Potential of battery storage systems to increase the self-consumption of photovoltaics in charging of electric vehicles in residential buildings

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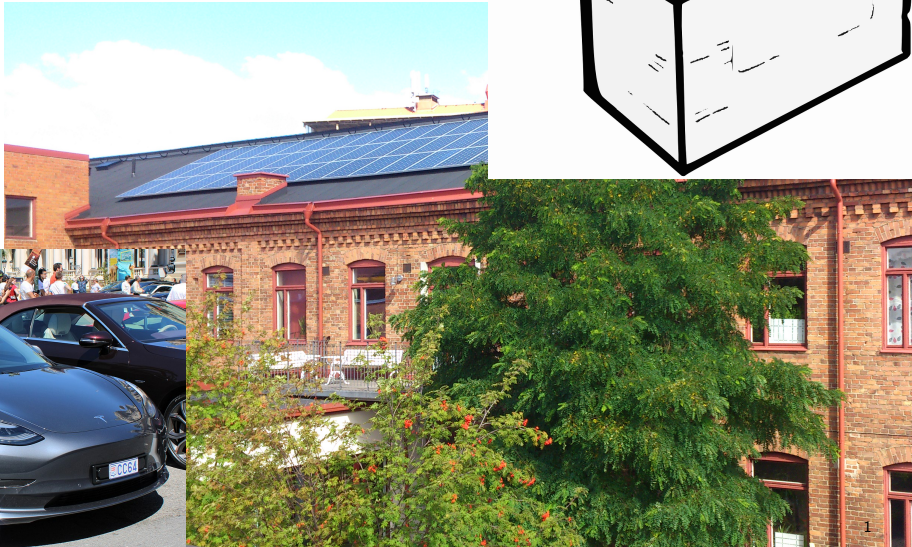

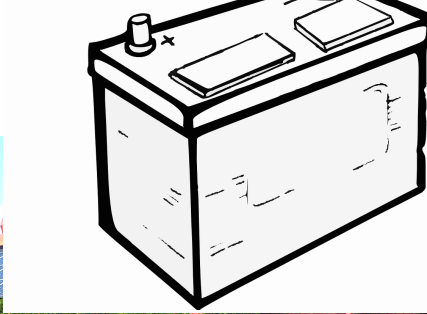

Aims

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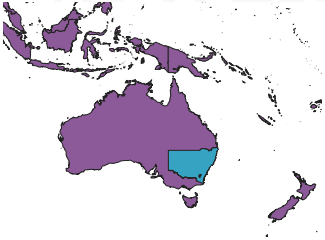
- How much can batteries improve this temporal mismatch?
- Compare different sizes of batteries.

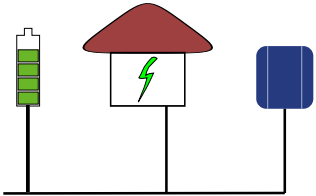
Data

- Ausgrid data from Ratnam et al. [1] NSW, Australia.
  1. 3-years 30-min PV and load data.
  2. 54 houses.
- EV (16 A 1-phase) simulated using Shepero and Munkhammar [2].
- Batteries 5–20 kWh, 5 kW charge/discharge.

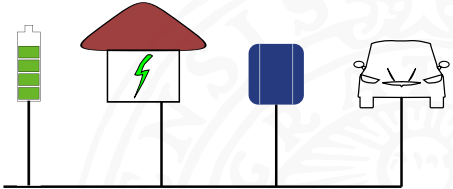


Simulation I

No EV



With EV



Temporal mismatch

Self-consumption

$$\frac{\text{PV} \Rightarrow \text{load}}{\text{PV}}$$

Self-sufficiency

$$\frac{\text{PV} \Rightarrow \text{load}}{\text{load}}$$

Temporal mismatch

Self-consumption

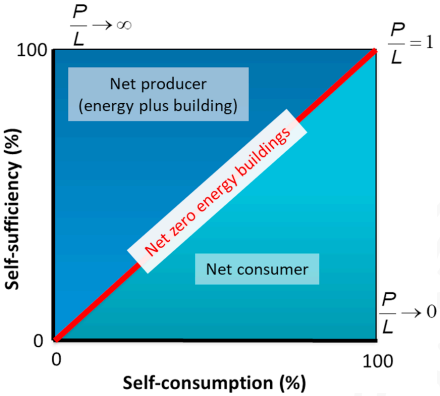
$$\frac{\text{PV} \Rightarrow \text{load}}{\text{PV}}$$

Self-sufficiency

$$\frac{\text{PV} \Rightarrow \text{load}}{\text{load}}$$

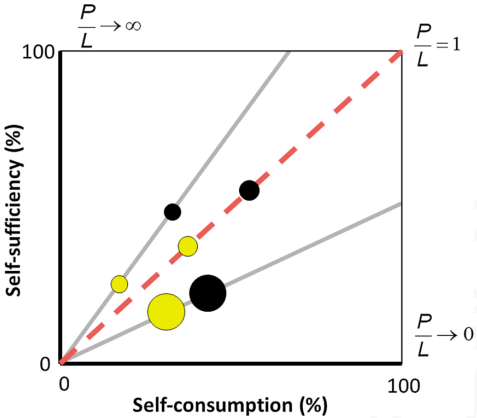
- SC = 100%, i.e., PV is fully consumed locally.
- SS = 100%, i.e., load is fully self-supplied.
- Ideally SC & SS=100%.

Temporal mismatch II



Luthander et al., Graphical analysis of photovoltaic generation and load matching in buildings: A novel way of studying self-consumption and self-sufficiency, 2019, Applied energy, 250, 748–759.

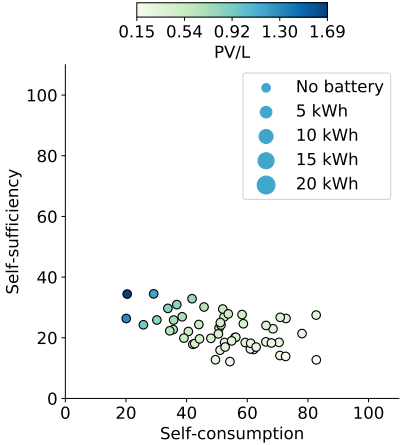
Temporal mismatch II



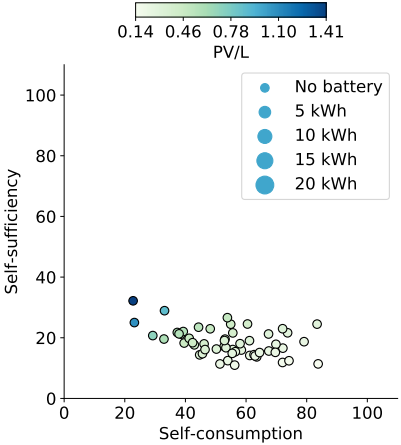
Luthander et al., Graphical analysis of photovoltaic generation and load matching in buildings: A novel way of studying self-consumption and self-sufficiency, 2019, Applied energy, 250, 748–759.

Results: No batteries

No EVs

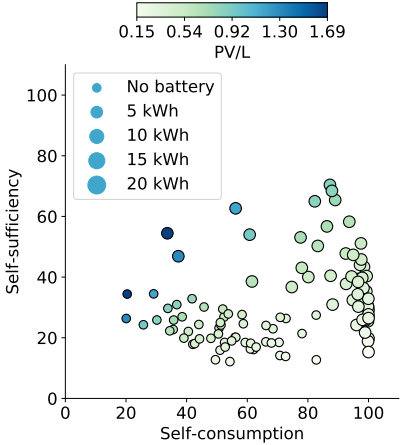


With EVs

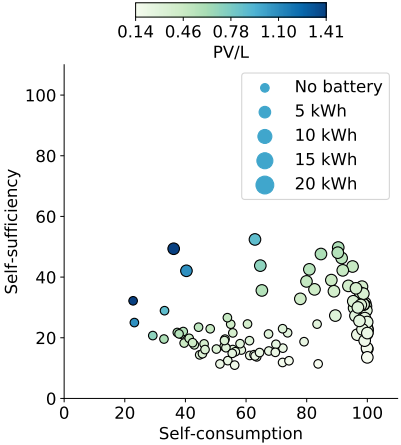


Results: 5 kWh

No EVs

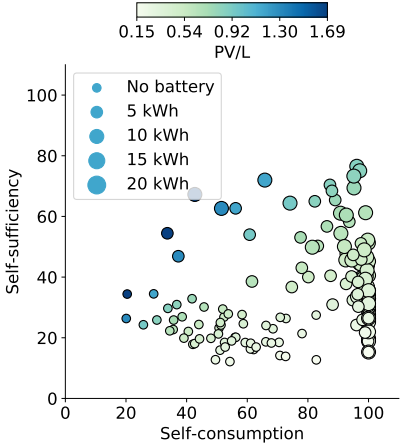


With EVs

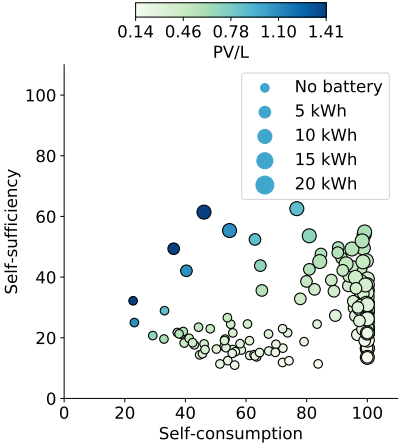


Results: 10 kWh

No EVs

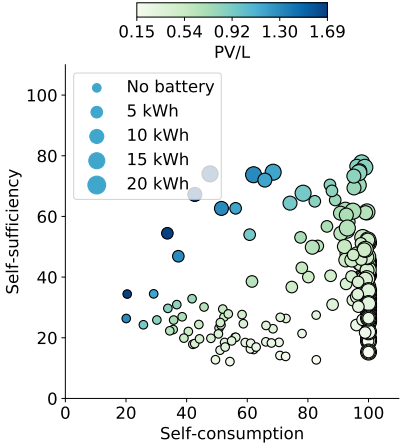


With EVs

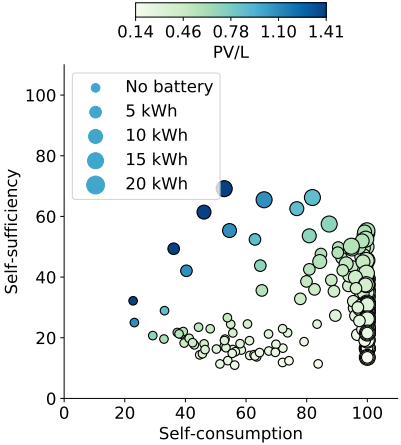


Results: 15 kWh

No EVs

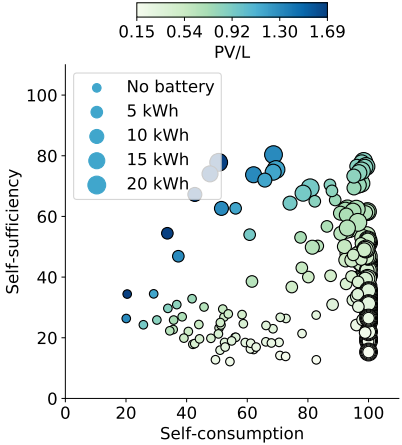


With EVs

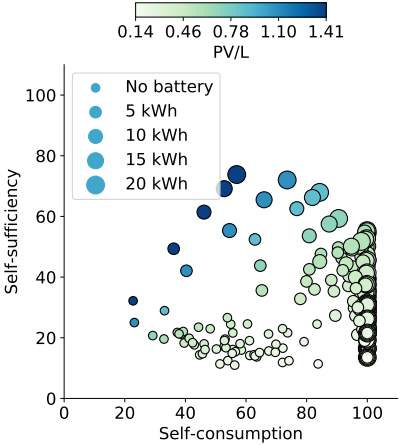


Results: 20 kWh

No EVs



With EVs



Results: II

Self-consumption

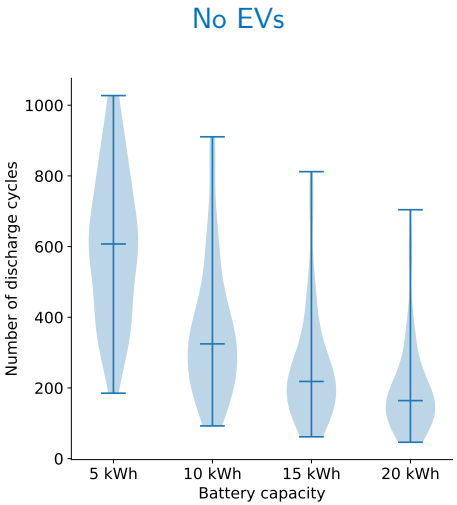
	0 kWh	5 kWh	10 kWh	15 kWh	20 kWh
No EVs	52%	+45%	+3%	+0	+0
With EVs	54%	+43%	+2%	+0	+0

Results: II

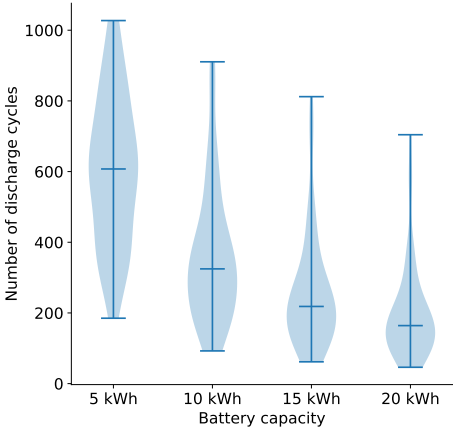
Self-sufficiency

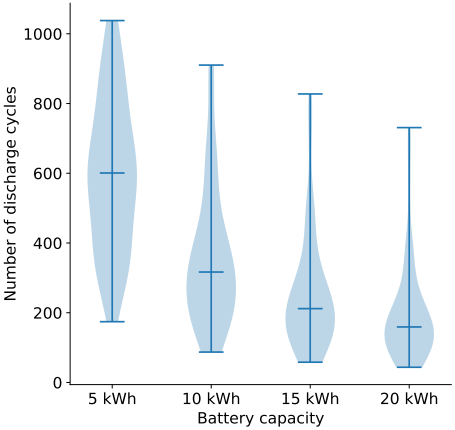
	0 kWh	5 kWh	10 kWh	15 kWh	20 kWh
No EVs	22%	+16%	+2%	+0	+0
With EVs	18%	+13%	+0	+0	+0

Results III


No EVs
Number of discharge cycles
0
200
400
600
800
1000
5 kWh
10 kWh
15 kWh
20 kWh
Battery capacity

Results III


No EVs
Number of discharge cycles
0
200
400
600
800
1000
5 kWh
10 kWh
15 kWh
20 kWh
Battery capacity


With EVs
Number of discharge cycles
0
200
400
600
800
1000
5 kWh
10 kWh
15 kWh
20 kWh
Battery capacity

Summary

- Batteries larger than 5 kWh did not improve the temporal mismatch.

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- The batteries are used to supply the load of the house, EVs had little impact.
- Batteries vary widely in their cycle-lives.

Open questions

- Batteries used to reduce peak power.
- Shared batteries.

?

References

[1] E. L. Ratnam, S. R. Weller, C. M. Kellett, and A. T. Murray, "Residential load and rooftop PV generation: an Australian distribution network dataset," *International Journal of Sustainable Energy*, vol. 36, no. 8, pp. 787–806, 2017.

[2] M. Shepero and J. Munkhammar, "Spatial Markov chain model for electric vehicle charging in cities using geographical information system (GIS) data," *Applied energy*, vol. 231, pp. 1089–1099, 2018.

Sources of figures

- Solar cells
- Tesla car