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Engineering Thermodynamics

How to model (and regulate) the future uptake of residential PV battery systems?

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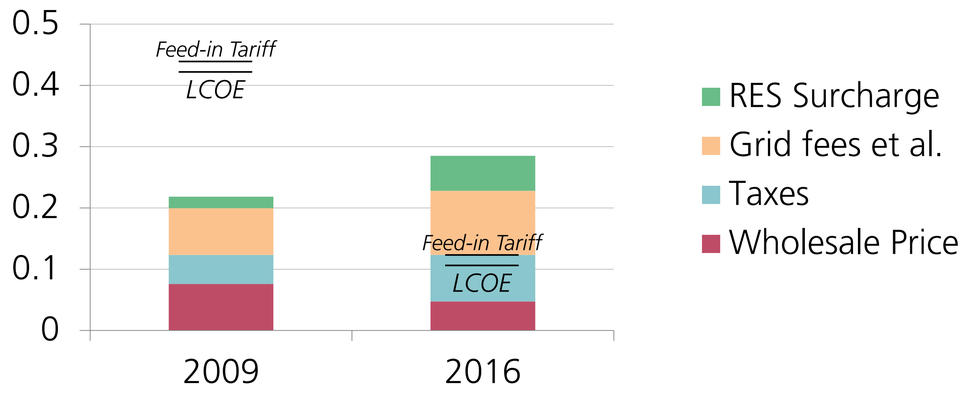
PROBLEM DESCRIPTION AND CASE STUDY



Retail prices and feed-in tariff for residential consumers in Germany (stylized) [1]

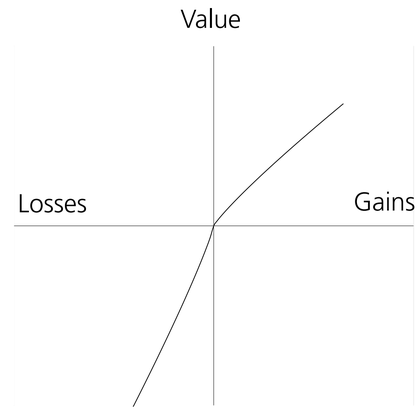
Assuming a frictionless, centrally optimized power system, residential PV battery systems are *not* "system optimal", as their incentives to being built and operated ("avoidance of grid fees, minimizing payments") are not in line with whole system operation ("offering electricity at the wholesale market"). Their uptake is determined by many heterogeneous decisions of non-market actors. How to model and regulate their deployment?

THEORY – REFERENCE-DEPENDENT UTILITY MEASURE

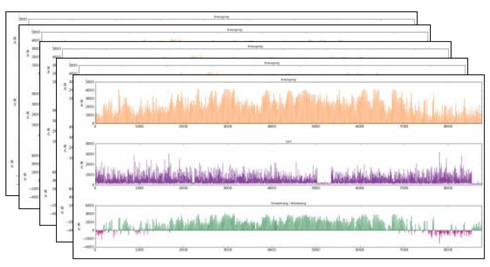
The objective of the work is to find some utility measure that correlates well with the observed deployment of residential PV battery systems:

Calculate NPV and IRR over time → Derive utility measure *U*(IRR, t) → Correlate with observed deployment

In [2], we postulate that potential PV adopters do not only rate its attractiveness in absolute terms of risk-adjusted IRR, but also in relative gains and losses, i.e. in *changes* of profitability, according to the value function of Prospect Theory [3].



METHODOLOGY – INTEGRATING DEPLOYMENT DYNAMICS INTO AN AGENT-BASED SYSTEM MODEL

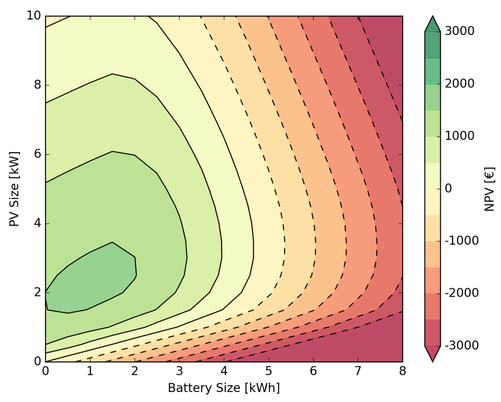


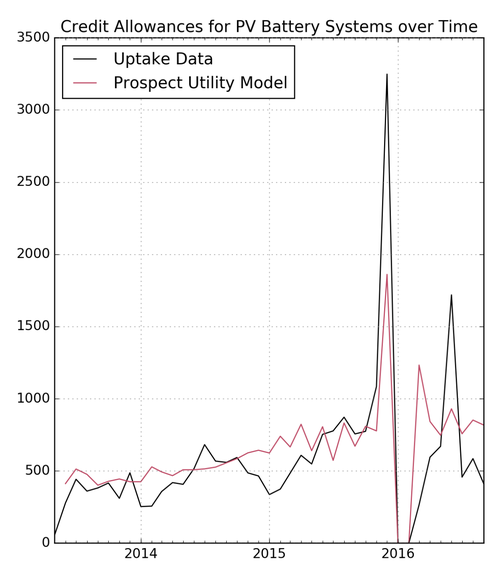
Technical modelling:

- Compute "egoistic" storage dispatch, deriving grid load and feed-in profiles for many configurations of PV battery systems
- Input: 74 high-resolution house-hold load (HTW Berlin) and PV generation profiles (DLR REMix-EnDat)

Economic Assessment:

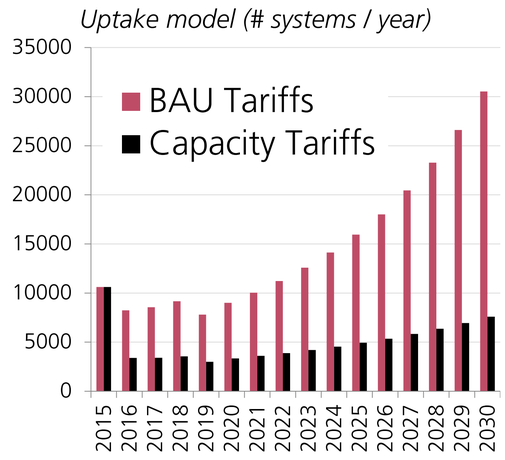
- Compute NPV/IRR matrices
- Input: remunerations, electricity rate strucuture, levies, …
- Further inputs: PV and battery cost scenarios





Uptake modelling:
Compare utility measure derived from Prospect model with historic uptake data

Market Model Integration:
Take prospective profitability of PV battery systems to endogenously simulate levels of deployment under different regulatory scenarios



RESULTS AND CONCLUSIONS – PV BATTERY SYSTEMS NEED FURTHER REGULATION

Concerns have been raised that increasing shares of self-consumption could have a parasitic, prisoner-dilemma like effect on the overall system. PV battery deployment dynamics can be reproduced taking the anticipation of absolute profitability, and additionally its *change*. This assessment requires an actor-based perspective. Levy and network charges structure have a major influence - capacity based tariffs reduce the prospective uptake considerably. Next, system effects will be studied in the framework of an agent-based electricity market model [4], with an internal representation of market prices (hourly basis, dynamically calculated in dependence of the generation mix).

REFERENCES

[1] W.-P. Schill et al. "Prosumage of solar electricity: pros, cons, and the system perspective," *Economics of Energy & Environmental Policy*, vol. 6, no. 1, 2017.

[2] M. Klein and M. Deissenroth, "When Do Households Invest in Solar Photovoltaics? - An Application of Prospect Theory," *under review in Energy Policy*

[3] A. Tversky and D. Kahneman, "Advances in prospect theory: Cumulative representation of uncertainty," *Journal of Risk and Uncertainty*, vol. 5, no. 4, pp. 297–323, 1992.

[4] M. Deissenroth et al., "Impact of Policy Instruments on Renewable Electricity Marketing: An Agent-Based Modelling Approach," *under review in Complexity*

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