PV Energy Yield Measurements of Electric Vehicle and Electric Vehicle Charging Station

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ABSTRACT: The current low PV price is a game changer. As opposed to the 1980s, electric vehicles today have the potential to act as important new electricity consumers. With the now very low prices for pho-tovoltaic (PV) installations and solar cells, new PV and EV combinations are emerging. The DC/AC production with PV and the AC/DC-charging of EV battery with solar carports can be viewed as an established technique and an amazing economic advantage. Yet, with the low price even for highly efficient solar cells (>20% efficiency), the EV surface itself today becomes an interesting infrastruc-ture for energy production with solar cells. The research activities of the Laboratory for Photovoltaic Systems (PV LAB) at Bern University of Applied Sciences (BFH) in Burgdorf-Switzerland presented here seeks to quantify both infrastructure approaches (electric vehicle charging station, solar cells on e-vehicle). The project is part of the IEA Technical Collaboration Program (TCP) “Photovoltaic Power Systems PVPS” Task 17 “PV and Transportation” [1].
Keywords: PV in transport, EV charging, reference measurements, PV charging station

1 INTRODUCTION AND AIMS

More than 35 years ago, pioneer Urs Muntwyler, now head of the Laboratory for Photovoltaic Systems (PV LAB) at Bern University of Applied Sciences (BFH) in Burgdorf-Switzerland, organized the first solar car races in the world, the Tour de Sol 85 [2]. Since then, Muntwyler and his team at the PV LAB at BFH have explored possibilities of coupling photovoltaics (PV) with electric vehicles (EVs) [3]. Current research activities are carried out in the framework of the IEA Task 17 “PV and Transportation” working group of the Technical Collaboration Program (TCP) on “PV Systems PVPS” led by Professor Hirota at Waseda University, Japan. The work in Task 17 includes the mounting of reference cells on the research e-vehicle “Nissan Leaf” of the PV LAB at BFH. The PV energy yield of these cells is measured in different seasons and under various conditions. Here, we present first results and compare them with PV production data from the associated e-vehicle charging station at the BFH-PV LAB. The results will be discussed in the context of market announcements for first EVs with solar cells on the chassis for 2020 and 2021/2022.

2 APPROACH

There are several methods to measure the energy yield of PV on a car. One of the preferred approaches is using a “pyranometer” to obtain precise energy yields. However, a certain cooling of the mounted pyranometer is expected as the car runs. It is also challenging to mount a pyranometer on a vertical car surface. In addition, installing a device on a car might injure other traffic users in case of an accident. After evaluating several reference cells, special reference cells (“high power solar GSE cells”) were hence ordered from Germany. These solar cells were mounted on five surfaces on the Nissan Leaf (see Figure 1):

- Hood of the car
- Roof of the car
- Vertical sides left and right
- Backside of the car

Figure 1: Research e-vehicle Nissan Leaf of the PV LAB at BFH (Burgdorf-Switzerland) showing photovoltaic reference cell measures irradiance levels on the right side of the car. Source: PV LAB at BFH.

All cells are connected to a standard Campbell data logger CR1000X as also used in the long-term PV monitoring program of the PV LAB at BFH Burgdorf-Switzerland [4]. A special lead acid battery with 12 V, charged from the car when it is running, provides the power supply. The experiment started in January 2020. Several user cases are defined and will be measured.

3 INNOVATION AND RELEVANCE

Studies in the 1980s indicated that the integration of “very expensive” and “long lasting” solar cells (25 year was a standard guarantee) in a car is a waste of resources, also considering a car’s lifetime of perhaps ca. 10 years [5]. Today, the integration of solar cells in cars has become a real option. The reason is the low price of solar cells. The Swiss Energy Strategy 2050 foresees no replacement of fossil cars any more in Switzerland after 2050. In the context of this decarbonization of the Swiss society, the replacement of ICE’s with EVs needs to be mainly achieved with PV.

There are about 5 million cars in Switzerland, and their replacement with EVs will need 8 -10 TWh electricity per year. This results in a requested installed PV power of about 10 GWp [6] for the EVs alone. EVs with inte-grated solar cells can lower this figure. This is the innovation and relevance underlying the research activities of the PV LAB at BFH Burgdorf-Switzerland described here. The integration of solar cells is now an option due to the low price of the solar cells. This raises new questions as:

- What is the benefit of solar-cells integrated into a car chassis?
- Is it an emotional benefit?
- Is it a benefit for the climatization of the car in hot regions?
- Is the range extension interesting enough and for which car concepts?
- How about the technical hurdles for the integration of the solar cells?
- What is the needed effort for the BOS systems?
- Is there a trade of between the size of the battery and the yield of the solar cells?
- What is the influence in different climate zones?
- Is there a benefit for high efficient solar cells as the surface is quite small and cars are ex-pensive?
- How much is the contribution to the energy balance of EVs in different uses and climate zones?
- What is the energy production due to several usage profiles and the parking time?
- How important are parking lots with good solar conditions in different seasons during the year?
- What is the trade-off between the EV solar production and solar carports?
- Is the new haptic of the car surface acceptable (see the acceptance of the “Think” EV with thermoplast surface) in the past?

More questions are welcome ➔www.pvtest.ch or an e-mail to: urs.muntwyler@bfh.ch!

More questions will also be found within the work of the IEA TCP task 17.

4 PRELIMINARY RESULTS AND CONCLUSION

Measurements conducted on 15 January 2020 are illustrated in Figure 2. The first results provide quantitative evidence that more than 5kWh could have been produced on a theoretical PV surface of 5qm on the car on 15 January 2020. Further analyses on the links between our measurements and meteorological conditions in January 2020 will be undertaken (as this month was very sunny, www.meteoswiss.ch) in Switzerland.

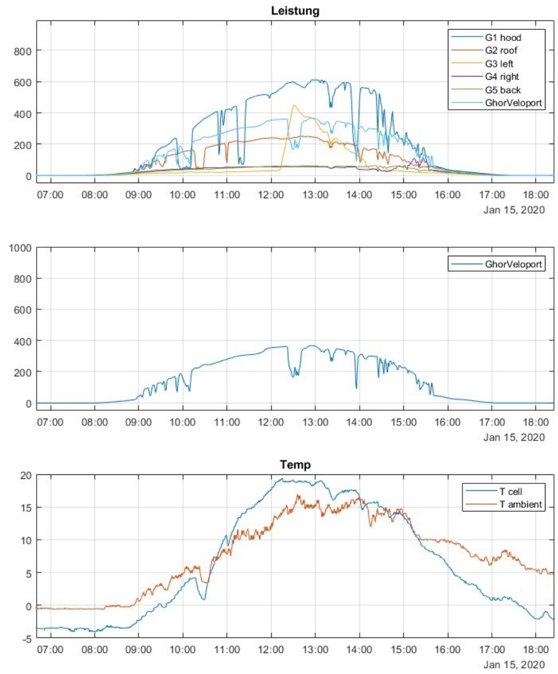

Figure 2: Top graph shows irradiance levels of all reference cells (G1-G5) on the car and the global irradiance on the horizontal plane (Ghor). The middle graph only points out Ghor. The bottom graph displays the ambient temperature and cell temperature of the cell mounted on the roof (G2_roof).

In summer 2020, the planned measurements will serve to evaluate the economic benefit of climati-zation of a car with PV-integrated solar cells. In the context of the simultaneously monitored asso-ciated electrical vehicle charging station at the PV LAB of BFH, the planning of parking lots for solar cars will be addressed.

5 ACKNOWLEDGEMENTS

This research is part of the activities of the Swiss Centre for Competence in Energy Research on the Future Swiss Electrical Infrastructure (SCCER-FURIES), which is financially supported by the Swiss Innovation Agency (Innosuisse - SCCER program). Co-financing from Bern University of Applied Sci-ences (BFH) is gratefully acknowledged. We also appreciate funding from the Swiss Federal Office of Energy (SFOE) and the collaboration with colleagues in Task 17 of the IEA TCP.

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