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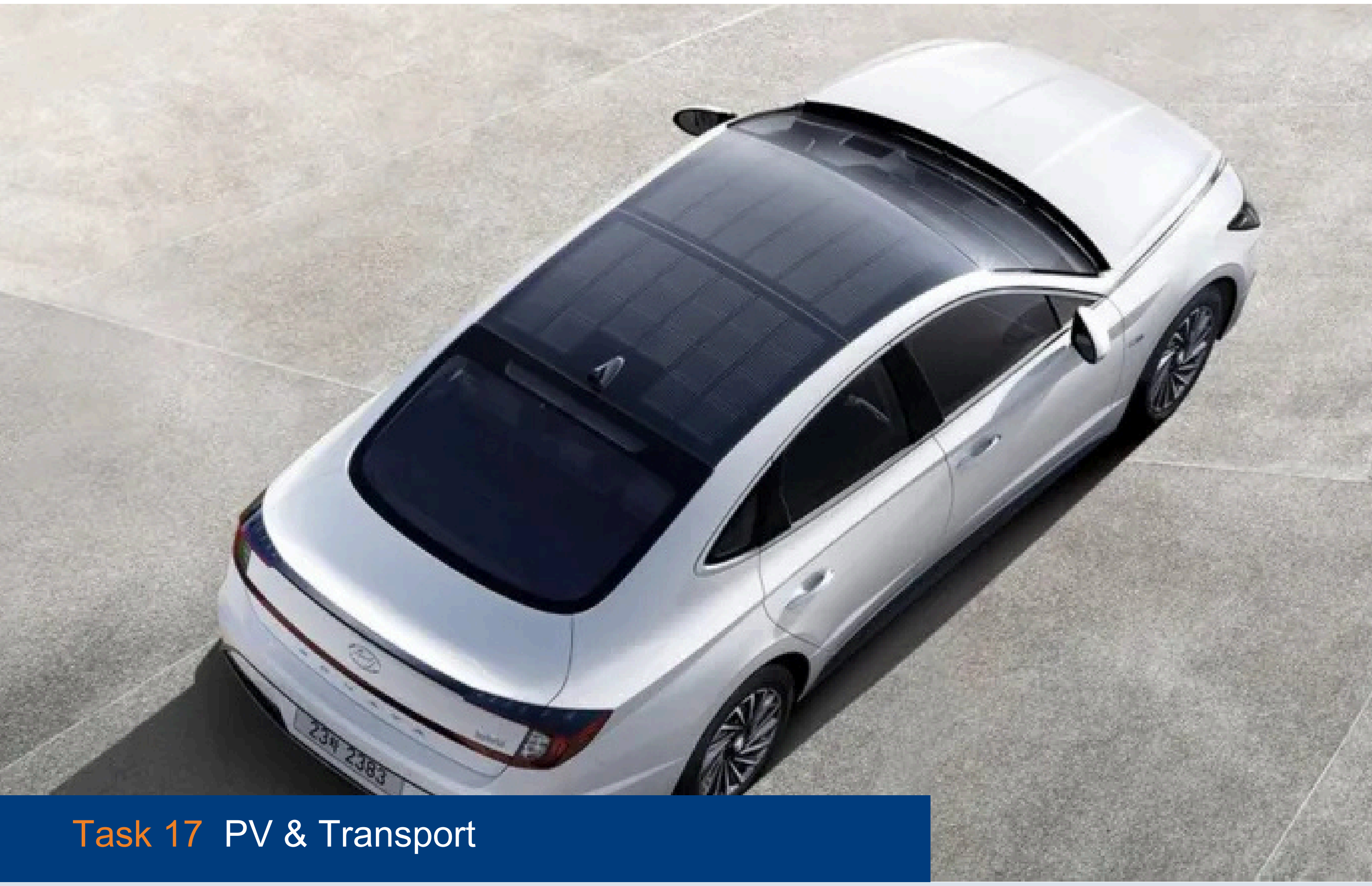

Task 17 PV & Transport

PVPS

FACT SHEET

Vehicle-Integrated PV

Status and Perspectives

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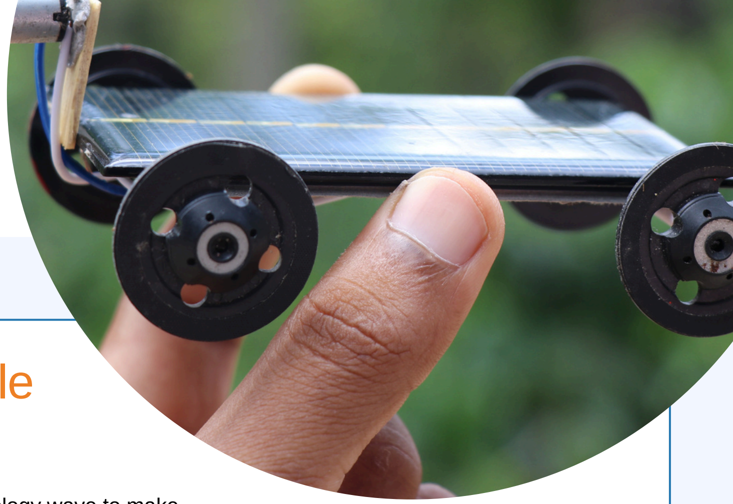


VIPV: A promise for more sustainable electric transport

Vehicle-Integrated Photovoltaics (VIPV) is well positioned to be the next technology wave to make transport more sustainable.

The transport sector is getting cleaner as EVs boast a global market share of currently over 20%[1] and are on pace to rapidly replace vehicles with Internal Combustion Engines (ICE cars).

Task 17 experts visiting Lightyear HQ in Venray, The Netherlands, October 2024.

This leads to a drop in emissions as fossil fuel is being replaced by electricity. Having a more efficient powertrain, Electric Vehicles (EVs) also consume only about a quarter of the energy/km compared to ICE cars.

VIPV promises to make transport even more sustainable, as its onboard PV can generate a significant part of its electricity needs, with **low CO_2 emissions**. There are also practical benefits, as a VIPV EV needs to be **recharged less often**. VIPV is[2] complementary to where local PV is used to provide electricity to charging stations.

VIPV as a **fuel saver on trucks and buses** already today offers an attractive return on investment to fleet owners. VIPV on boats, trains, and aircraft also has great potential but is not addressed in this factsheet.

Advantages of VIPV

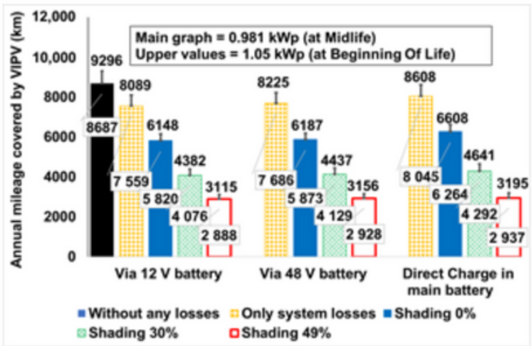
Cost and Independence: VIPV on normal EVs will give drivers a greater autonomy, will have them need to charge less often and will reduce the external energy consumption of the vehicles. For vehicles developed “on a clean sheet” to optimally integrate VIPV, these benefits will bigger, and VIPV will also be cost effective and have a reduced environmental impact. VIPV can reduce the investments needed for (public) charging infrastructure and for grid capacity expansion.

High Efficiency: Thanks to a more efficient vehicle design, solar EVs may consume only around 11 kWh/100 km, while onboard electricity generation may decrease this number down to some “net” 9 kWh/100 km.[3]
For reference, 14 kWh/100 km is considered quite efficient today for a mass-market EV (https://ev-database.org/). For the transport sector, VIPV represents a huge untapped efficiency potential.

CO_2 Emissions Reduction: VIPV offers low carbon electricity in most markets, while countries with low grid emissions may see minimal net benefits. For passenger cars in Japan, VIPV can reduce emissions by up to 220 kg CO_2-eq/year.[4]

Increased autonomy: Depending on location and technology, VIPV on optimized solar passenger cars, like the Lightyear 0, could achieve around 4 500 solar km/year (depending on the architecture, with shading losses estimated at 30%).

Yearly distance covered by VIPV in Paris with Lightyear 0 main characteristics: 0.981 kWp (midlife)/1.05 kWp (best of life) solar roof, 10.9 kWh/100 km consumption, and 60 kWh battery.



Source: Presentation by CEA-INES at the Task 17 Workshop in Lyon, April 9th, 2024

[1] IEA (2024), World Energy Outlook 2024, p. 159.

[2] Life Cycle Analysis shows that electricity produced by VIPV does come with CO2 emissions, although lower than grid emissions for most countries.

[3] Lightyear 0 case (see below): Based on 25 000 km/year, of which ~4 500 (18%) are solar, the 10.9 kWh/100km consumption could, thanks to VIPV, come down to (100/118)*10.9 = 0.92 kWh/100 km.

[4] Task 17 PV and Transport – State-of-the-Art and Expected Benefits of PV-Powered Vehicles, page 7.

VIPV's value proposition

VIPV on trucks and light commercial vehicles: solar panels on truck cabins, trailers and light commercial vehicles efficiently power auxiliaries and electric systems (e.g. AC, fridges, freight lift systems). As truck generators are particularly inefficient, fuel cost savings allow for a payback time of 3-4 years. It is estimated that already thousands of VIPV trucks are on the road every day.

VIPV on buses: Electric buses equipped with PV could achieve 3% solar-powered annual mileage in Europe (relatively less surface available compared to trucks).

Progress on technical challenges

Solutions have been proposed for **optimal electricity generation,** taking into account shading and variation in PV orientation.

Optimizing Power Management: by designing efficient power electronics and efficient power systems and battery architectures to complement the "blank sheet" specific VIPV approach.

VIPV technology is ready for **pilot line production**. The next step is to **increase the number of road tests with manufacturers and drivers** to start gaining the experience necessary for mass-market uptake.

Manufacturing of a Lightyear VIPV panel in the Netherlands.

Road to market uptake

Reducing costs: VIPV innovators are paving the way to mass adoption by reducing manufacturing complexity and costs from 2–5 USD/Wp to under 1 USD/Wp for passenger vehicles. At such price levels, **VIPV electricity costs may be at the same level as electricity from the grid**: A 600 Wp system may generate 200 kWh/yr of usable electricity. For a lifespan of 15 years, not including interest costs, the costs would come down to 0.2 USD/kWh.

Market Adoption: It is worth noting that VIPV performances are closely linked to the type of vehicle, region, and use case. Hence, manufacturers and drivers are invited to **study if the conditions are met for VIPV to bring value**.

If regulators would impose stricter efficiency criteria for vehicles, VIPV's contribution to the vehicle's electricity needs will be relatively more important and could help to **achieve a lower "net" kWh/100 km consumption from a system's perspective**.

Technical Insights

Efficiency Goals: Current VIPV systems operate at efficiencies of 18–25%. Perovskite/tandem and thin-film technologies may exceed 30% by 2030.

Current Trends: Crystalline silicon (c-Si) dominates the market for VIPV technology today, but tandem and perovskite technologies are expected to grow significantly by 2030, driven by their higher efficiencies and small carbon footprint.

System Aesthetics: BC (back-contact) technology is preferred for its minimal visible metallization and aesthetic appeal.

Preferred Cover Materials: Glass for the roof for durability and efficiency. Polymer for doors, bonnets, and boots to reduce weight, to enable curved designs, and for pedestrian safety.

Weight Constraints: Flexible PV panels make it possible to not add too much weight to a vehicle.

Intermediate Battery Storage: Using a **low-voltage battery** for storing solar electricity when parked combined with **periodical transfer** to the HV battery will reduce system base losses.

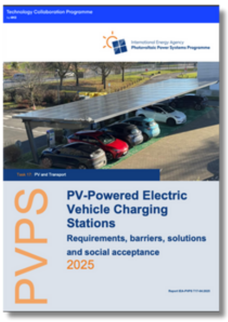
About IEA PVPS Task 17

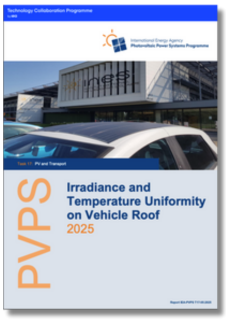
The 10 countries conducting research in **Task 17** aim to **clarify the potential** of the utilization of PV in transport and to propose how to proceed towards realizing the concepts.

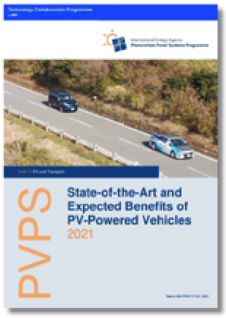
Task 17 is complementary to other global initiatives on VIPV:

- **PVInMotion** organizes global **annual scientific congresses** on solar mobility research.
- **ASOM**, the Alliance for Solar Mobility, is a platform seeking to establish and foster the **solar mobility industry**.
- VIPV is also recognized as a topic in the **Horizon Europe Work Programme 2025 Cluster 5** and in the EU Solar Energy Strategy from 2022.

If you are interested in more insights and detailed data, explore the latest publications from Task 17:







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