Photovoltaics for on-board charging

The Lade-PV project aims to investigate the profitability of photovoltaics use as an additional power source in commercial electric vehicles (EVs). A photovoltaic converter connects the PV solution to the in-vehicle CAN network(s) to manage the battery charging.

Figure 1: I drive electrically powered by photovoltaic on my roof (Source: Fraunhofer ISE)

Solar power produced on the vehicle can help to save power coming from the EV battery and, thus, improve vehicle's CO_2 emission balance. To demonstrate the marketability of PV (photovoltaic) applications in freight transport, several German companies teamed in the Lade-PV project sponsored by the Federal Ministry for Economic Affairs and Climate Action (German: Bundesministerium für Wirtschaft und Klimaschutz, BMWK). The project managed by Fraunhofer Institute for Solar Energy Systems ISE has started in summer 2019 and should end in summer 2022. Participating parties are Fraunhofer Institute for Transportation and Infrastructure Systems IVI, TBV Kühl-fahrzeuge, Sunset Energietechnik, Alexander Bürkle, as well as M&P Motion Control and Power Electronics.

In the project, suitable lighweight PV modules for subsequent on-roof mounting and full integration, as well as CAN-based components for power electronics are being developed. The cost-effective production of large PV-module quantities in a production line is conceptually developed. The modules and components are installed in electric commercial vehicles to conduct practical tests. First implementations of the concept are already under testing on the street-legal vehicles. An energy prediction model should estimate the irradiation potential and enable a cost analysis. The project's aim is to demonstrate energy savings of more than 5 % thanks to additional PV usage.

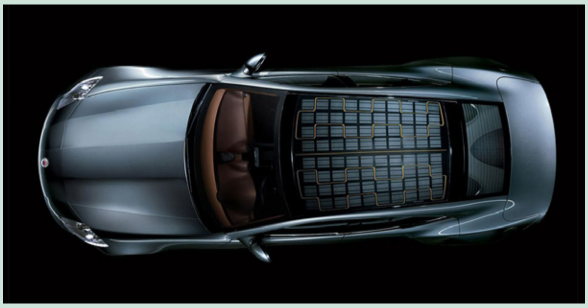
Connecting to the CAN in-vehicle network

The involved power electronics were adapted to the automotive requirements. Project partner M&P Motion Control and Power Electronics developed a DC power converter that collects and controls the solar power delivered by the PV modules. The converter is connected to the in-vehicle CAN network and manages the power exchange with the electric vehicle battery. Thus, the battery can be charged by the available solar power and the mileage provided by a battery-charge is increased. In refrigerated vans, the energy delivered by the PV solution can be also used for the electric Peltier cooling of the load.

PV modules and power electronics

The goal of the project is to develop particularly light and robust PV modules for subsequent on-roof mounting and ▷

Vehicle-integrated photovoltaics



The PV car roof from A2-solar on the hybrid Fisker Karma car has an aesthetically attractive design (Source: A2-solar)

Vehicle-integrated photovoltaics (VIPV) designates the mechanical, electrical, and design-technical integration of photovoltaic modules into vehicles. The PV modules blend seamlessly into the vehicle exterior and are connected to electric loads or the drive battery in electric vehicles by means of the CAN networks. In general, the concept is also suitable for vehicles using combustion engines. Simultaneously, the PV modules replace other components of the vehicle, e.g. the roof or the bonnet. VIPV increases the mileage of electrically powered vehicles and improves their CO_2 balance. The aesthetic expectations on integration into the vehicle design are especially high for cars. For utility vehicles (e.g. trucks and buses), particularly lightweight PV modules are needed to avoid restricting the load capacity. Further application areas include caravans and mobile homes, coaches, buses, trucks, delivery bicycles, trams, trains, ships, aircraft, and drones. According to the Fraunhofer Institute for Solar Energy Systems ISE, the technical potential of at least 55 GWp is given in Germany.

Application examples are given by electric cars, which are additionally equipped with PV modules. The applied PV modules usually meet additional aesthetic requirements, e.g. special designs and curvature are possible. The additional PV power can increase the mileage by several kilometers per day. In refrigerated vans, the PV electricity can be used for the electric Peltier cooling of the load. In this way, the same cooling power can be generated with less usage of the refrigeration unit and the diesel consumption can be reduced. The integration of PV modules onto the refrigerated compartment requires particularly lightweight modules which do not compromise the thermal insulation.

of full integration. The application-optimized modules should be able to be produced in the price category of standard modules or even cheaper (less than 0,4 €/W respectively less than 75 €/m²). For this purpose, innovative material combinations for lamination are evaluated and tested. The targeted full integration of the PV modules into the roof surface saves additional costs for framing and material. To test the roadworthiness of the modules, relevant tests according to the relevant IEC standards are adapted and conducted.

Figure 2: The refrigerated van from TBV uses integrated PV modules to support the refrigeration of the compartment (Source: TBV Kühlfahrzeuge)

Due to space and weight requirements, the power volume and weight of the modules' connection to the EVs' electrical system should be minimized. New semiconductor technologies are tested. The integrated power electronics packaging and thus also the thermal management of the components are adapted correspondingly. Additionally, the power electronics and PV modules are tested according to the automotive requirements. The developed energy management concept should be suitable for connection to non-electric commercial vehicles as well.

Energy forecast, evaluation, and test

An energy forecast model considers the on-board energy-consumers and forecasts the PV power yield based on different routes, ranges, charging times, and energy quantities. The measurement data is collected from sensors installed on vehicles in the real traffic. This allows to record the irradiation potential for different route types, occupancy rates, as well as different usage and shading scenarios (e.g. cities, country roads, or motorways). The recorded data evaluation allows a specific estimation of the energy potential.

The demonstration vehicles are equipped with PV modules to test connection concepts, cable management, and integration of power electronics. The savings in real operation are to be tested with different users, route profiles, and travelling times (e.g. daytime, early morning, evening). In addition, the handling, compatibility to involved in-vehicle processes, and the applicability in practice shall be demonstrated. ◀

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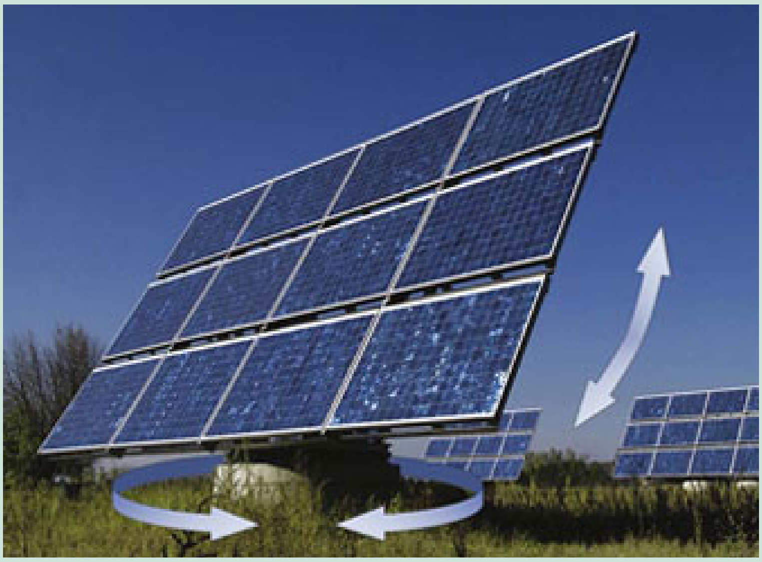
CANopen in photovoltaic systems

CAN is used in photovoltaic (PV) power generation for a long time e.g. in solar tracking systems, inverters, sensors, etc. As a standardized approach, the CiA 437 application profile for grid-based photovoltaic systems was developed by CAN in Automation (CiA) and companies from the photovoltaic industry. It defines the CANopen interfaces for PV systems including controllers, inverters, different sensors, solar panel trackers, etc. The profile specifies pre-defined communication objects and process data (current, voltage, power, etc.) to be exchanged in a standardized way. When implementing the profile, device manufacturers may supply diverse applications using the same standardized electronic CANopen interface implementation and simply adapting the required functionality. A system designer may combine CANopen devices from different manufacturers implementing the required profile-compliant functionality. The according spare parts can be also made available from different sources. For development, analysis, and maintenance of the devices, off-the-shelf CANopen tools may be used.



In PV systems solar radiation is directly converted to electrical current with the help of solar cells based on semiconductor technology. The CiA 437 profile specifies standardized communication interfaces to control the PV power generation solutions. (Source: Posital-Fraba)

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