Economic Impact of PV Forecast Inaccuracies on a Corporate Parking EV Charging Station

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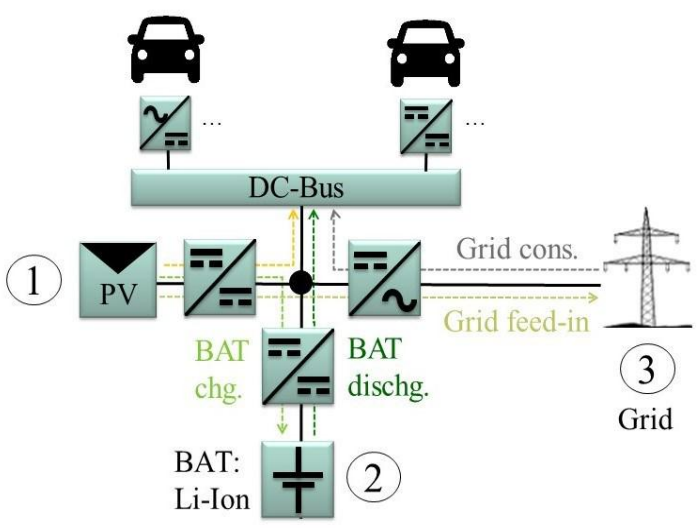
Motivation

- Global increase in share of EVs and RES leads to power fluctuation on demand and supply side
- Integration of RES decarbonizes the vehicle sector
- Economical viable solutions through RES and EVs

Objective

- Evaluate economic impact of PV forecast and sizing on a corporate parking charging infrastructure
- Avoid efficiency losses and achieve economic benefits due to DC coupling
- Profitability for share holder

Methodology and Data



Environment: Workplace (corporate)
Coupling: DC-coupling
Components: PV, BAT, converters
Charging points: 10·5 kW DC and 10·3.7 kW AC
Charging priorities: (1) PV, (2) BAT, (3) grid

Annual Costs	Annual Revenue
$C(a) = E_{grid} \cdot p_{grid} + (E_{BAT} + E_{PV_{dir}}) \cdot p_{EEG}$	$R(a) = E_{PV} \cdot p_{exc.} + E_{EV}$
NPV	**Objective**
$-I_o + \sum_{a=1}^{n} \frac{R(a) - C(a)}{(1+z)^a}$	$\min p_{EV}$ s.t. $NPV \leq 0$

Charging data: Real workplace charging data derived from past data (avg. energy demand 13.88 kWh, parking duration 7.1 h, arrival time 06:55)
PV data: KIT campus north solar site, year 2020
PV prediction method: Persistence forecast

Market data: German market, year 2022,e. g. grid price p_{grid} (18.5 Ct/kWh [1]), feed-in tariff p_{exc} (4.74-6.24 Ct/kWh [2]) and PV, BAT and converter prices s. [3], [4])

Observation period n: 20 years

Evaluation metrics: Marginal charging tariff p_{EV}, self-sufficiency
Charging strategies: (1) uncontrolled charging, (2) self-consumption maximized charging with (a) perfect PV forecast or (b) persistence forecast

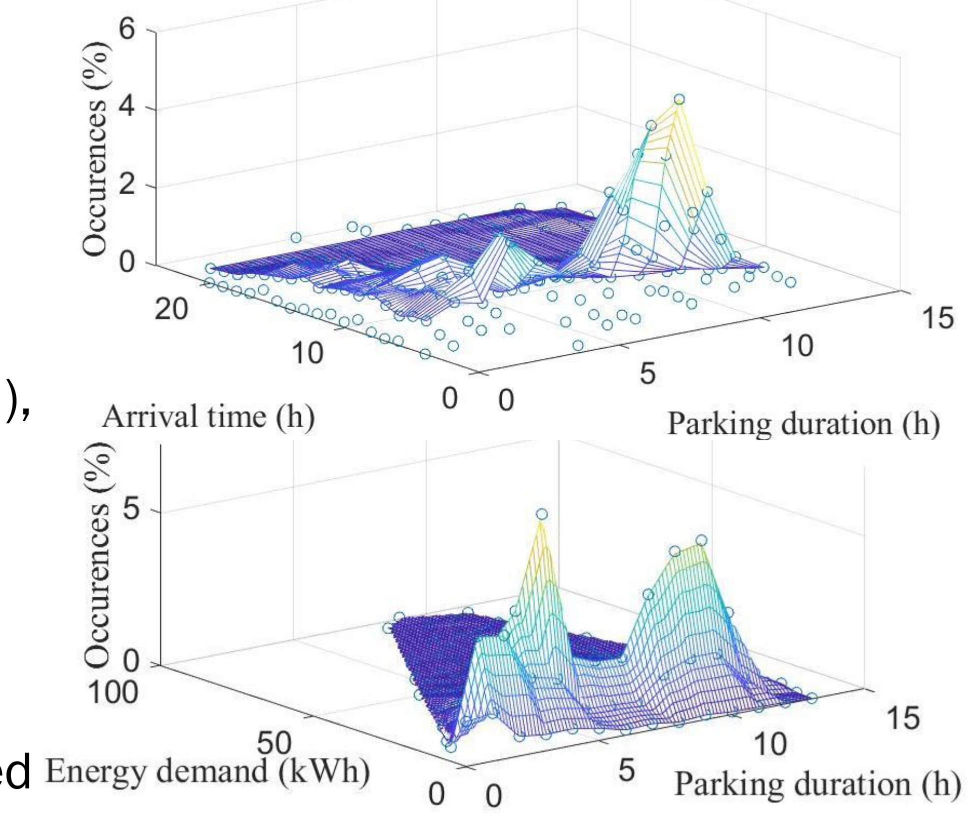


Fig. 1: Occurences of the combination of arrival time or energy demand and parking duration.

Results and Analysis

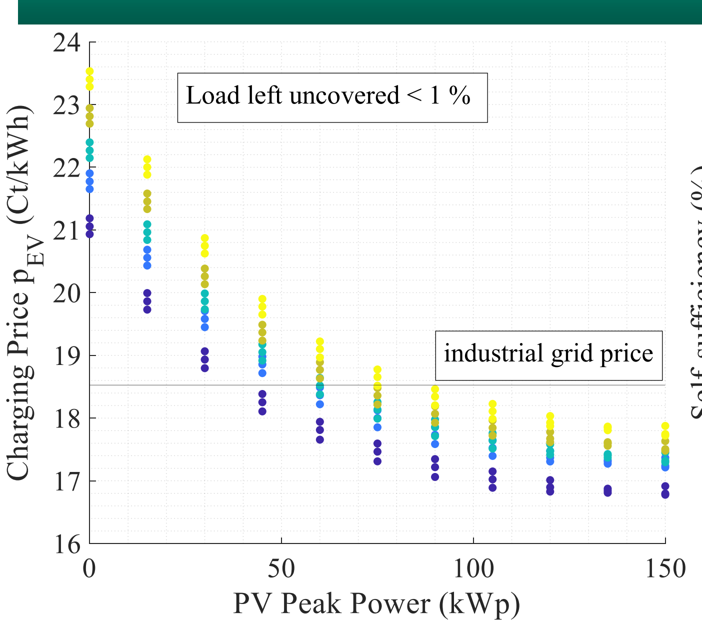


Fig. 2: Charging price without charging strategy for different PV and BAT sizes.

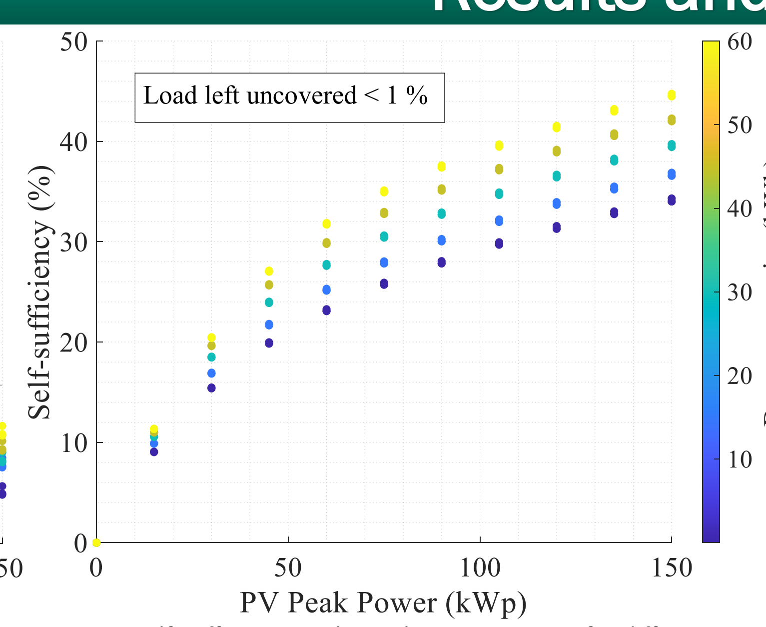


Fig. 3: Self-sufficiency without charging strategy for different PV and BAT sizes.

Economically optimal system: 120 kWp PV, 0 kWh BAT, 75 kW grid (< 1% of uncovered load)
Marginal charging tariff ↑ with BAT & grid converter size ↑
Optimum between 16.9 (uncontr.) & 13.9 (perf.) Ct/kWh
Self-sufficiency ↑ with BAT size ↑ & grid converter size ↓
PV prediction influence > 100 kWp

a. -100 €/a towards perfect charging
b. +4000 €/a towards uncontrolled charging
c. -1 pp self-sufficiency towards perfect charging
d. +20 pp self-sufficiency towards uncontrolled charging

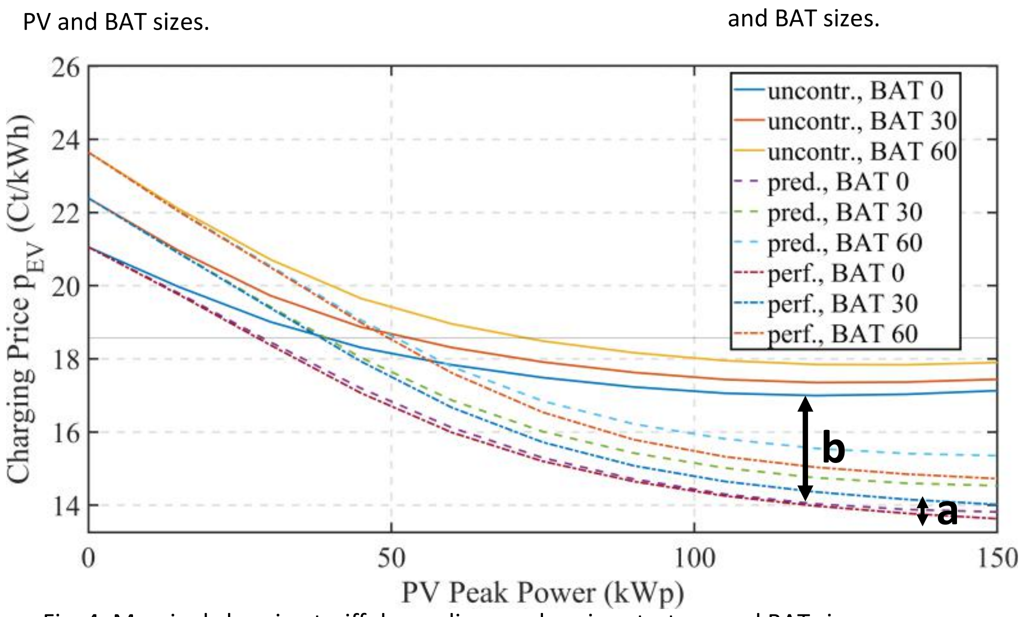


Fig. 4: Marginal charging tariff depending on charging strategy and BAT size.

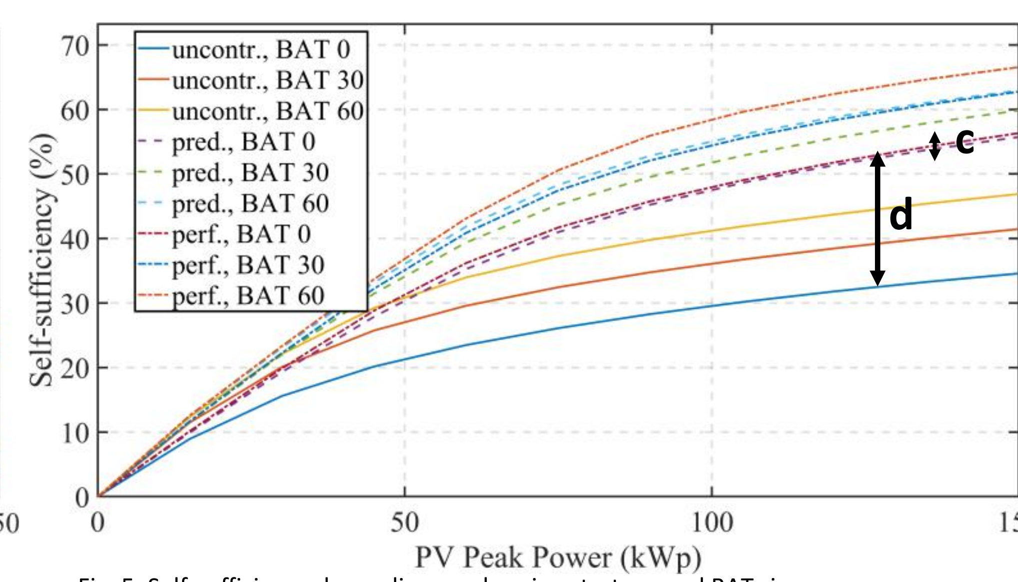


Fig. 5: Self-sufficiency depending on charging strategy and BAT size.

Outlook

- Load uncertainty
- Electricity market participation
- V2G
- BAT aging

EVCS: Electric Vehicle Charging Station, PV: Photovoltaics, BAT: Stationary Battery, DC: Direct Current, AC: Alternate Current, PF: Persistance Forecast, E =Energy, p= Price, exc. : feed-in, z = interest rate, n = number of years, Io = investment, ↑ increase, ↓ decrease, i.c.t : in comparison to, CP: Charging Points

[1] "Preise Netznutzung 2022" [Online]. Available: https://www.transnetbw.de/files/pdf/transparenz/netzzugang-und-entgelt/preisblaetter/ , **[2]** "Eeg-registerdaten und -fordersätze." [Online]. Available: ¨ https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/ErneuerbareEnergien/ **[3]** „Vorbereitung und begleitung bei der erstellung eines erfahrungsberichts." [Online]. Available: https://www.zsw-bw.de/uploads/media/zsv-boschundpartner-vorbereitung-begleitung-eeg.pdf **[4]** "Marktuebersicht batteriespeicher 2021." [Online]. Available: https://www.carmen-ev.de/wpcontent/uploads/2021/09/