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pura vida | renewable energy

Faculty of Geosciences
Copernicus Institute of Sustainable Development
Connecting knowledge for sustainability

Optimal use of photovoltaic solar energy for electric driving

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Pura Vida Renewable Energy has developed the concept 'Zonnig rijden' ("Sunny driving"), a solar carport including an electric vehicle EV of choice. However, photovoltaic (PV) solar power supply and electricity demand of a vehicle are not necessarily matched in time. PV is typically high around noon, while EVs are charged mostly in the morning and early evening. We perform simulation studies on the imbalance of EV demand and PV supply. We look into what type of driving behaviour is best suited for the EV/PV combination and how much the balance can be improved by energy storage and smart charging.

Methodology

"Zonnig rijden"

- Includes 15 solar panels, good for 3700 kWh per year, a charging station and an EV of choice

Scenarios EV use

- We construct five scenarios for EV use, based on possible business cases for Pura Vida

Reducing imbalance

- We introduce energy storage and smart charging to reduce imbalance demand and supply

Simulations

- We perform year simulations with 15 minutes time-steps for each scenario

Evaluation

- We evaluate for **PV self-consumption**, the relative amount of PV power consumed by the EV

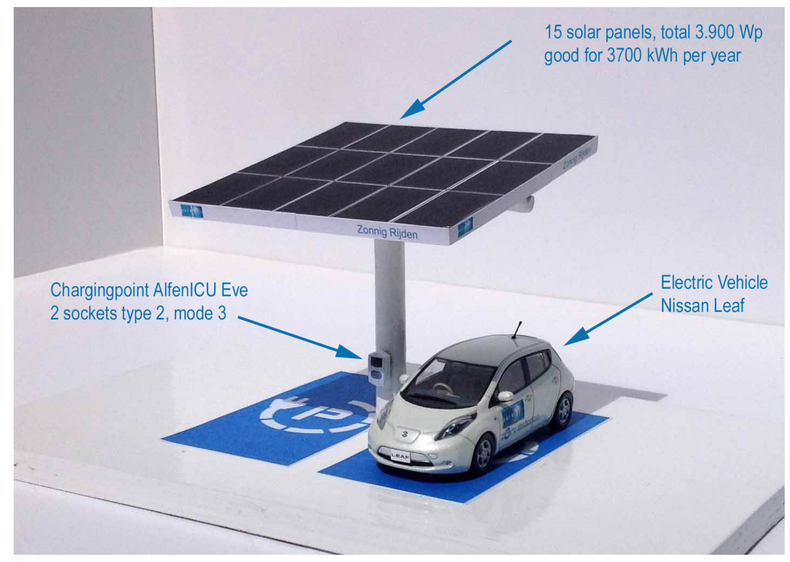

Figure 1
Overview of solar carport "Zonnig rijden"

Scenarios for types of EV use

1: Business car

- 1-3 work related trips per day (10-100 km)

2: Lease car

- Commuting (10-50 km), longer private trip (20-100 km) during weekend

3: Rental car

- 1-3 trips (10-50 km) per day

4: Family car

- 30% use, short trips (10-30 km) during weekdays and longer trip (20-100 km) during weekend

5: Second car

- Two short trips (10 km) per day for taking children to school and groceries, etc. Longer trip (40 km) during weekend

EV type

- We simulate all scenarios with two different EVs, a Tesla Model S and a Nissan Leaf

	Tesla Model S	Nissan Leaf
Battery capacity (kWh)	85	24
Consumption (kWh/km)	0.233	0.211
Range (km)	340	150
Charging power (kW)	22	6.6

Reducing the imbalance

No control (reference)

- The EV charges at maximum capacity until it is full

Battery

- A battery of 10 kWh is used for PV power storage

Smart charging

- The EV charges only when PV power is available
- Unless there is insufficient PV power required for making a trip, then energy is drawn from the grid
- For each scenario a minimum range is defined. The energy level of the EV must be sufficient for this range at all times

Scenario	Minimum range (km)
1: Business car	50
2: Lease car	10-50
3: Rental car	30
4: Family car	30
5: Second car	10

Results

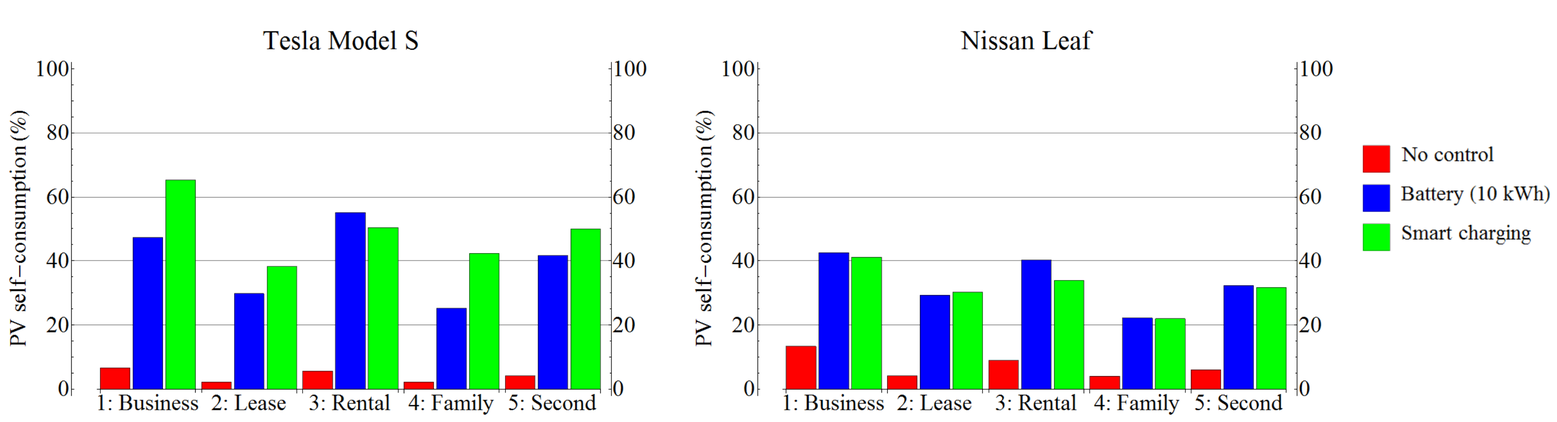

Figure 2a
Simulation results for Tesla Model S

Figure 2b
Simulation results for Nissan Leaf

- Simulation results are presented in Figure 2
- PV self-consumption is very low in all scenarios with no control strategy
- However, with energy storage and smart charging large improvements are possible
- The Nissan Leaf performs better in case of no control, the Tesla Model S performs better with storage and smart charging
- Scenario 1: business car has the highest self-consumption of PV-power and scenario 2: lease car and 4: family car the lowest

Conclusions

- **The imbalance between EV demand and PV supply is very high for various driving behaviours**
- **Energy storage and smart charging can greatly reduce the imbalance**
- **A Tesla Model S (or similar) works good in combination with storage and smart charging**
- **Scenario 1: Business car is the most interesting for "Zonnig rijden"**
- **Making trips during the day allows more PV to be used for EV charging as compared to being stationed at the solar carport**

Acknowledgements
We would like to thank LomboXnet for providing the data for the PV power profiles