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PV-Powered Electric Vehicle Charging Stations

Preliminary Requirements and Feasibility Conditions

Manuela Sechilariu (IEA PVPS Task17 – Task co-Manager & Subtask 2 Leader)

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Presentation plan

- **Trends in PV-powered charging stations development**
- **Requirements, barriers and solutions for PV-powered charging stations**
- **Possible new services associated with the PV-powered charging stations (V2G, V2H)**
- **Societal impact and social acceptance of PV-powered infrastructure for EV charging and new services**

Trends in PV-powered charging stations development

The PV-powered charging stations (PVCS) development is based either on a PV plant or on a microgrid*, both cases grid-connected or off-grid.

**Microgrid: PV plant, storage, loads, power management*

Although not many PV installations are able to fully meet the energy needs of EVs, and the charging of EVs is dependent on the public grid, the number of projects are rapidly increasing.

Infrastructures designed mainly for charging EVs				
			Infrastructure	Comments
On-grid	With storage	Car parking shade	MDT-TEX smart PV shelter (Germany, 2018)	✓ Possibility of shifting the charging without constraining EV users ✓ Reduction of the load on the grid during peak hours x Power grid dependency: the storage systems are charged from the power grid x Installations remain insufficient for full charging
			SECAR E-Port (Austria, 2018)	
			V3 Superchargers (Las Vegas, United States, 2019)	
			Car parking shade project (Aix-Marseille-Provence, France, 2020)	
Off-grid	With storage	Car parking shade	Electric bus charging (Queensland, Australia, 2020)	✓ Grid independent and 100% sustainable x Low stationary storage capacity compared to the EV battery capacity x Installations remain insufficient for full charging
			EV ARC™, Beam Global, San Diego, United States, 2020)	
	Without storage	Car parking shade	SEVO Sunstation (United States, 2019)	✓ 100% renewable energy ✓ No utility bill ✓ Real-time energy use analytics
			Fastned	✓ 100% renewable energy ✓ Fast charger: Up to 300 km of autonomy in 15 minutes

Trends in PV-powered charging stations development

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**Microgrid: PV plant, storage, loads, power management*

Although not many PV installations are able to fully meet the energy needs of EVs, and the charging of EVs is dependent on the public grid, the number of projects are rapidly increasing.

Infrastructures designed mainly for supplying buildings, but EV charging may be developed				
			Infrastructure	Comments
On-grid	With storage	Car parking shade	Self-consumption PV, GÉMO store (Trignac, France, 2019)	✓ Reduction of the electricity bill ✓ Self-consumption ✓ Electricity can be sold where PV production is high x Despite the size, low number of charging terminals
		Building roof	PV self-consumption project (Madagascar, 2018)	
	Without storage	Car parking shade	PV power plant (Nouméa-La Tontouta International Airport, New Caledonia, 2021)	✓ Redistribution of energy to power grid ✓ Self-consumption x No smart consumption to optimize energy use x Despite the size, low number of charging terminals
		Building roof	PV rooftop plant for a Robinson shopping mall (Thailand, 2018)	
Off-grid	Without storage	Car parking shade	PV power plant (Saint Aignan de Grandlieu, France, 2020)	

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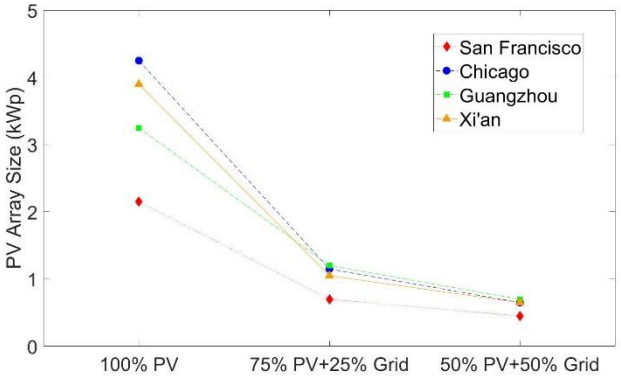
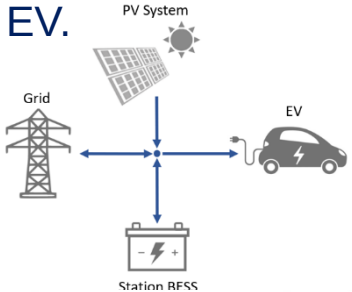
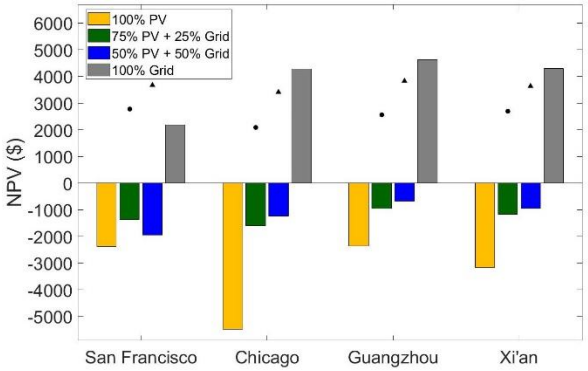
Requirements, barriers, and solutions for PVCS

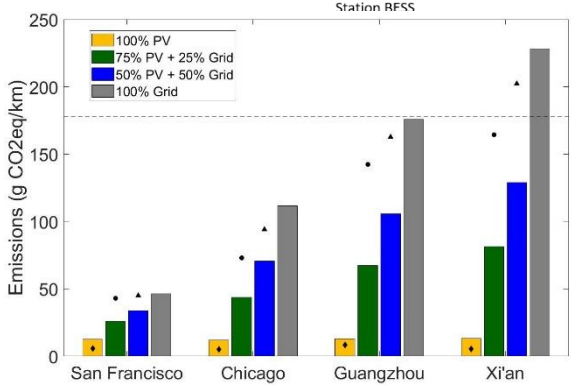
Feasibility assessment of PVCS microgrid based using a simulation model, which estimates the system's energy balance, yearly energy costs, and cumulative CO2 emissions in four scenarios
For a microgrid of optimized size, the use of PV systems in all four analysed locations can be a feasible EV charging solution from a technical, financial and environmental perspective in comparison to a gasoline-fueled vehicle and in comparison to a grid-charged EV.



PVCS based on microgrid







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Requirements, barriers, and solutions for PVCS

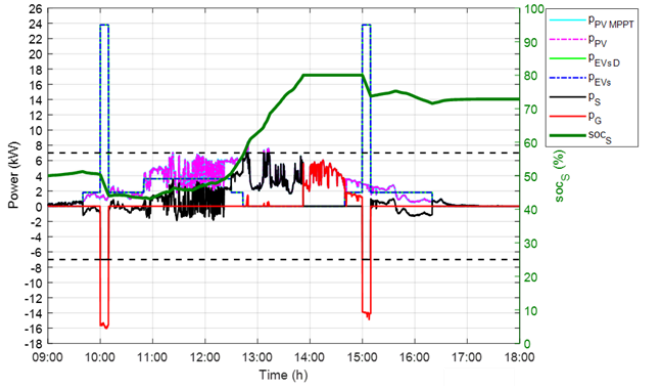
Preliminary requirements and feasibility conditions for increasing PV benefits for PVCS

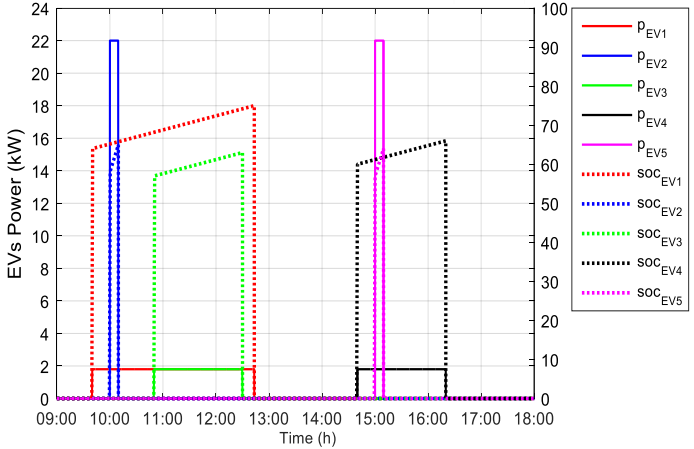
Slow charging mode

- Charging power of up to 7 kW
- Based on PV and stationary storage energy
- Stationary storage charged only by PV
- Stationary storage of optimized size
- EV battery filling up to 6 kWh on average
- User acceptance for long, slow charging

Fast charging mode

- Charging power from 7 kW up to 22 kW
- Based on public grid energy
- Stationary storage power limited at 7 kW
- User acceptance of higher environemental charging costs





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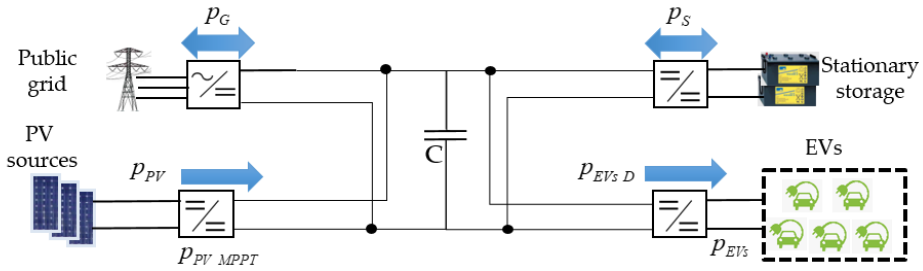
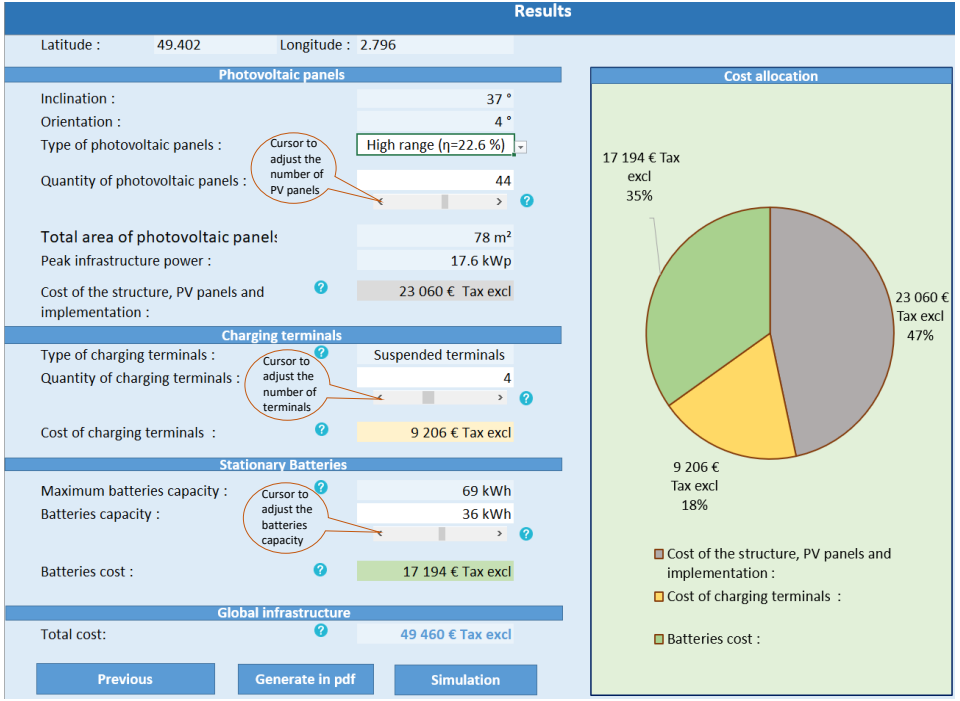


Requirements, barriers, and solutions for PVCS

Assessment of PV benefits for PVCS: 3-step methodology based on a technical and economic tool for use by local stakeholders to help them determine the preliminary requirements and feasibility conditions for PVCS with a view to optimizing PV benefits.

- PV-powered charging stations including stationary storage and grid connection
- Decision-making model including the PV benefits assessment information
- Technical and economic tool for local stakeholders, allowing to identify the preliminary requirements and feasibility conditions for PV-powered EV charging stations leading to an optimization of PV benefits



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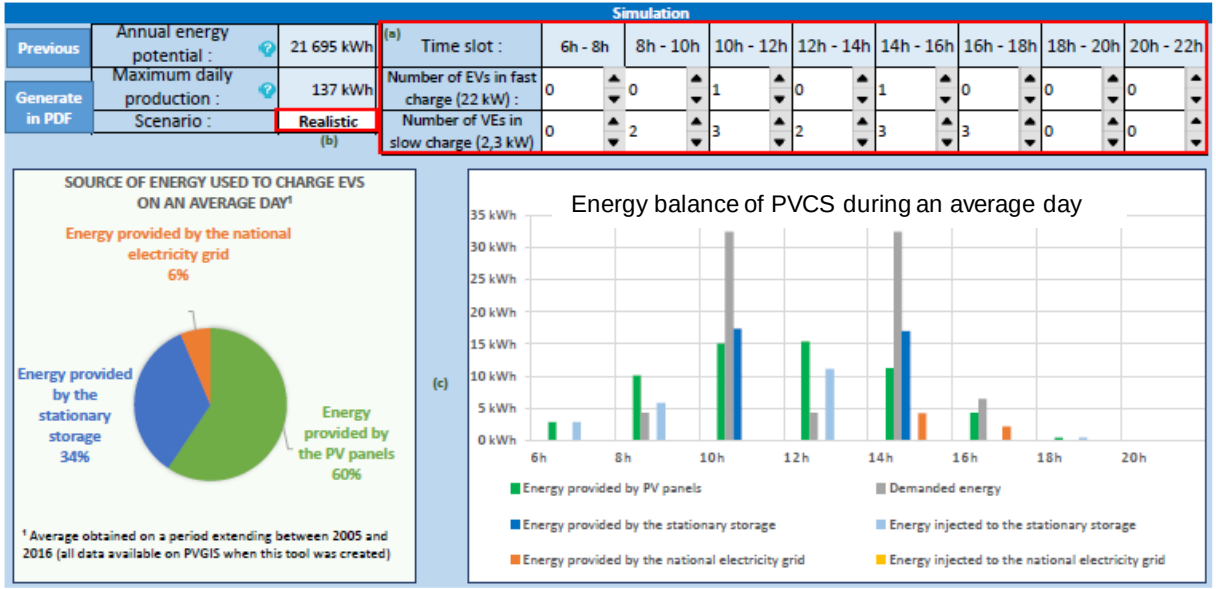
Requirements, barriers, and solutions for PVCS

Assessment of PV benefits for PVCS: 3-step methodology based on a technical and economic tool for use by local stakeholders to help them determine the preliminary requirements and feasibility conditions for PVCS with a view to optimizing PV benefits.

The design methodology included the use of an algorithm, resulting, phase by phase, in the constitution of the techno-economic tool whith an easy-to-use interface.



Next step: integrate CO_2 emissions and the total cost of energy, (over the lifespan)

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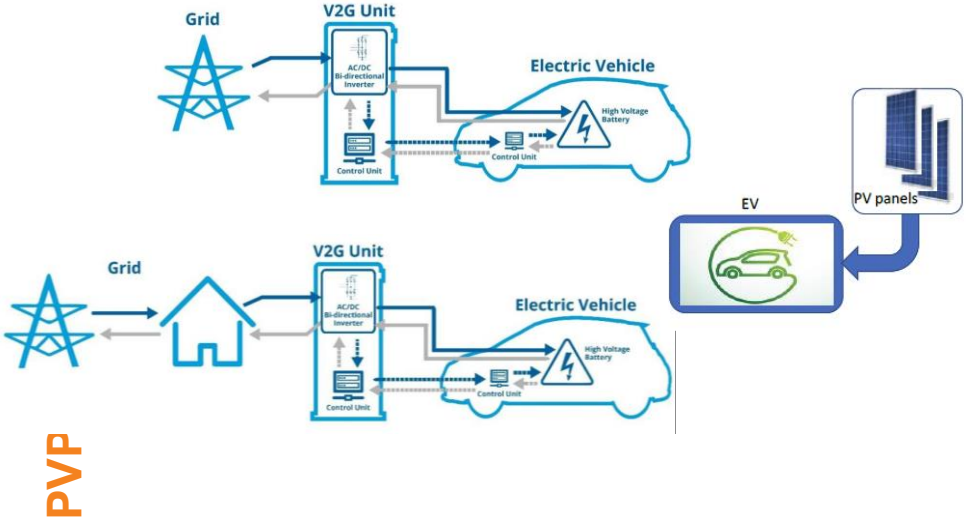
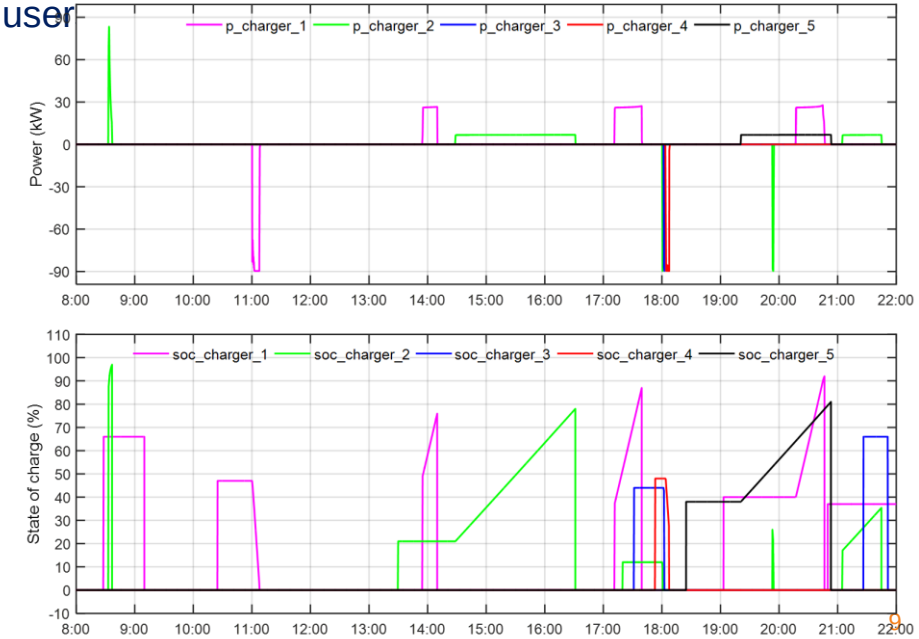
Trends in V2G / V2H services and impact of PVCS

PVCS would provide an environmental benefit in the operation of V2G / V2H services, although V2G / V2H systems are not yet ready for industrial-scale use, as a number of difficulties remaining to be overcome and requiring solutions.

A successful implementation of V2G / V2H will depend on the growth of the EV fleet.

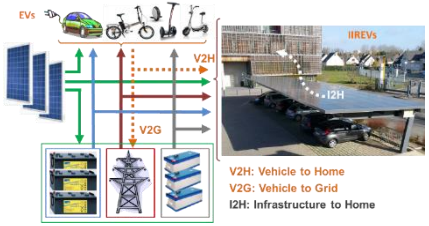
Power management strategy with integrated V2G reduces the peak pressure on the public grid while meeting the needs of user

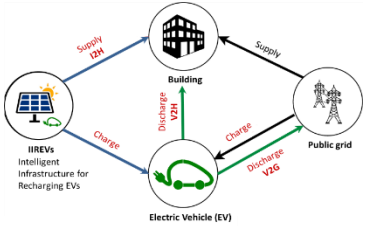


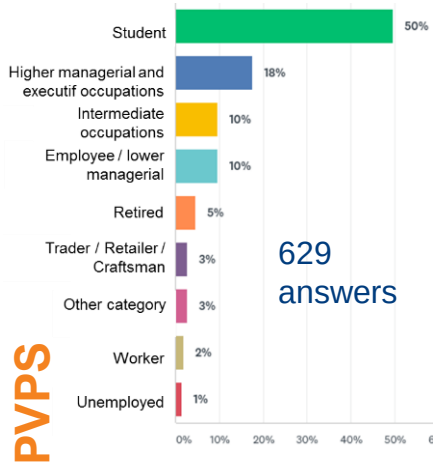


Societal impact and acceptance of PVCS and V2X

Case study in France based on a survey on the social acceptance of PVCS and new services: the results indicate that PVCS is socially acceptable to a large majority, although some aspects such as location, business model, and design require careful consideration.







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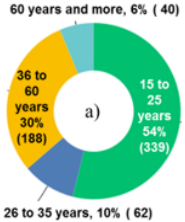
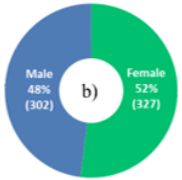
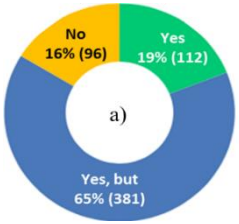
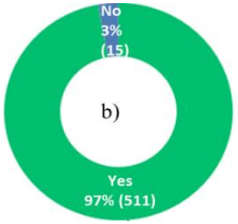


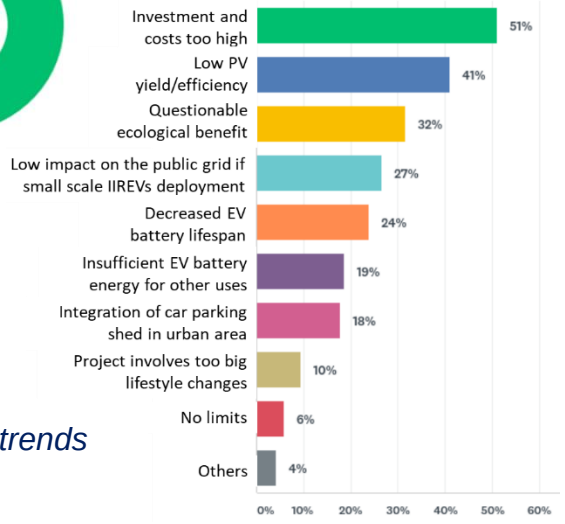


General trend to the discharge acceptance (a);
General trend to the recharge of EVs by PV panels (b)





PVCS project limits general trends



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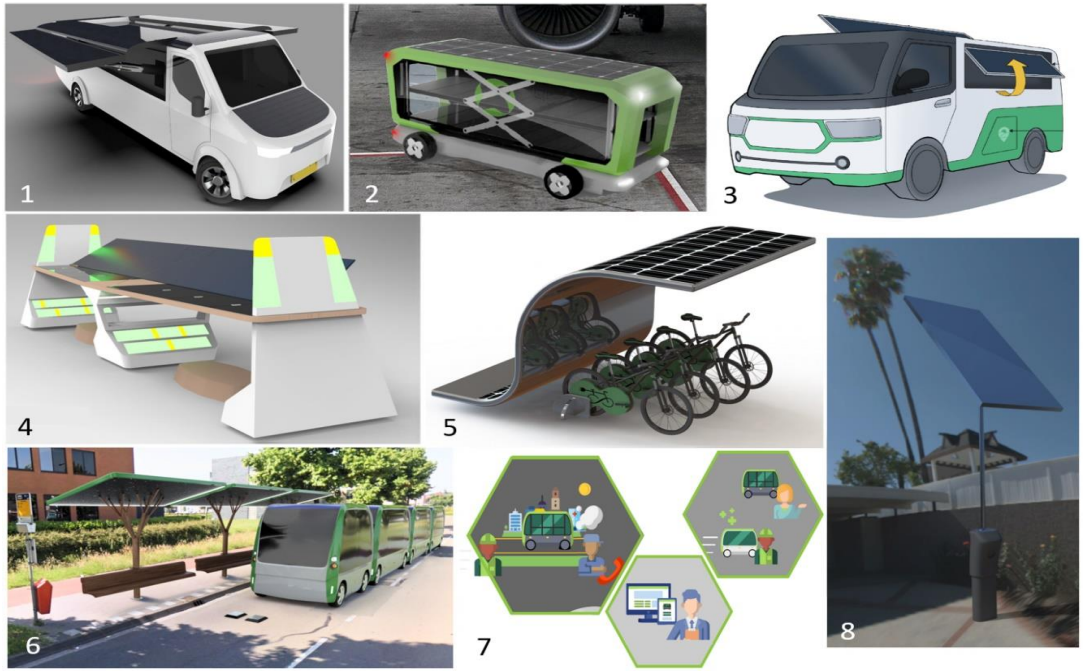
Societal impact and acceptance of PVCS and V2X

Design of new innovative conceptual PV applications for electric mobility systems
PVCS design is a relevant topic for user acceptance of PVCS as well as for communicating to users their function and their focus on sustainability,
However, space constraints regarding PV cells, modules or arrays were hardly observed.



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The way forward

- PV-powered charging stations (PVCS) may offer significant benefits to drivers and an important contribution to the energy transition
  - Their massive implementation will require technical and sizing optimisation of the system, including stationary storage and grid connection, but also change of the vehicle use and driver behavior
  - Long parking time for EVs, short driving distance (around 45 km), and slow charging mode are the most realistic requirements and feasibility conditions for increasing PV benefits for PVCS
  - EV charge controlling allowing intelligent communication between the operators and the end-users, based on powerful algorithms, remains necessary to increase PV benefits for EVs charging.
- PVCS have the potential to further decrease the CO2 emissions impact of electrified transport
  - Techno-economic and environmental approaches including a life cycle analyze will be important for assessing the role and benefits of PV electricity for EV charging infrastructures.
- V2G / V2H services
  - Are not yet ready for industrial-scale use
  - Including a well-designed power management strategy, would provide an environmental benefit
- Social acceptance of PVCS and V2G / V2H services → to identify factors that potential users perceive as benefits or barriers
  - Global acceptance to a large majority
  - Some aspects (location, business model, and design) require careful consideration
  - PVCS design is a relevant topic for user acceptance

Thank you

Manuela Sechilariu: manuela.sechilariu@utc.fr