be „painted" on the car-body.

The electrical efficiency of the commercially available thin film technology is only 4-6%. In the research laboratories efficiency is beyond the 20% by thin film and 10 % by the organic materials. [13]

Professor Prashant Kamant developed new and cheap paintings at the Notre Dame University in 2012.

In this new approach the formerly in e.g. silicon crystal fixed quantum points are put in a special paintings that can be painted on any shape of conductors. The core material is cadmium-sulphite or selen-sulphide covered titandioxide nanostructure. The CdS/TiO_2 film PV panels or painted forms (e.g. car) has similar characteristics to the mono- or poli-crystalline PV cells. The fig. 7. shows that the new painting type cells has the same characteristics as the traditional amorphous cells (fig. 6. – Donasolar DS-40).

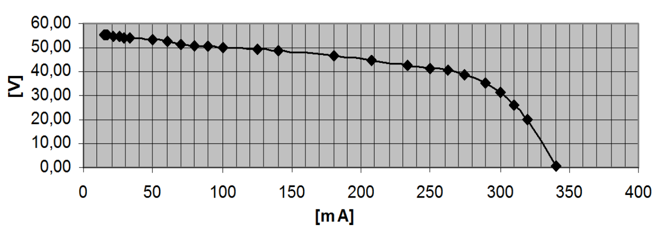

Fig. 6. Typical PV characteristic

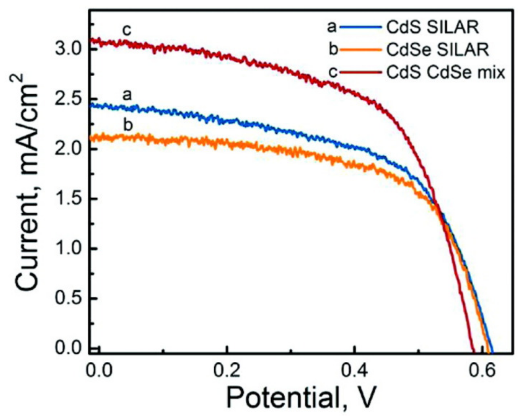

Fig. 7. Curves for solar paints formed with the pseudo-SILAR deposition process. The mixed CdS/TiO2–CdSe/TiO2 paint outperforms paints composed of only CdS/TiO2 or CdSe/TiO2 [1]

Table I.: Photoelectrochemical Performance of Solar Paints [1]

electrode	ratio	method	J_{sc} (mA/cm^2)	V_{oc} (mV)	FF	η (%)
CdS/TiO_2	1.5:1.0	mix	2.26	600	0.52	0.71
CdS/ZnO	2.25:1.0	mix	3.01	675	0.28	0.57
$CdS/ZnO/TiO_2$	2.0:1.0:0.2	mix	3.63	685	0.36	0.89
CdS/TiO_2	1.0:3.5	SILAR	2.33	615	0.61	0.87
$CdSe/TiO_2$	1.0:5.0	SILAR	2.12	608	0.64	0.83
$CdS–TiO_2/CdSe–TiO_2$	1.0:1.5	SILAR, mix	3.1	585	0.59	1.08

The only problem of the paining type of PV solution is the low efficiency. The mono crystalline cells have 15-17, the policristalline has a little bit lower, and the amorphous panels has 5-7 percent electrical efficiency. The painting has only ~1 % (see next Table).

If we have a car with $6m^2$ painted area and the actually irradiated area is $5m^2$, the maximum power is 1000 W *5 * 0,01 kW = 50 W. The estimated daily average production is about is 0,3 kWh/day – that enough for 1,5 km voyage.

B. Home PV system with local storage capacity

The average daily mileage is 50 km/day.

If we calculate with the generally accepted 0,2 kWh/km energy need, we need to refill 10 kWh/day. Counting with the efficiency of the storage (80%) the daily energy harvest need approx 12,5 kWh. The necessary PV capacity mounted on the rooftop is 2-3 kW_p.

- The individual production and load curve has different shapes. These can be fit in three ways:
- store the surplus – borrow the lack from the network. It do not really differs from the independent charger and independent home PV system.
- island mode store the total energy in a battery – and can be regain in any time (e.g. night time charging)
- the third solution is a relative small battery that runs in semi-island mode – where the battery smoothens the network in-out feeding.

C. Central PV system at the parking house

The most practical solution for the daylight charging is the daytime charge at the workplaces. As we mentioned the paring area roofs (heat shelters and or the direct car-painted PV solutions do produce remarkable electricity, the best option is the usage of the normal chargers (no speed charging) at the parking lots of the employees of an office.

In case of gas engine cars normally we fuel it weekly-biweekly, but in this case we load it fully. If we charge the car at each day "beside the main activity", "as diversion", (and maybe for the account of the company), we shall load in only the daily energy need. The total normal load process takes 6-8 hour, de load for partial discharge takes only 1-3 hours.

The employees arrive between 8-9 AM and leave between 4-5 PM. The charging process takes approximately 2-5 hours, so "there is enough time". The problem is that the employees arrives in a narrow time band and if everybody starts the charging soon after the arrival, the charging energy need will produce a sudden load peak not only in the local consumption but also in the consumption of the business quarter if other offices apply too this strategy. The individual chargers are not really controllable, so we can turn in and off that.

The solution is the delayed charge start. We must follow roughly the daily PV generation curve. The PV system is connected to the distribution network but the basic idea is to minimize the load consumption from the external net. The central scheduler can realize the following algorithm:

IF	there is PV production
AND	there is surplus production over the present charging load
THEN	permission of new charger start
IF	there is PV production
AND	there is NO surplus production over the present charging load
THEN	waiting list (e.g. FIFO)

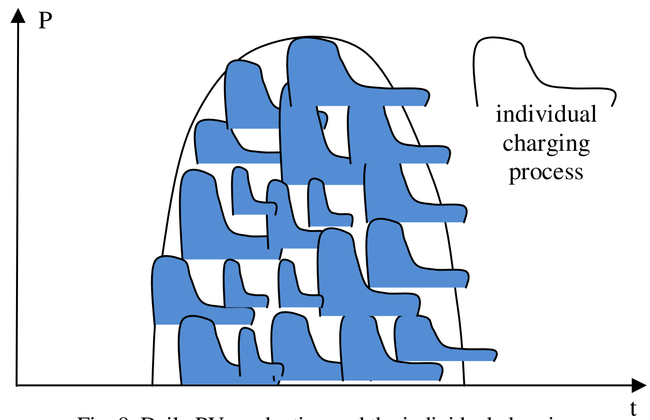

Fig. 8. Daily PV production and the individual charging processes

$$E_{PV} \approx E_{charge}$$

$$\int_{t_1}^{t_2} P_{PV}(t)dt \approx \sum_{i=1}^{n} \int_{t_1}^{t_2} C_i(t)dt$$

where

E_{PV} = the energy produced by the PV during period $t_1 - t_2$

E_{charge} = the energy consumed by the chargers during period $t_1 - t_2$

P_{PV} = the actual power of the PV cells

C_i = the actual power of i-th charger

In case of a 60 car fleet the daily necessary energy is approx. 600 kWh. The necessary PV capacity is approx. 100 kW_p.

III. Test site

At Óbuda University we have developed a test site to measure, to plan and to develop local control solutions discussed above. We installed a 3 kW_p network connected PV system, an EV charger and an electric scooter.

Fig. 9. The 3 kW_p PV plant – EV and charger – E-scooter at Óbuda University

IV. Conclusion

The EV-s should be fuelled during office hours in parking houses from PV systems. The Thin film technology PC paintings and the PC covered parking places are useful, but the necessary amount of the refuelling requires more area. If we have a building mounted fixed direction PV plant, the production is not synchronous with the need of the "in the office arriving" cars. We roughly planned an algorithm that can control the charging demand by the actual PV generation.

V. Acknowledgement

We thank for the data preparation to students Gábor Szijártó, Engelbert Ruff and Gábor Szigethy.

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