2nd E-Mobility Power System Integration Symposium

15 October 2018; Stockholm, Sweden

# Increased Utilization of residential PV Storage Systems through locally charged Battery Electric Vehicles

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# Motivation of the study

- ‘First mover’ charge their Battery Electric Vehicles (BEVs) at home
  - weak charging infrastructure
  - wish to use of own-generated renewable power
  - reduced cost of charging

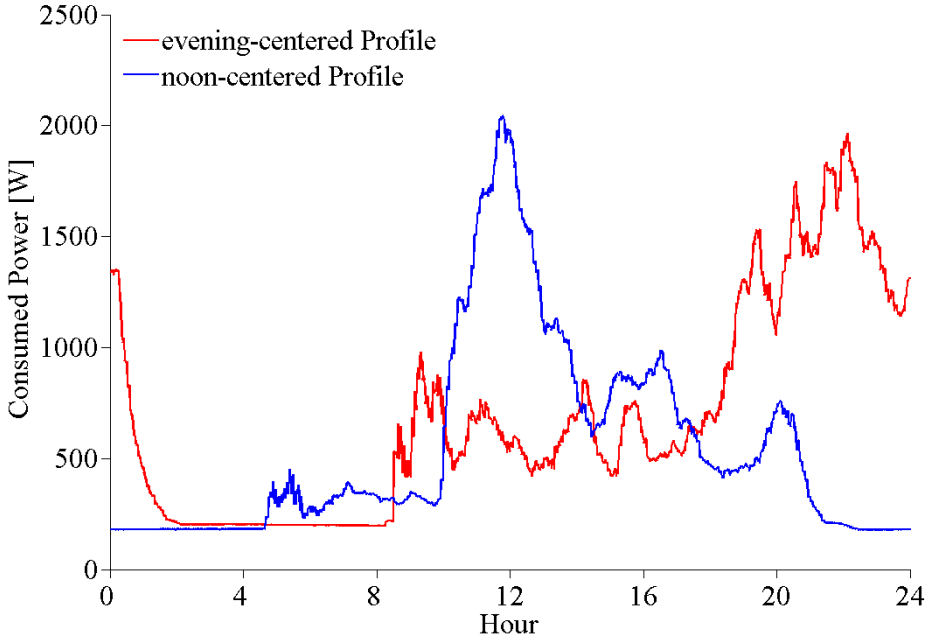
- How much increase of the utilization of a residential PV storage system is caused by home charging?

- How much own consumption can be achieved?

# Study design

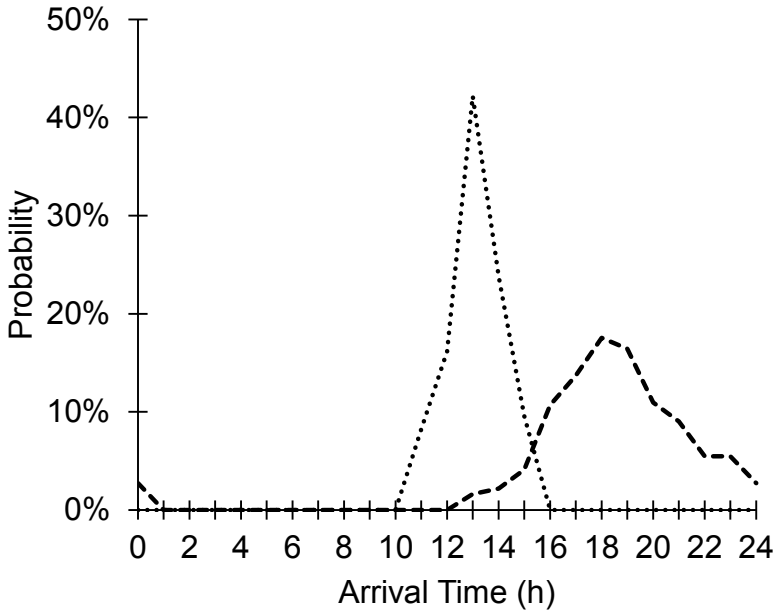
- Study of charging a BEV with local produced solar power
- Parameters
  - 2 kinds of load profiles of the household
  - 2 PV system sizes
  - Energy content of the battery from 0 to 14 kWh
  - Daily driving distance according to 2 scenarios
  - 4 charging patterns
- Results:
  - Equivalent full battery cycles
  - own-consumed energy
- MATLAB simulation for one year with 15 min steps

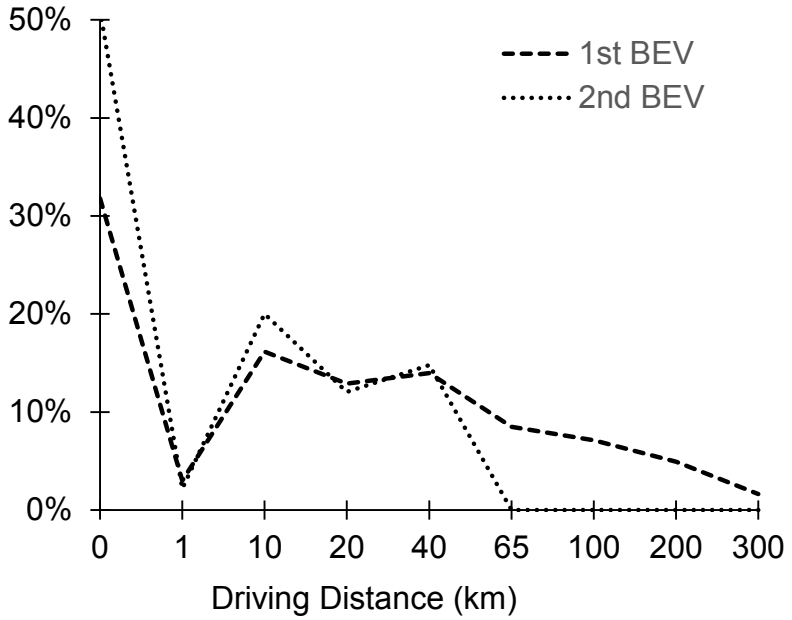
# Household load profiles




- Two extreme household load profiles, scaled to a energy demand of 4,000 kWh/a

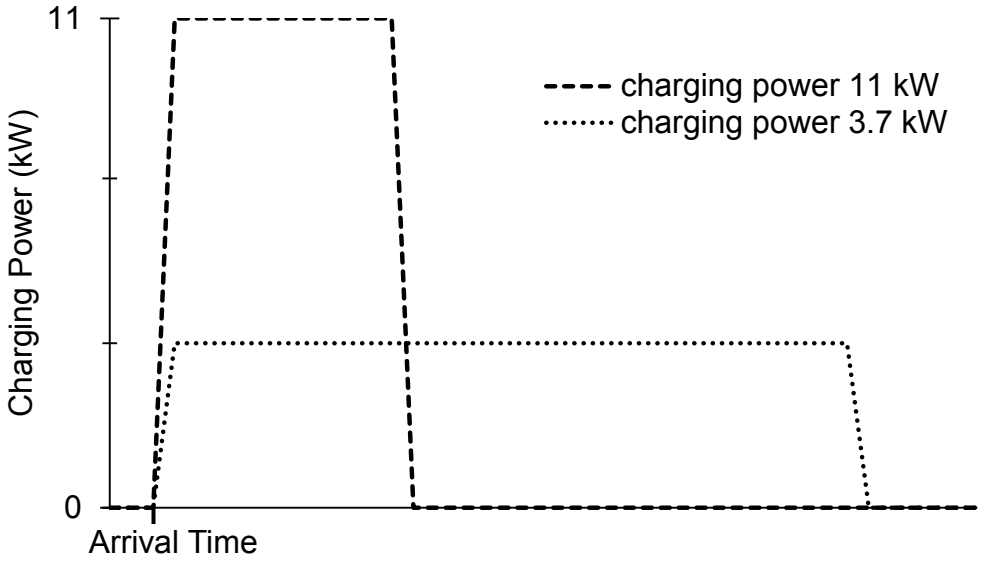
# BEV Probabilities of arrival times and driving distances



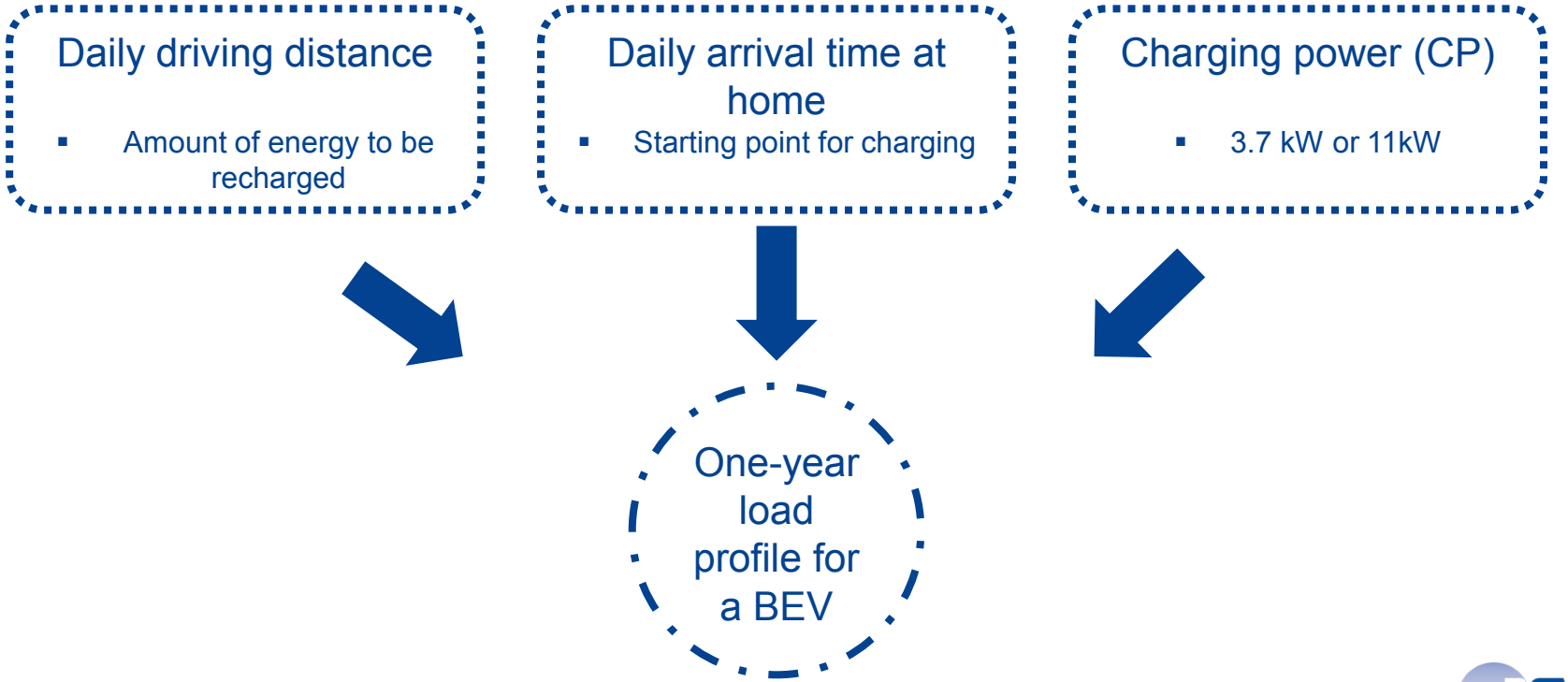

- Daily vehicle use and arrival time is picked using the Monte Carlo Method

# Simplified charging process




Charging duration depending on driving distance

# Modelling of a BEV one-year load profile



# Solar Power Production and Use

- South facing PV system located in Southern Germany with 1,000 kWh/$kW_p$ (data from 2011)
- PV System sizes of 4 and 10 kWp
- Batteries with 0 to 14 kWh

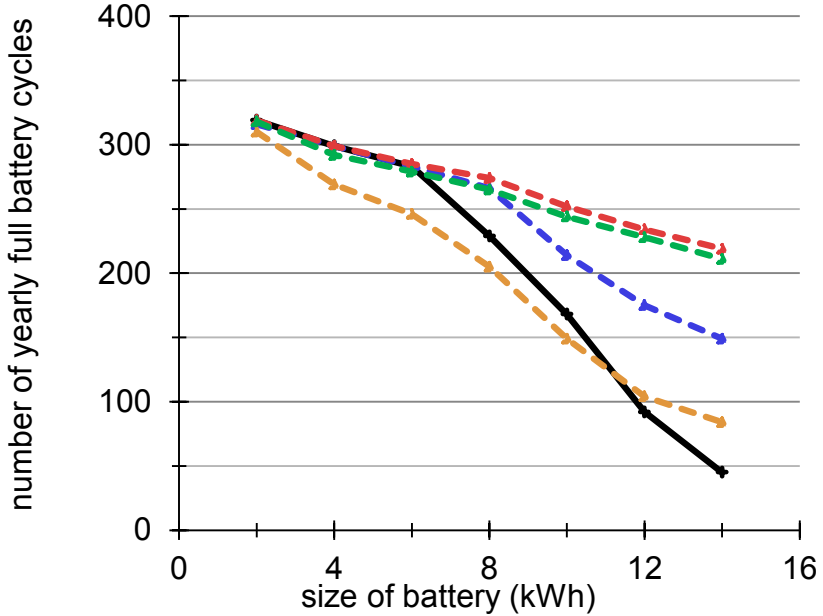
# Simulated Scenarios

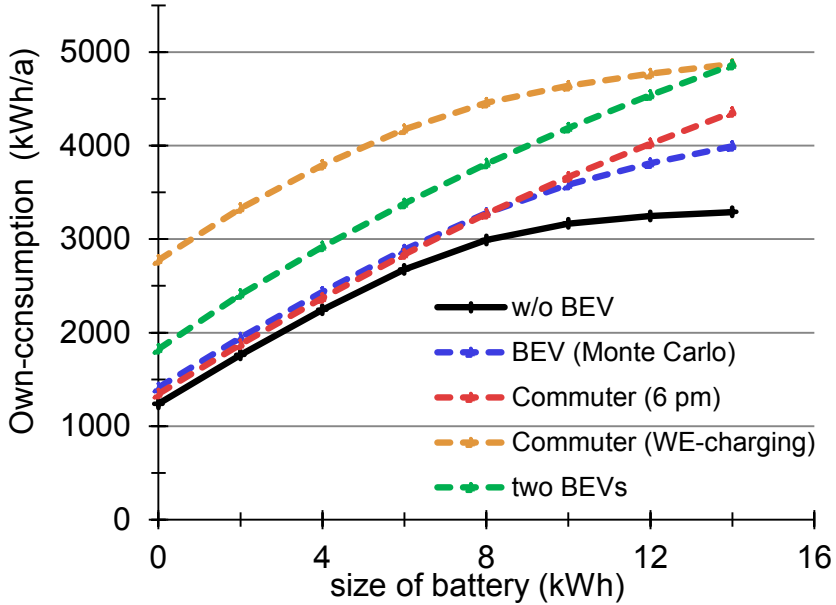
| | HH w/o BEV | BEV (Monte Carlo) | Commuter 6 pm | WE-charging Commuter | Two BEVs* |
|---|---|---|---|---|---|
| **Electrical demand** | 4,000 kWh/a | 4,000 kWh/a + 2,700 kWh/a | 4,000 kWh/a + 3,450 kWh/a | 4,000 kWh/a + 3,150 kWh/a | 4,000 kWh/a + 4,150 kWh/a |
| **BEVs** | - | 1 | 1 | 1 | 2 |
| **Daily Driving Distance** | - | 0 km - 300 km<br><br>(≙ 13,500 km/a) | workday: 50 km<br>weekend: 0 km - 300 km<br>(≙ 17,250 km/a) | workday: 50 km<br>weekend: 25km + 25km<br>(≙ 15,750 km/a) | workday: 0 km - 40 km**<br><br>(≙ 20,750 km/a) |
| **Arrival Time** | - | 12 a.m. - 12 p.m. | workday: 6 p.m.<br>weekend: 12 a.m. - 12 p.m. | weekend: 9 a.m. and 7 p.m. | workday: 11 a.m. – 3 p.m.**<br>weekend: - ** |
| **Charging Pattern** | - | daily after arrival | daily after arrival | on the weekend | daily after arrival |

* 1st BEV like “Commuter 6 pm” ** Applies to the 2nd BEV

# Simulation of a household

## evening centered, 10 kWp PV-System & 3.7 kW CP

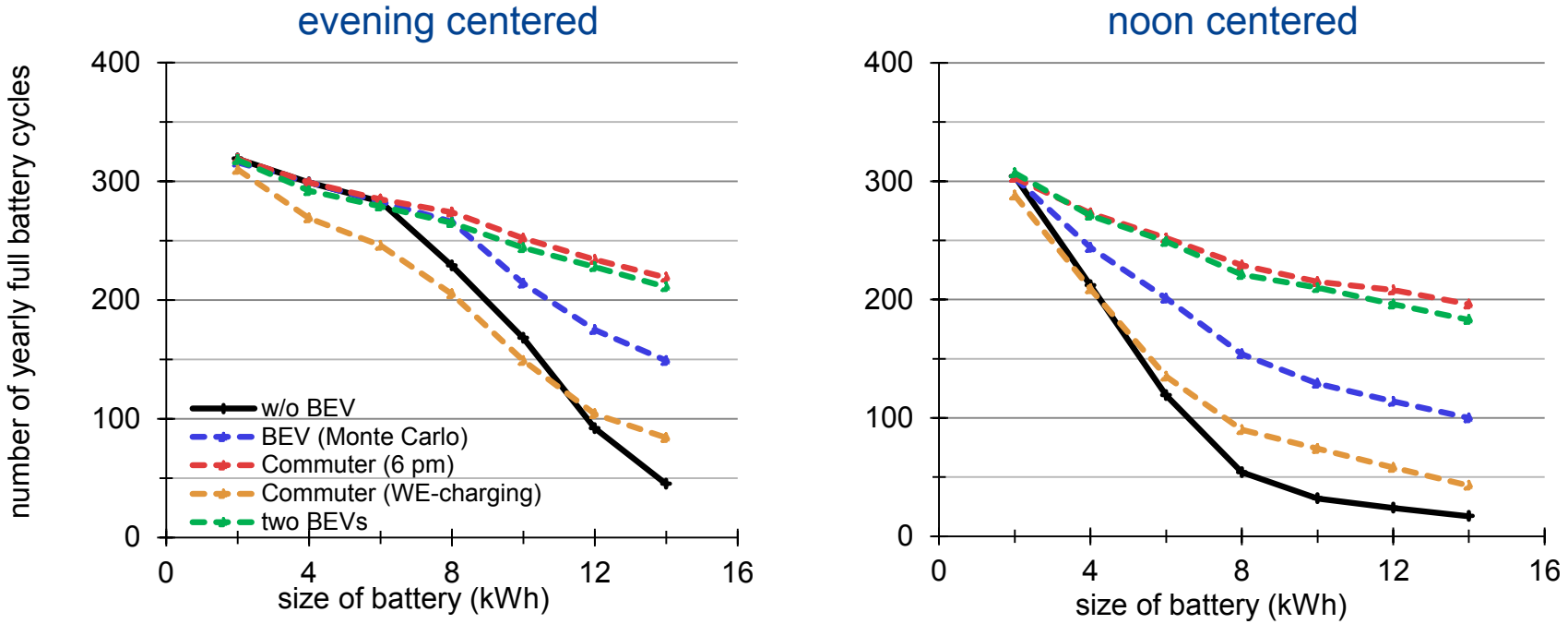



→ The utilization of large batteries is improved generally by the demand of the BEV but “sun-shine hour” charging decrease utilization

# Comparison of results related to household profiles

## 10 kWp PV-System & 3.7 kW CP

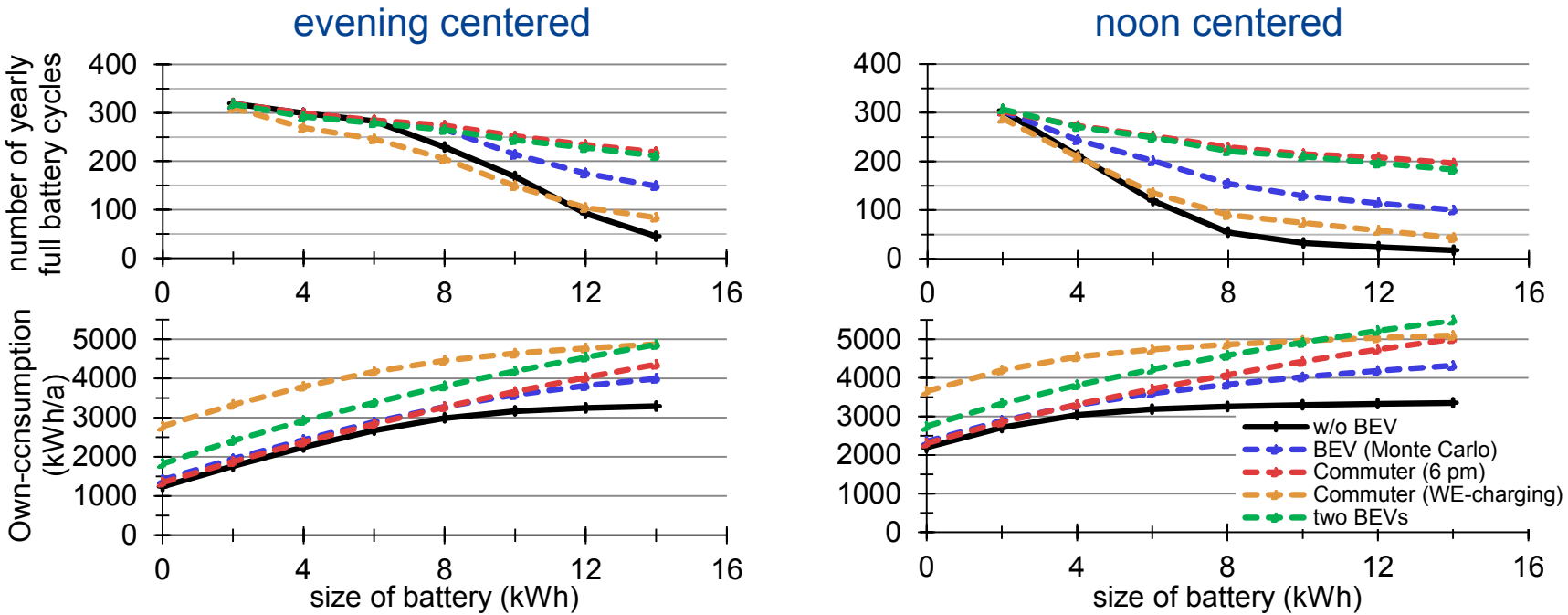



→ Higher utilization of the battery system at the evening centered profile

→ Increase already for small batteries at the noon centered profile

# Comparison of results related to household profiles

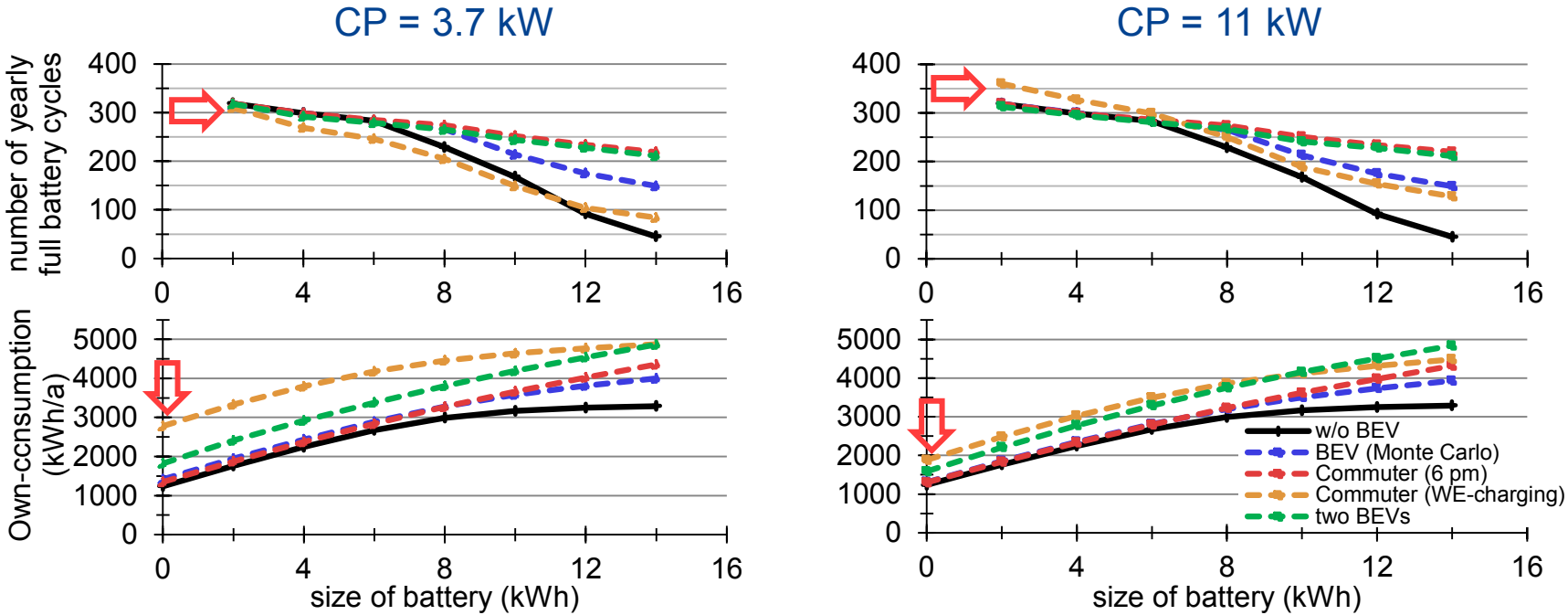
## 10 kWp PV-System & 3.7 kW CP




→ Also increase of utilization at noon centered profiles together with increasing own-consumption

# Comparison of results related to charging power

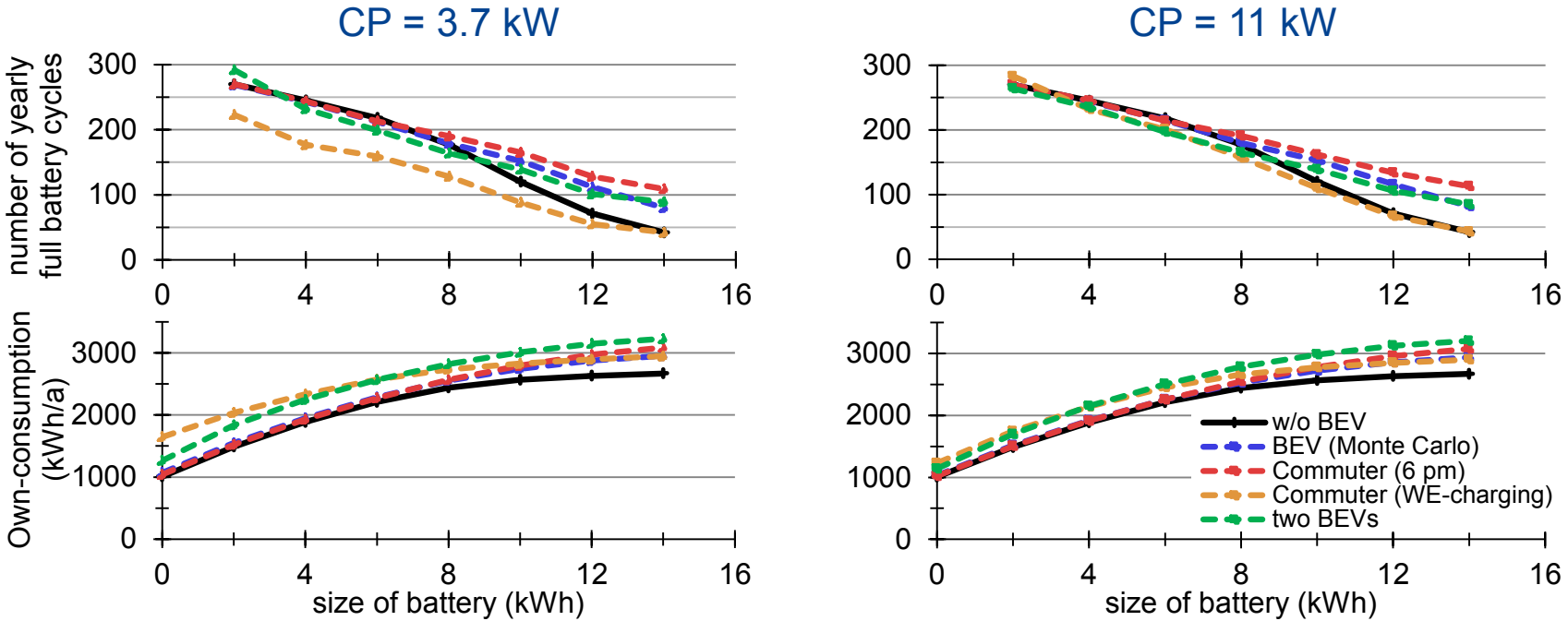
## evening centered, 10 $kW_p$ PV-System




→ Only WE-charging with higher CP improves the utilization of all battery sizes but it has a bad effect on the own-consumption

# Comparison of results related to charging power

## evening centered, 4 $kW_p$ PV-System




→ No suitable power generation to supply the demand of the BEV

→ Utilization increase only a little bit at large batteries

# Summary

- Large PV systems are key to increasing own-consumption and the utilization of batteries:
  - goal: yearly PV generation > yearly consumption
- 50% of own-consumption can be achieved with such PV system (10 kWp)
- “sun-shine hour” charging leads to almost 50% own-consumption even without battery
- For evening charging to reach 50% of own-consumption batteries of > 10 kWh are needed
- Higher charging power reduces own-consumption for all battery sizes – less for large batteries
- The additional demand for charging BEV increases the utilization of large batteries in particular for evening charging

// Energy with a future

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# Thank you for your attention!

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