The system friendliness of solar self-consumption under different regulatory regimes

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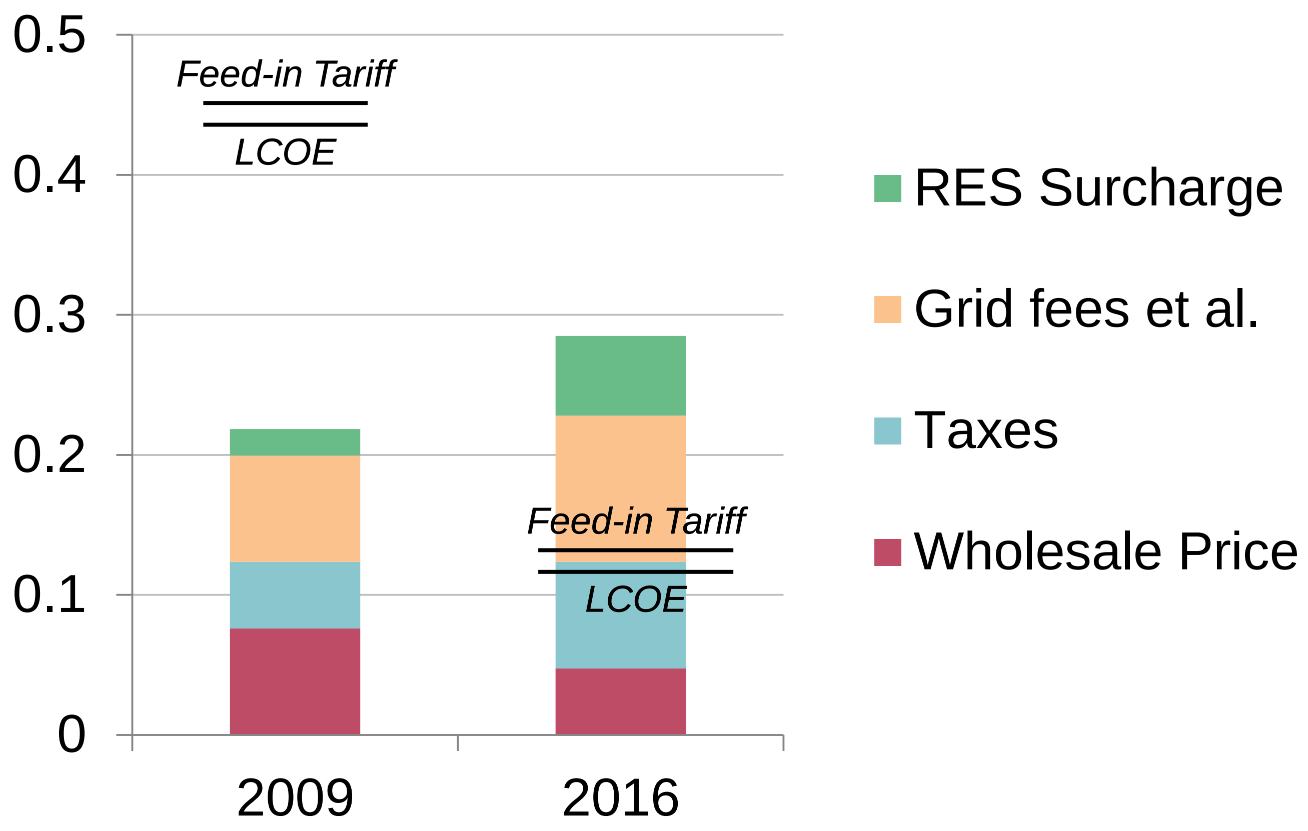
Retail Electricity prices and levies – the incentive to self-consume

Example from Germany



Today: direct incentive for consumers to self-consume in Germany („prosumer“)

With increasing amount of prosumers, the yellow bar increases for the remaining consumers (cf. prisoner‘s dilemma)

Schematic depiction adapted from Schill et al. (2017)

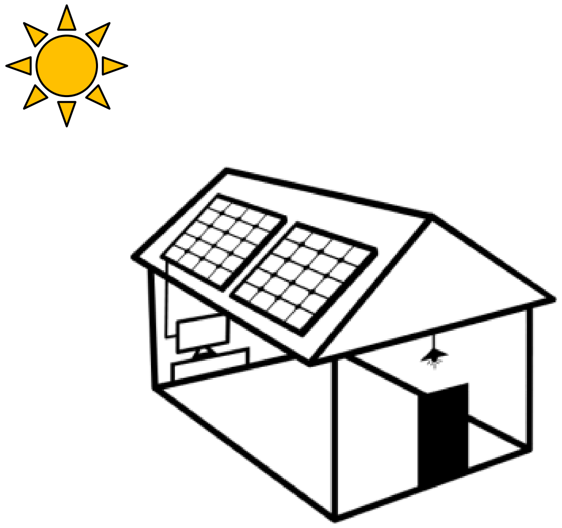
Motivation – Why study self-consumption in a systems context?

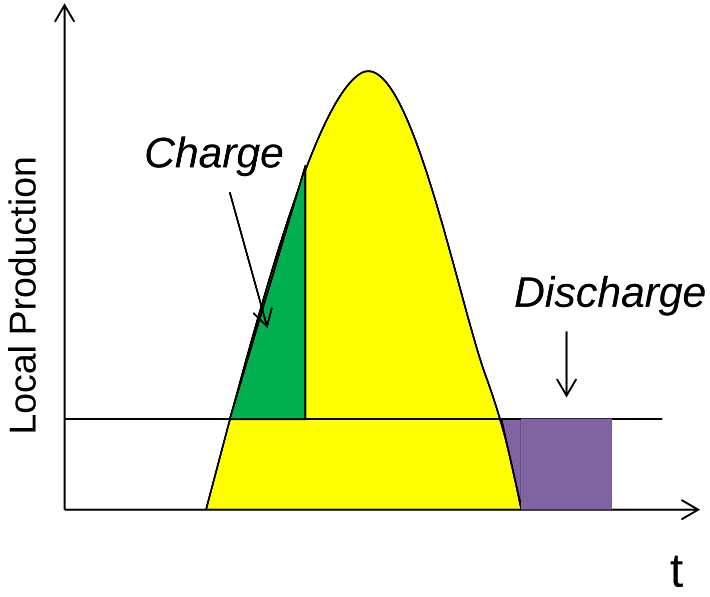
Uncertain yet expectable cost degression of PV-battery systems

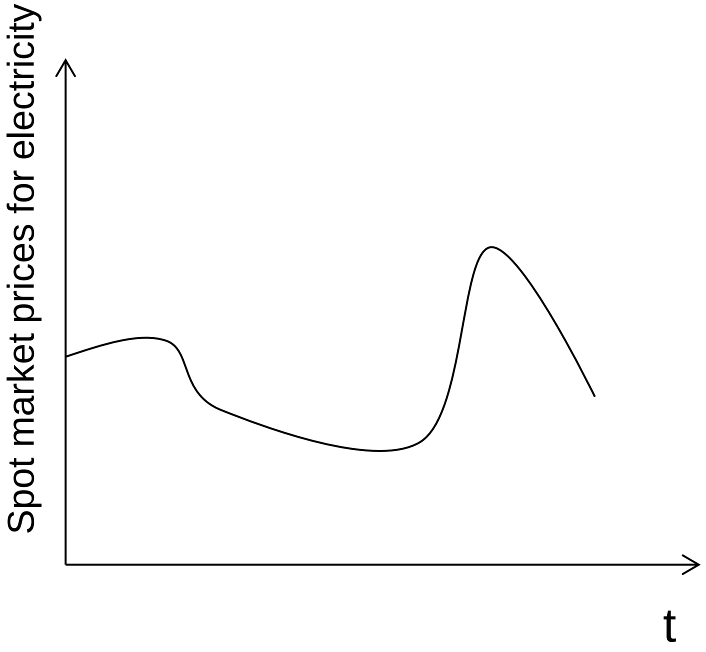
Potential parasitic effect on the energy system as a whole ("Death Spiral of the Grid")

Non-optimal incentive for household PV-battery system operation and investment

Case 1 – Market signals propagate correctly to Prosumers
Sunny Day in the entire market zone

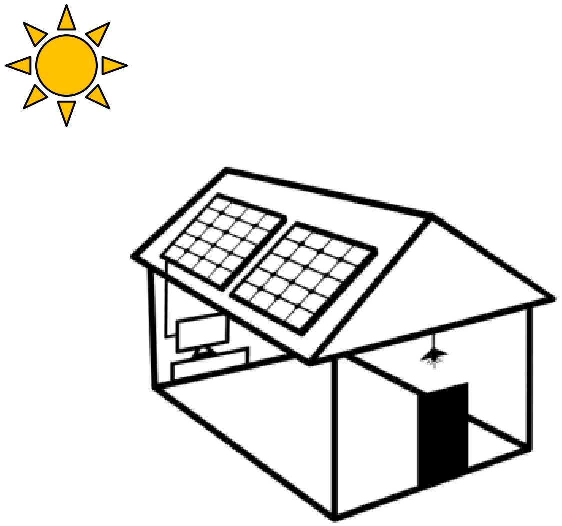


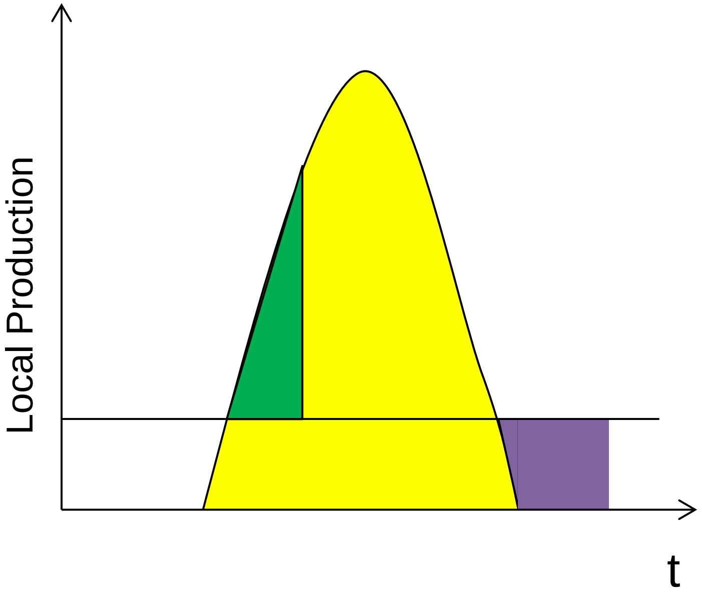


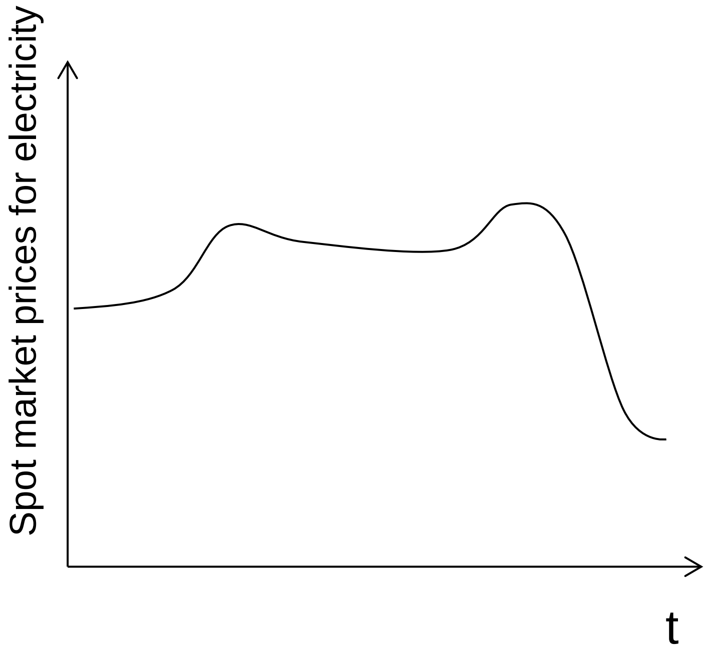


Schematic depiction

Case 2 – Market signals do *not* propagate correctly to Prosumers
Sunny day at our PV site, overcast in market zone





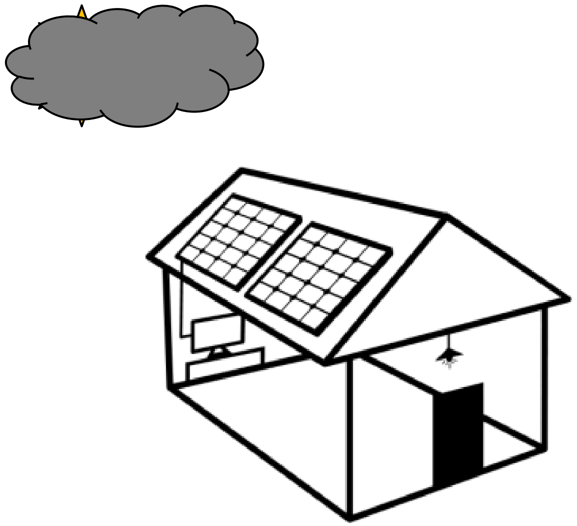


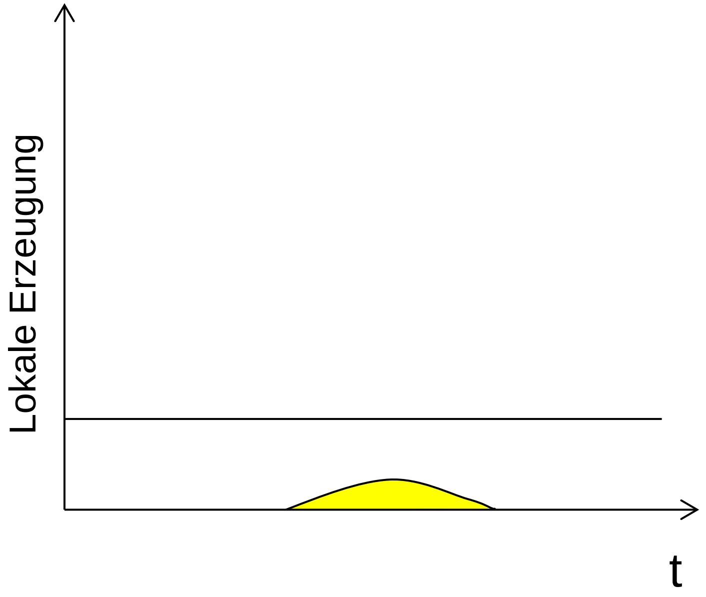
Schematic depiction

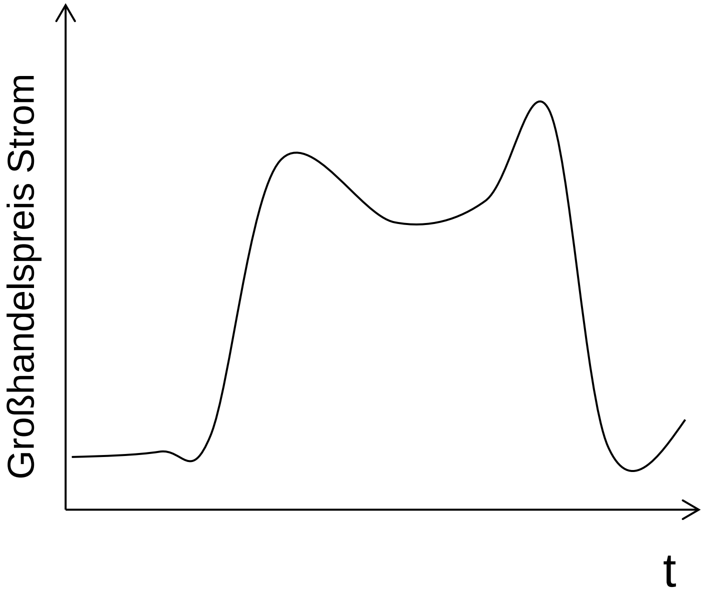
State of charge inconsistent with market signals:

Charging at high prices (scarcity),
Discharge at low prices (surpluses)

Case 3 – Market signals do *not* propagate correctly to Prosumers
Windy night, overcast winter day





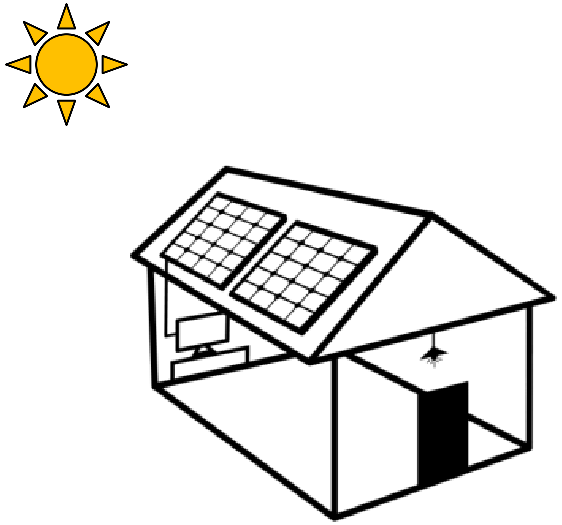


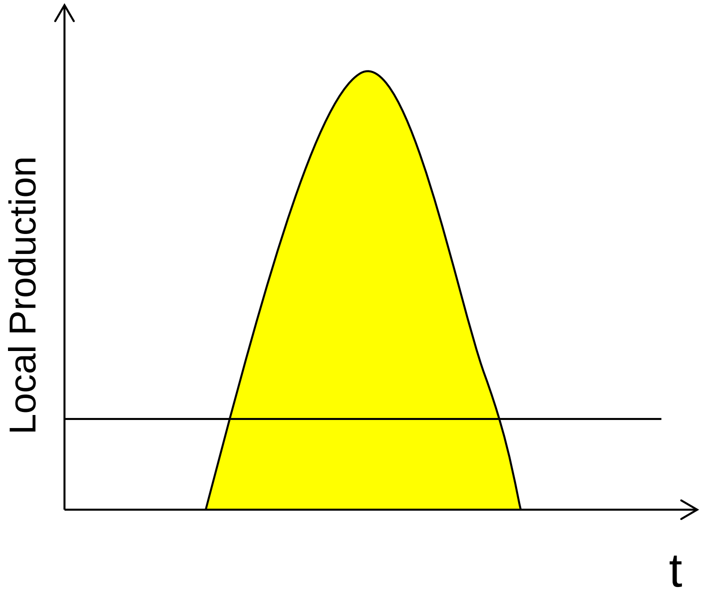
Schematic depiction

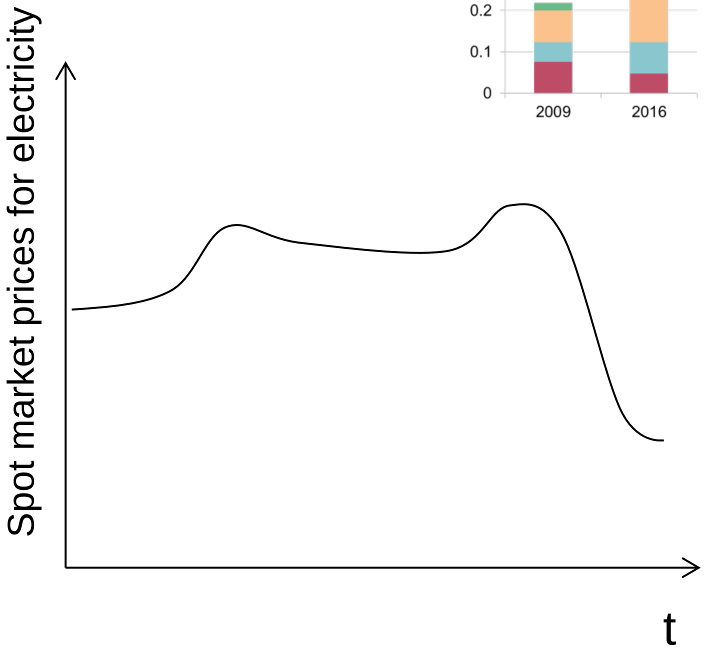
State of charge inconsistent with market signals:

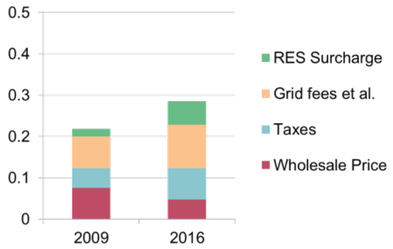
Storage is not used, even if there is a price/scarcity delta

Case x – How can market signals propagate correctly to Prosumers?









Schematic depiction

When would it be optimal to charge and discharge if the prosumers saw time-varying price signals for consumption and generation?
How to incentivize system-friendly dispatch of batteries?

Motivation – Why study self-consumption in a systems context?

Uncertain yet expectable cost degression of PV-battery systems

Potential parasitic effect on the energy system as a whole („Death Spiral of the Grid“)

Non-optimal incentive for household PV-battery system operation and deployment

→ Almost no system level evaluations so far:

- Heterogeneous incentives
- Hard to incorporate non-optimal behavior in system models
- High data requirements (load and generation)

System-friendliness indicator (SFI)

- The system-friendliness indicator measures how close the household battery dispatch is that to the ‘ideal’ case. It considers the short-term welfare of the battery of the self-consumption system:

$$\Delta W_{Battery} = W_{PV-Battery\ System} - W_{PV\ System}$$

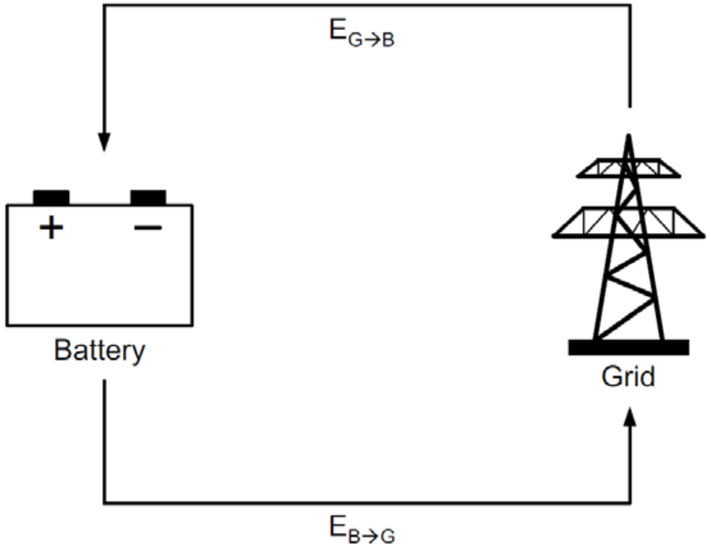
- The ***SFI*** is obtained by comparing it to an arbitrage battery of the same size:

$$SFI = \frac{\Delta W_{Battery}}{W_{Arbitrage}}$$

- Internal validation: When households were exposed to wholesale market prices for generation and consumption, the SFI is very close to 1

Arbitrage Case

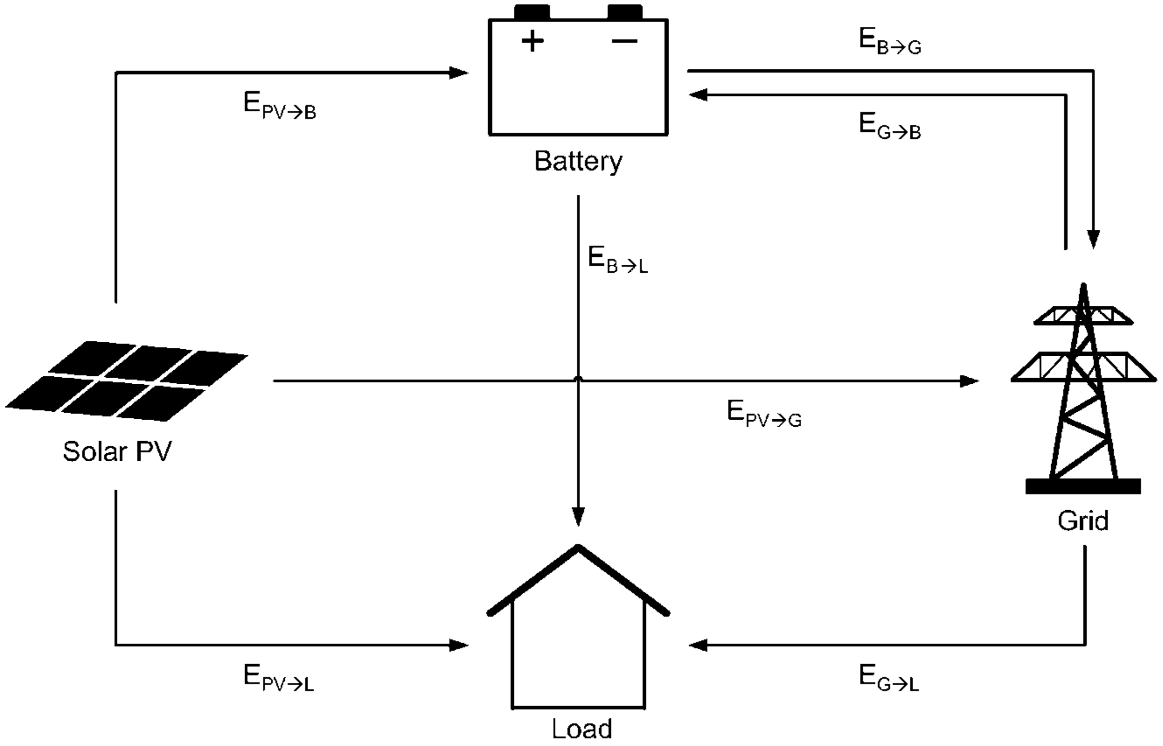
- Ideal case is complete responsiveness to price signals. This means a storage that operates on arbitrage
- Storage maximizing revenue exposed to wholesale market prices



Time Varying Cases

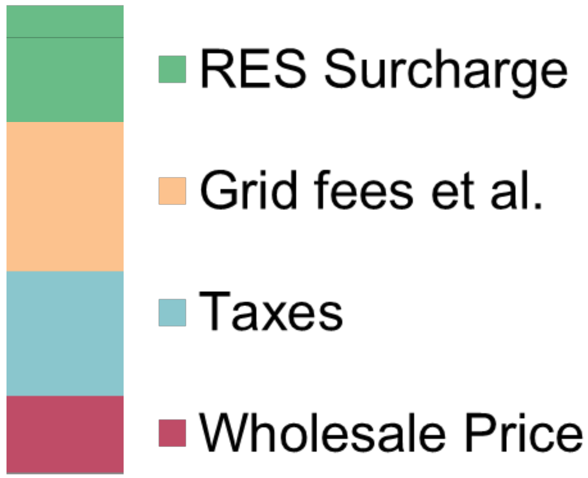
- Consumer feeds energy to the grid for a fixed or a variable feed-in tariff (FIT)
- Buys electricity for a variable or fixed retail price
- Battery can feed into the grid for wholesale market prices

- Model will be made open source (BSD license), release note on https://forum.openmod-initiative.org/



Evaluated policy cases – Policy design elements

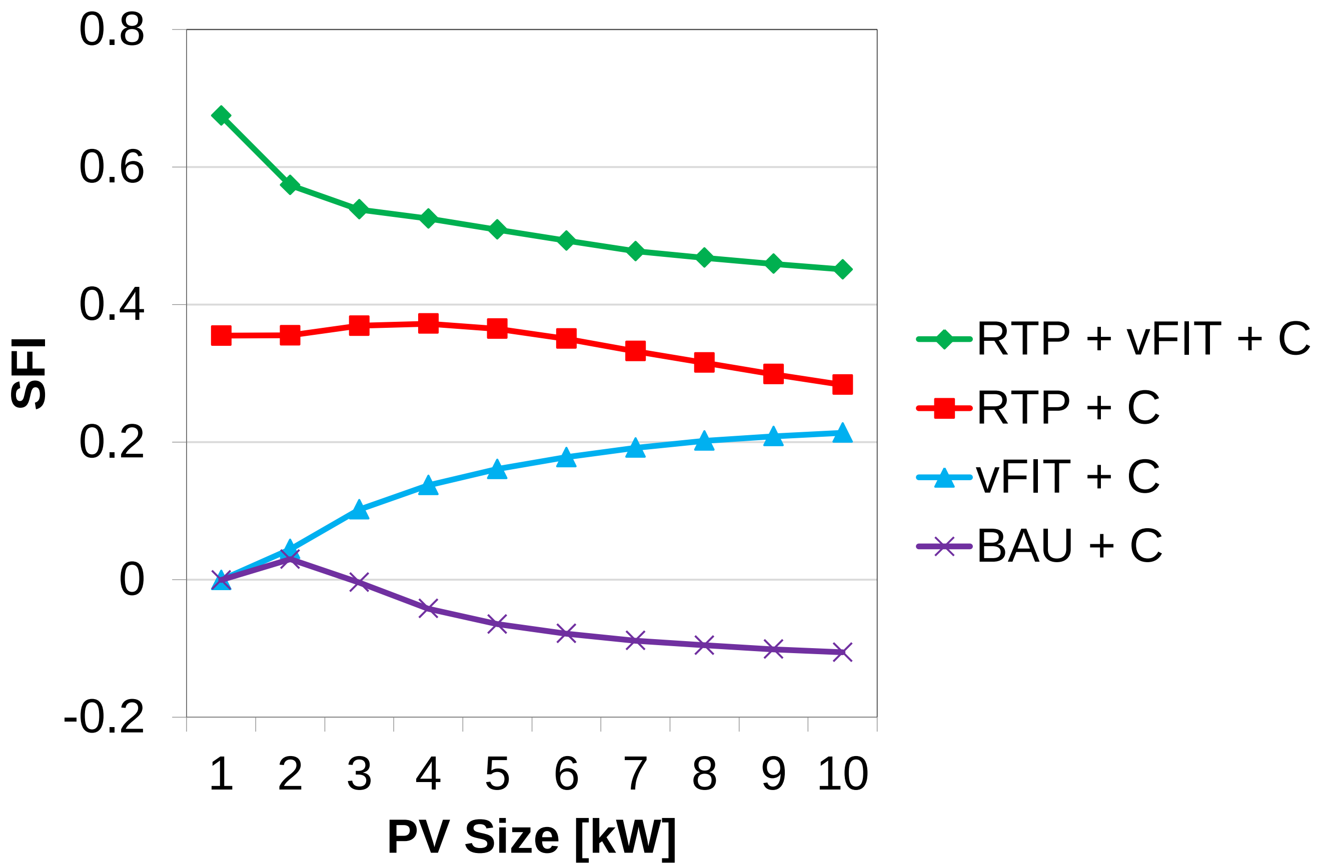
Case	Real Time Pricing	Variable FIT	Capacity-based
BAU	✘	✘	✘
C	✘	✘	✔
RTP	✔	✘	✘
RTP + C	✔	✘	✔
vFIT	✘	✔	✘
vFIT + C	✘	✔	✔
RTP + vFIT	✔	✔	✘
RTP + vFIT + C	✔	✔	✔



- Evaluated across 74 households and 100 PV and storage combinations
- All policies neutral to the regular consumers (same payments for electricity per year) by design

Results: System-friendliness indicator (SFI)

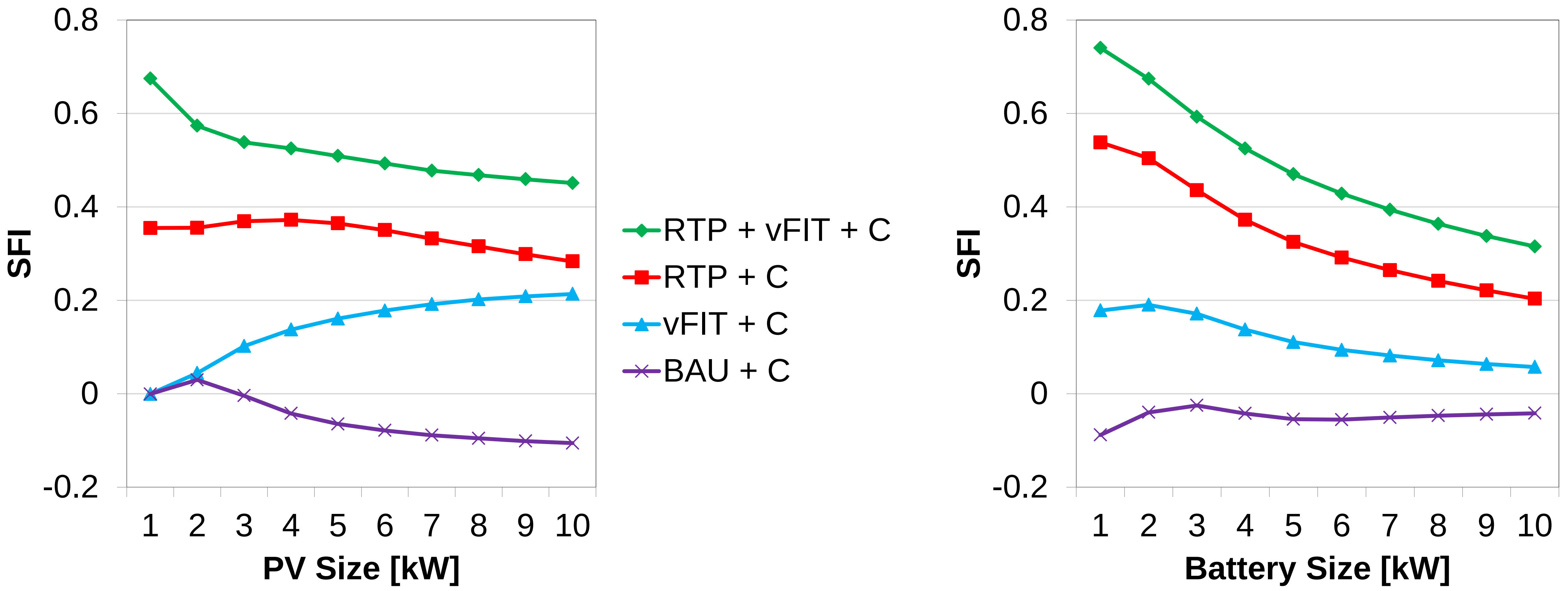
Example case: 4 kWh battery, capacity network charges



Results: System-friendliness indicator (SFI)

Example case: 4 kWh battery, capacity network charges

4 kW PV system



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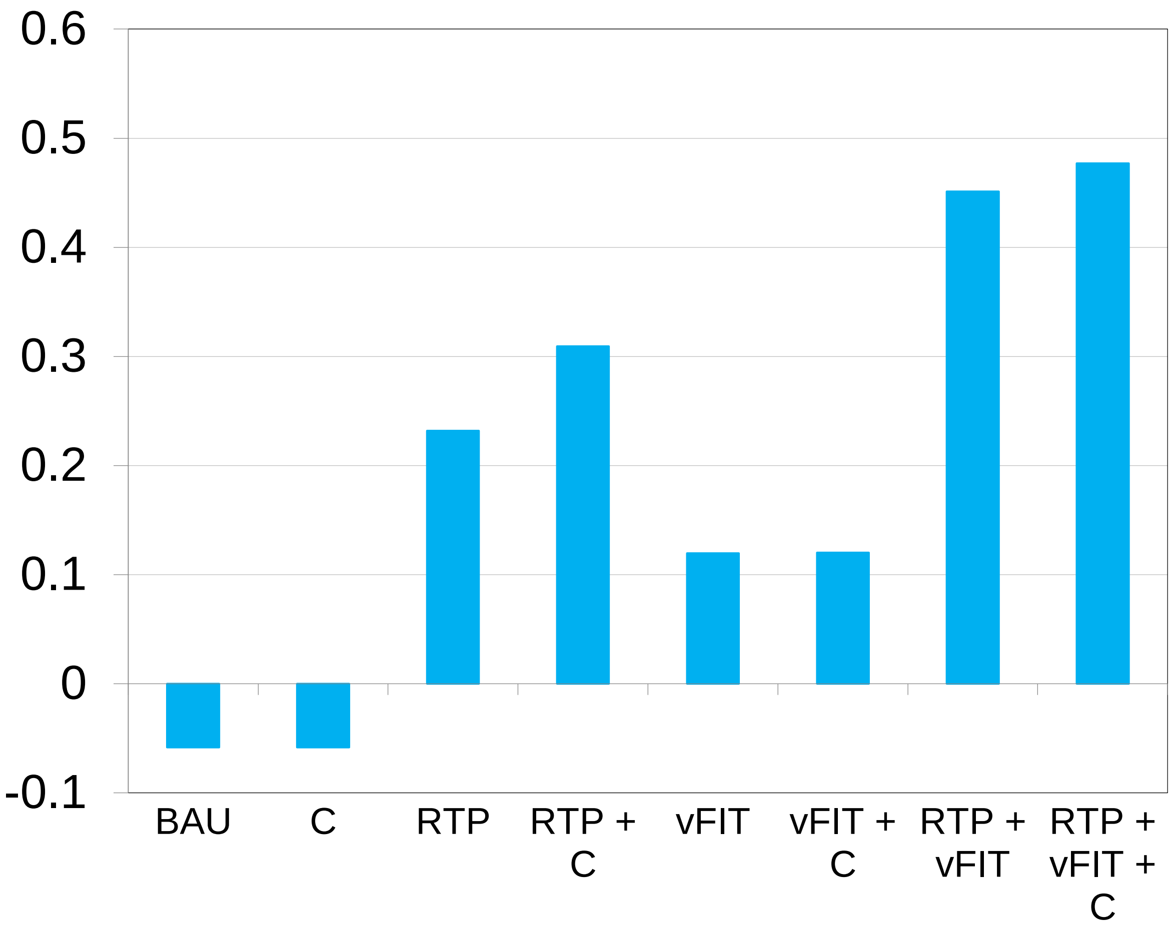
Results: System-friendliness indicator (SFI)

Mean values for all investigated cases



- Operation of self-consumption batteries in business-as-usual case slightly system-unfriendly
- Real-time prices can better the SFI considerably
- Variable feed-in tariff less successful
- Best result obtained for combination of all policy design elements
- SFI not close to 1 because of other extras like taxes

Discussion and Conclusion

- SFI: Novel method to assess the system-friendliness of prosumer storages proposed
- Time-varying feed-in tariff, real-time prices and capacity tariffs are investigated
- Scarcity signals transmitted to prosumers can improve their system-friendliness
- Both dynamic prices for generation and consumption can better the *SFI*
- *SFI* is best if two-way price signal (for generation and consumption) is transmitted
- Flat capacity tariffs also have a significant impact on the system-friendliness and improve the attribution of network charges, adverse for the business case of self-consumption

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