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Prosumage of solar electricity: batteries, heating and mobility

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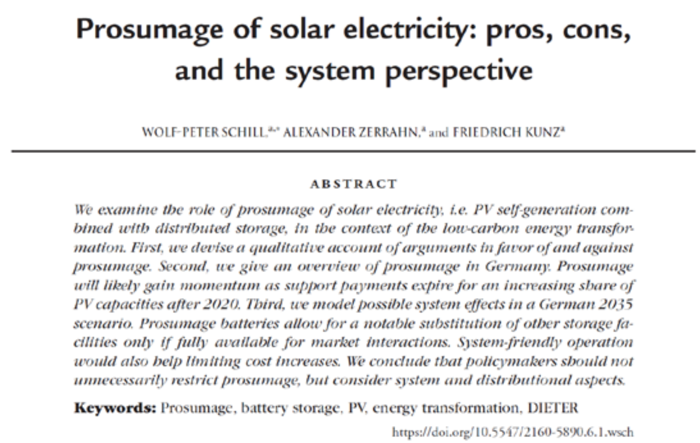
Overview

1. Introduction
2. The model
3. Input data
4. Results
5. (Preliminary) Conclusions and future research

1 Introduction

Background: Our article in IAEE's EEEP (2017)

- Qualitative discussion of prosumage from an economic perspective
- Quantitative illustration of selected system effects
- Focusing on battery storage and different operational strategies
- https://doi.org/10.5547/2160-5890.6.1.wsch



Prosumage of solar electricity: pros, cons, and the system perspective

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ABSTRACT

We examine the role of prosumage of solar electricity, i.e. PV self-generation combined with distributed storage, in the context of the low-carbon energy transformation. First, we devise a qualitative account of arguments in favor of and against prosumage. Second, we give an overview of prosumage in Germany. Prosumage will likely gain momentum as support payments expire for an increasing share of PV capacities after 2020. Third, we model possible system effects in a German 2035 scenario. Prosumage batteries allow for a notable substitution of other storage facilities only if fully available for market interactions. System-friendly operation would also help limiting cost increases. We conclude that policymakers should not unnecessarily restrict prosumage, but consider system and distributional aspects.

Keywords: Prosumage, battery storage, PV, energy transformation, DIETER

https://doi.org/10.5547/2160-5890.6.1.wsch

- Updated version forthcoming as a book chapter in „Energy Transition – Financing consumer (co-)ownership in renewables“, Lowitzsch, J. (Edt.), Palgrave Macmillan

Extension: prosumage and sector coupling [work in progress]

- People may increase self-consumption also by electric heating or electric mobility
- We look at electric storage heaters and battery-electric vehicles
- Evaluation of system effects compared to batteries

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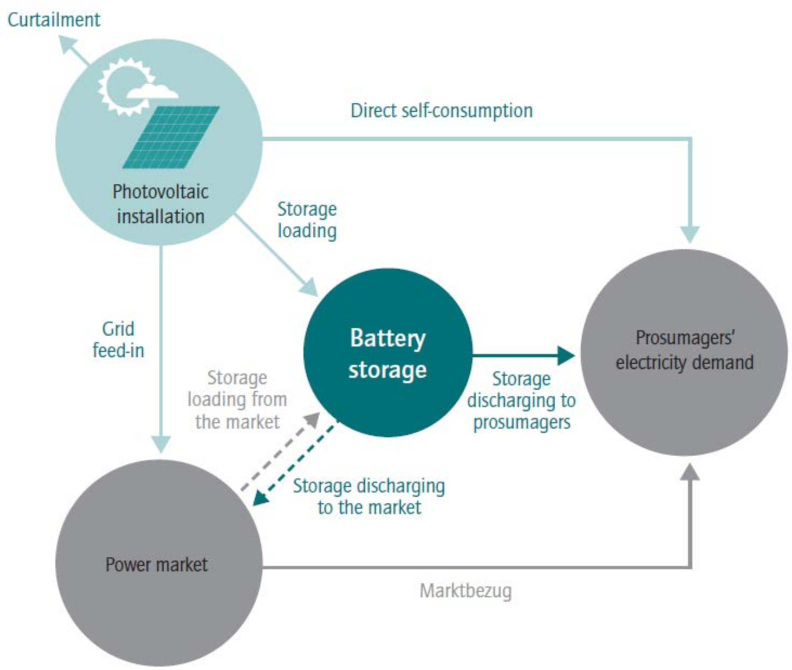
How we define PRO-SUM-AGE

- **PRO**duction of renewable electricity (PV)
- Con**SUM**ption of self-generated electricity
- Stor**AGE** to temporally align supply and demand



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Prosumagers

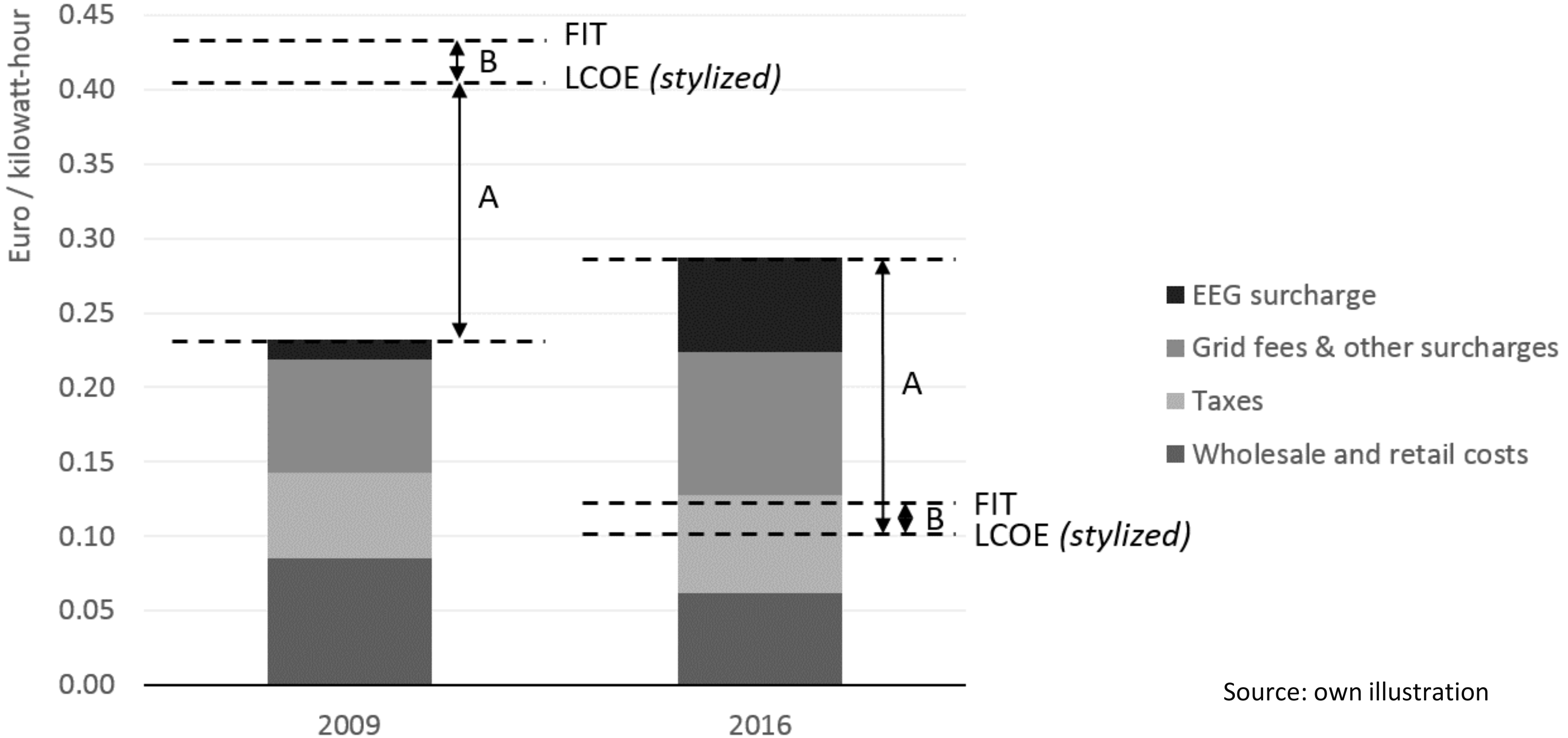
- produce their own renewable (PV) electricity at times,
- draw electricity from the grid at other times,
- feed electricity to the grid at other times,
- and make use of storage (stationary batteries, vehicle batteries, heat storage)

Self-consumption* vs *self-generation

Incentives for prosumage through FITs, LCOEs, and household tariffs

- Volumetric grid charges and EEG surcharge – but not on self-generation
- Strong decline of FIT compared to household tariff ("Socket parity")

→ *We do not explicitly model this kind of incentive*



Source: own illustration

Pros and cons depend on the perspective

- Prosumagers and other consumers
- Incumbent industry, new industry, service providers
- Electricity system / system operators

→ Further reading: EEEP article + book chapter

Arguments in favor of prosumage

- Consumer preferences
- Lower/more stable electricity costs
- Participation/acceptance of energy transformation
- Activation of private capital
- Distribution grid relief

Arguments against prosumage

- Increasing system costs
- Distributional impacts

Arguments with ambiguous conclusions

- Transmission grid relief
- Flexibility
- Driver for sector coupling
- Energy efficiency vs. rebound effect
- Local and macroeconomics benefits, increased competition
- Political economy, path dependency, and policy coordination
- Data protection and security

Analysis with an extended version of the DIETER model

- Open-source electricity system model: www.diw.de/dieter
- Minimization of yearly system costs for dispatch and investment, hourly resolution
- Linear program, implemented in GAMS
- Exogenous inputs: cost and capacity data, time series on load and renewables
- Endogenous variables: costs, dispatch and investments

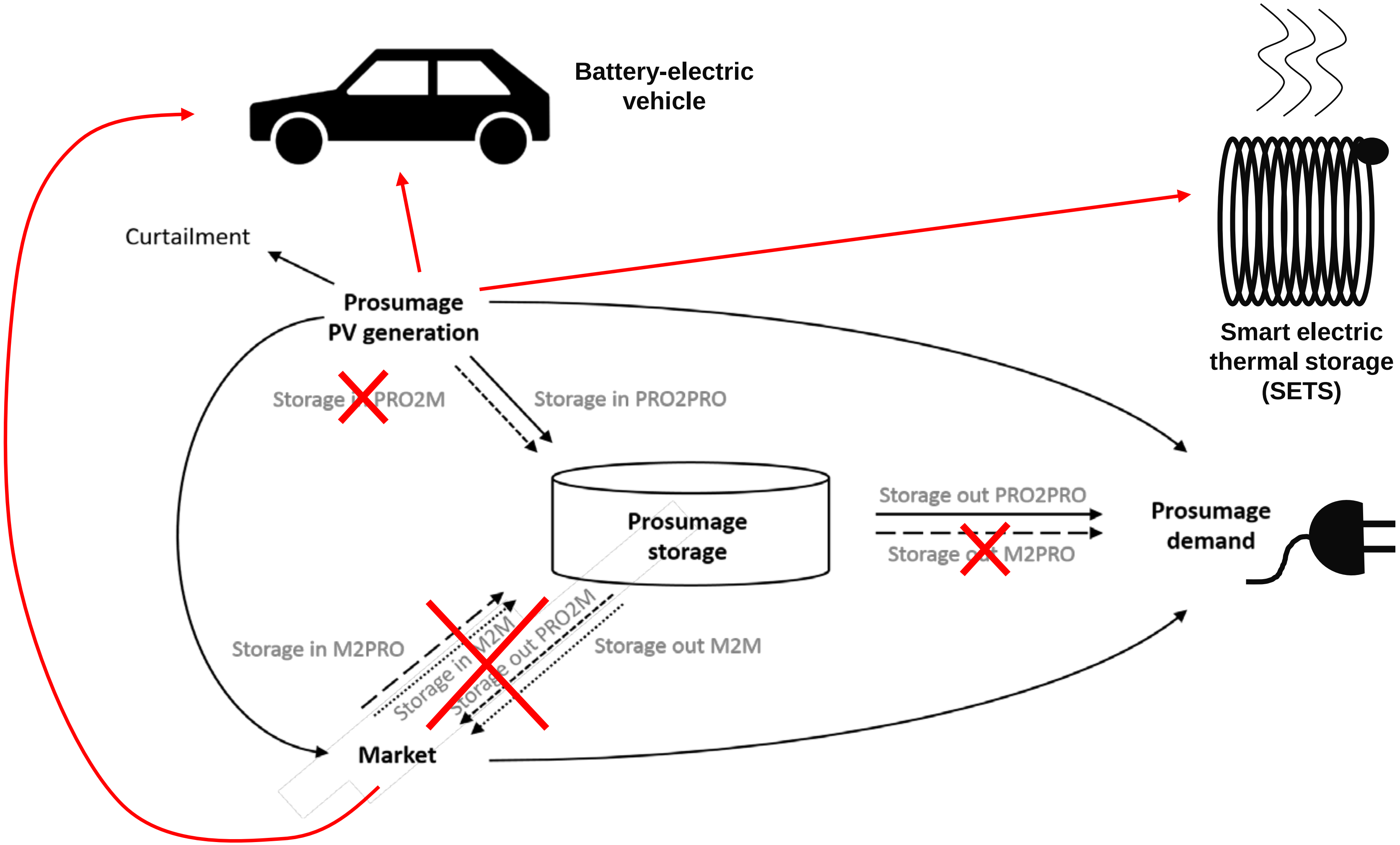
Representation of prosumage

- Some fraction of electric load and PV is assumed to engage in prosumage
- Varying (exogenous) minimum self-consumption restrictions

Options for increasing self-consumption

- Stationary Li-ion batteries
- Smart electric thermal storage (SETS)
- Battery-electric vehicles (BEV)

Model extension: electric heating and electric mobility

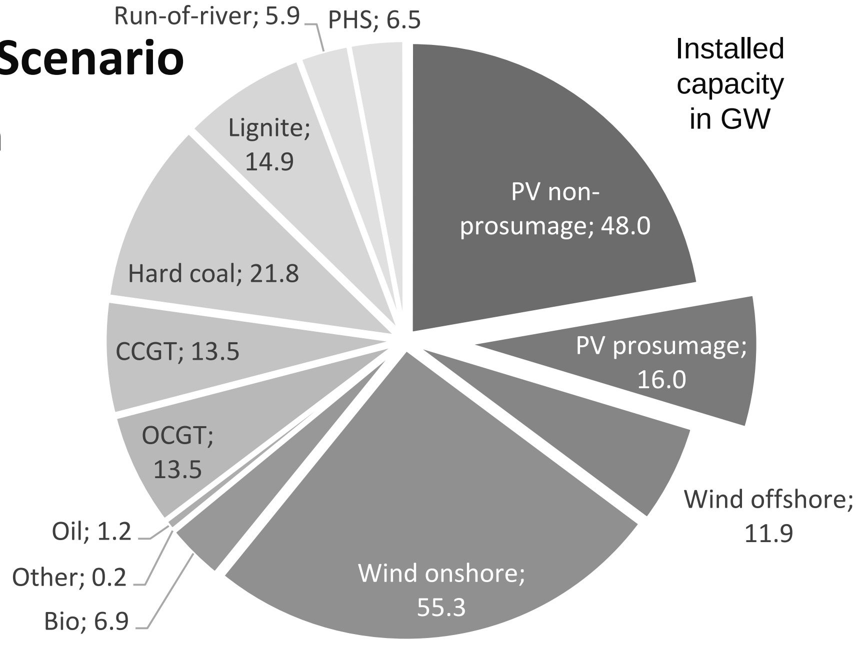


Assumptions on different prosumage options

	Electricity supply	Additional electricity demand	Investment cost	Other assumptions
Stationary li-ion batteries	Only self-generated	No (only losses)	65 €/kW 300/kWh	• E/P free • No connection to grid
Smart electric thermal storage	Only self-generated	Yes	350 €/kW (=44 €/kWh)	• E/P 8 hours • No connection to grid • Natural gas back-up assumed • Fluctuating heat demand profile (Horizon 2020 project)
Battery-electric vehicles	Self-generated and from grid	Yes	- (one BEV per household)	• 3.7 kW / 30 kWh • „Free lunch“ • No V2G • Time-varying charging availability profile (based on empirical German data) → available in 90% of hours

Scenario for 2030 leaning on EU Reference Scenario

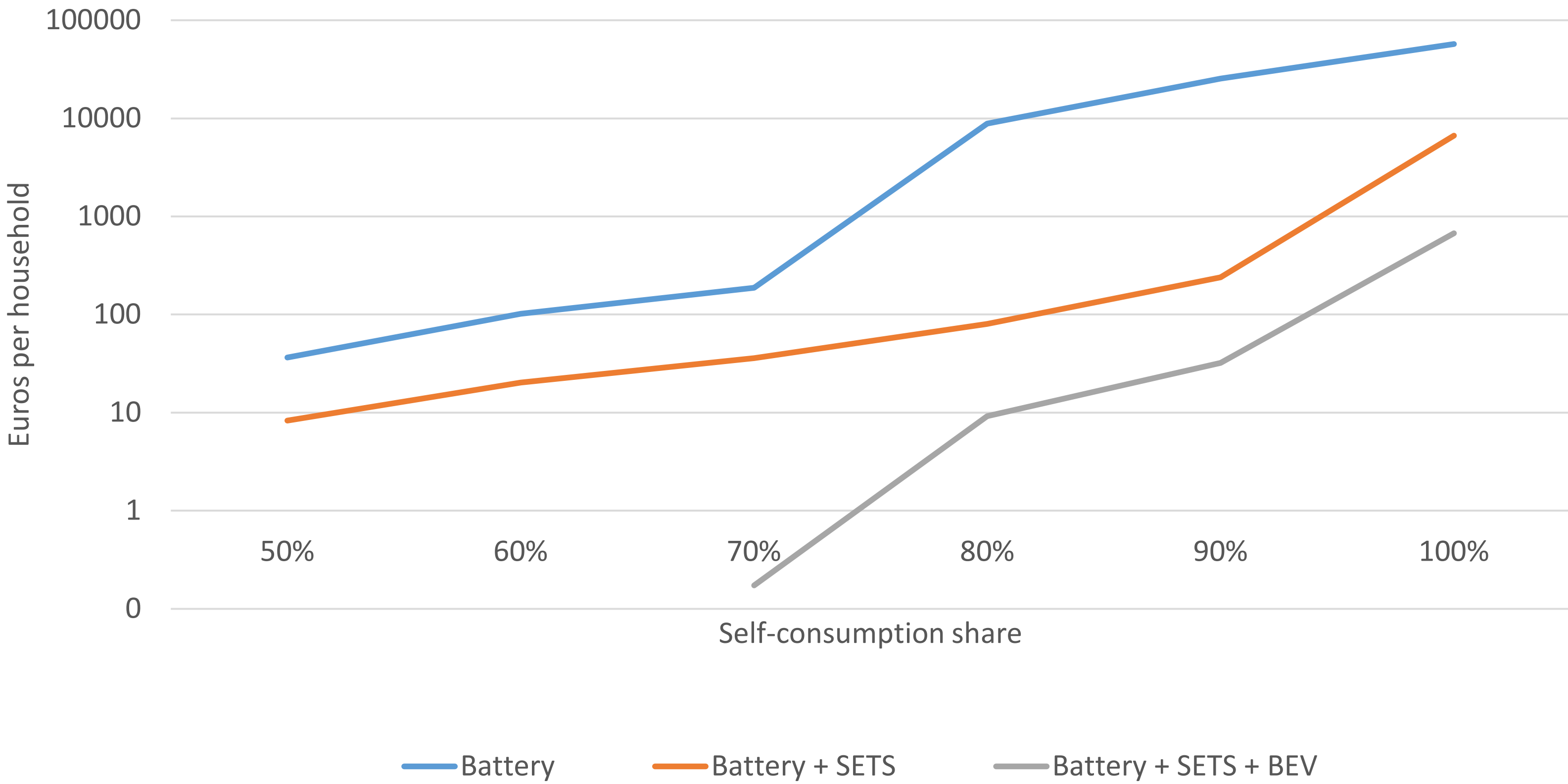
- ~53% renewables in electricity consumption
- 25% of PV capacity attributed to prosumage segment, such that yearly PV generation = yearly load (w/o sector coupling)
- ~3.5 million prosumage systems with 4.6 kWp each
- Baseline self-consumption ~40-50%
- Endogenous investments in prosumage storage or SETS



Further parameter assumptions

- System-average PV and load profiles also for prosumers
- No changes in generation portfolio
- No change in size of PV systems

4 Results: System costs, related to prosumager households

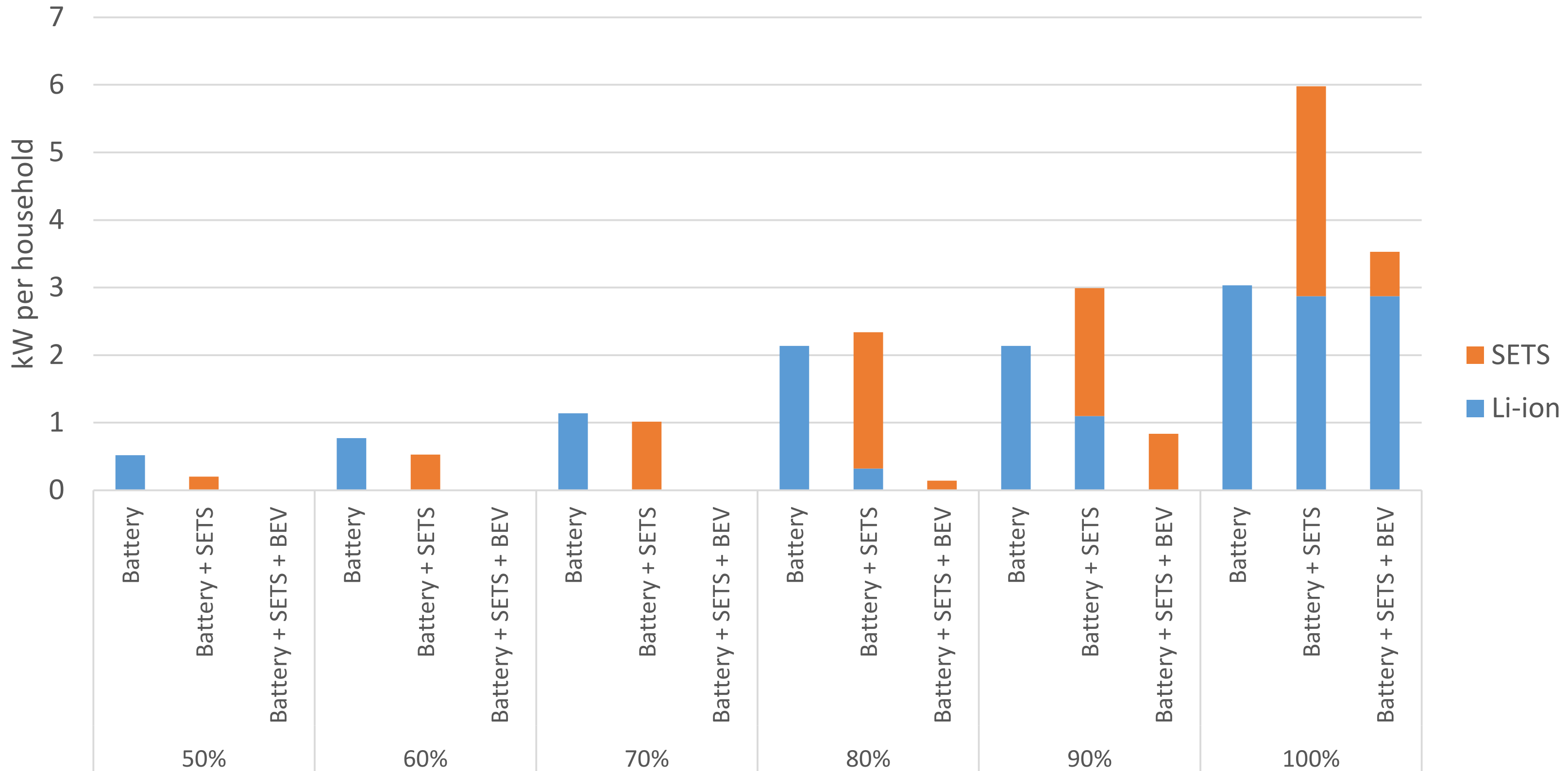


→ Battery only: system costs increase strongly beyond 70% (log scale)

→ Much lower costs if SETS are used, even more so if BEV are available

→ What are the drivers?

4 Results: Investments into storage (power) per prosumager household



→ Moderate investments in storage power (4 kWp PV) …

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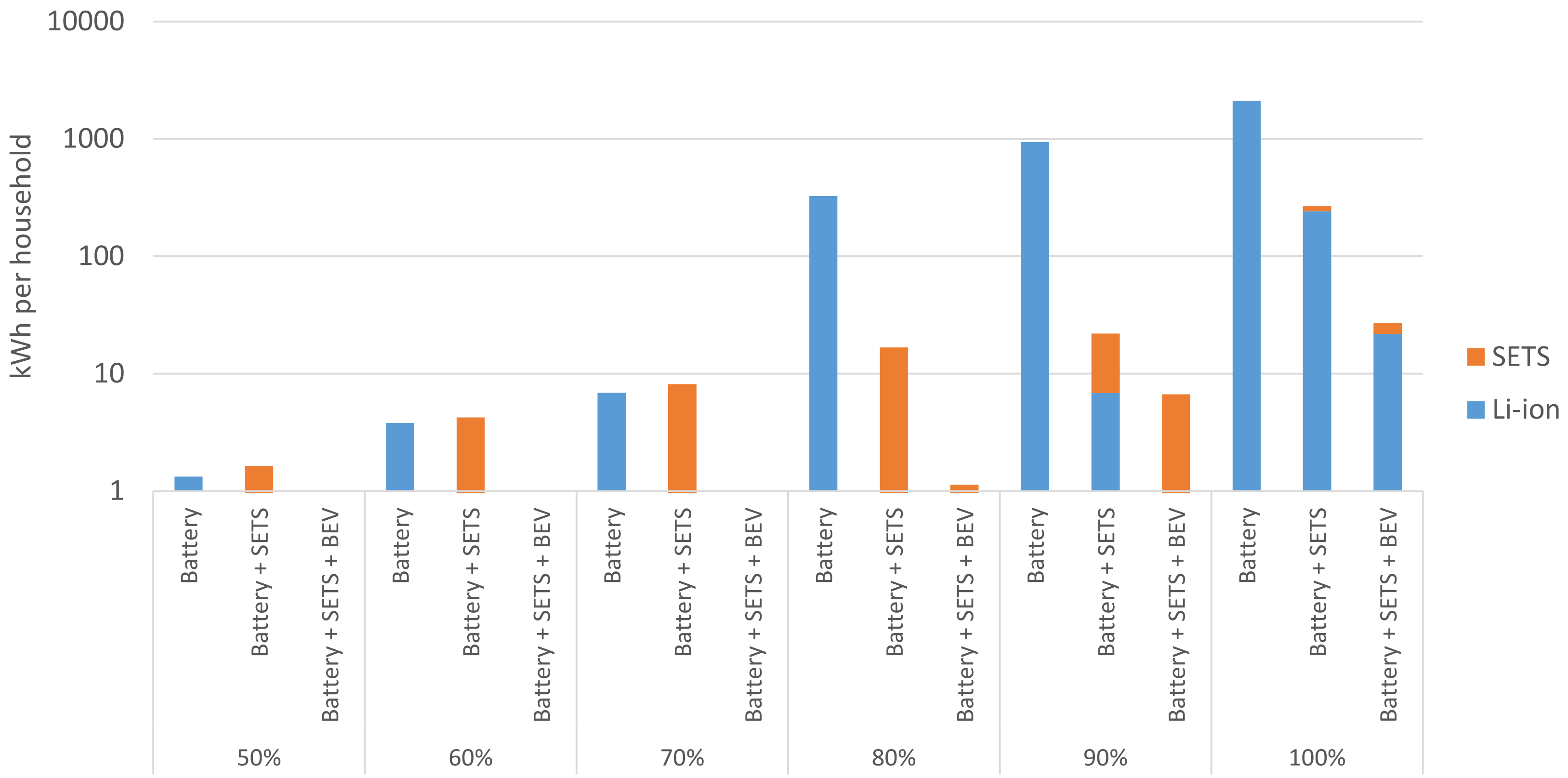
Results: Investments into storage (energy) per prosumager household

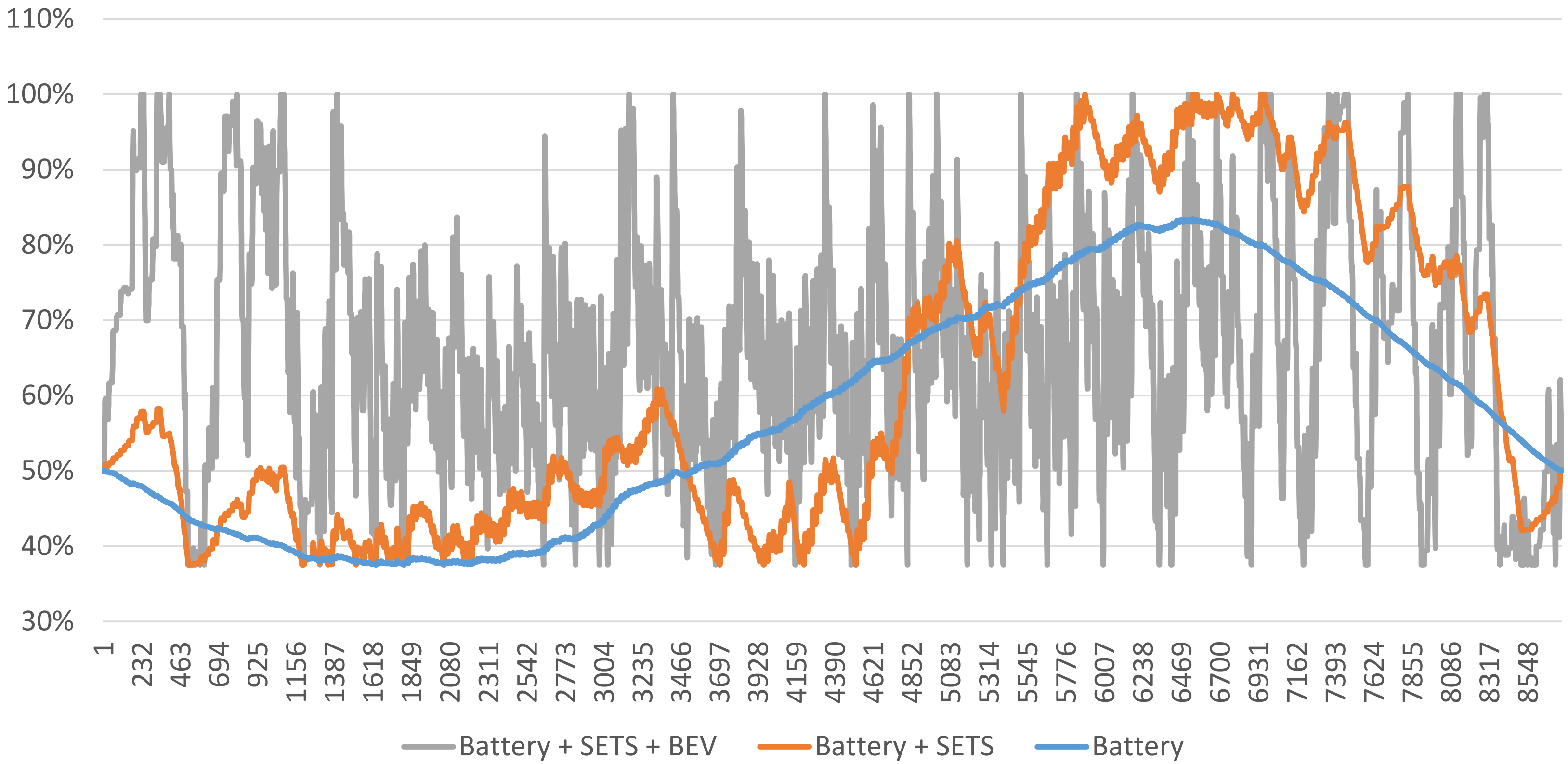


→ …but extreme investments into battery energy beyond 70%, “long-term storage”

→ 80-100%: much lower investments required if SETS (and BEV) are available

→ Drivers: differences in investment costs, flexibility, and electricity demand

Results: Hourly storage charging level of stationary batteries (100% cases)



→ Batteries only: seasonal smoothing of variable PV and load profiles

→ If BEV are available: much more plausible short-term balancing

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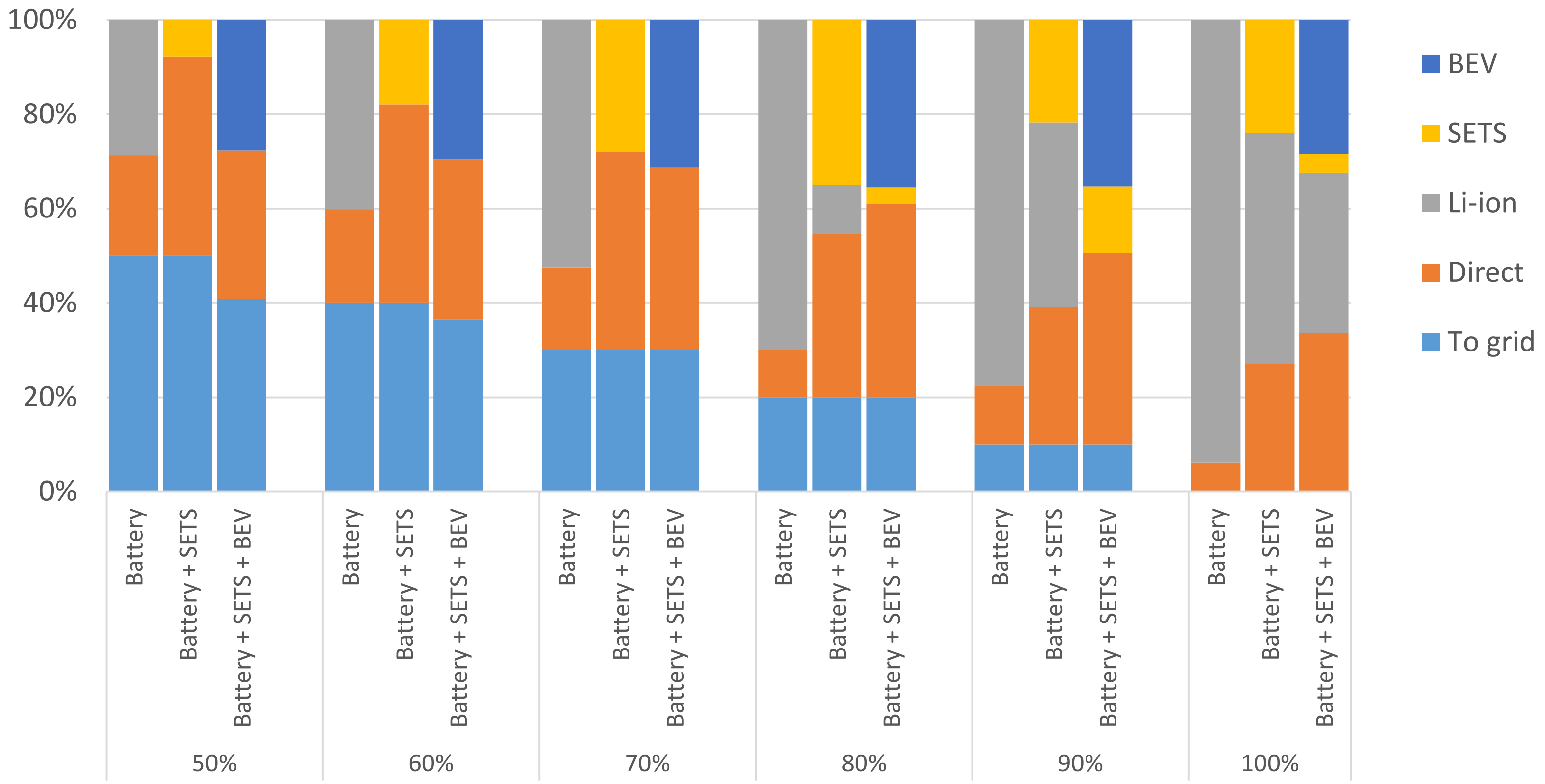
Results:
Shares of prosumagers' PV generation used for different options



→ Hardly any battery use if other options are available (except 100%)

→ BEV crowd out SETS

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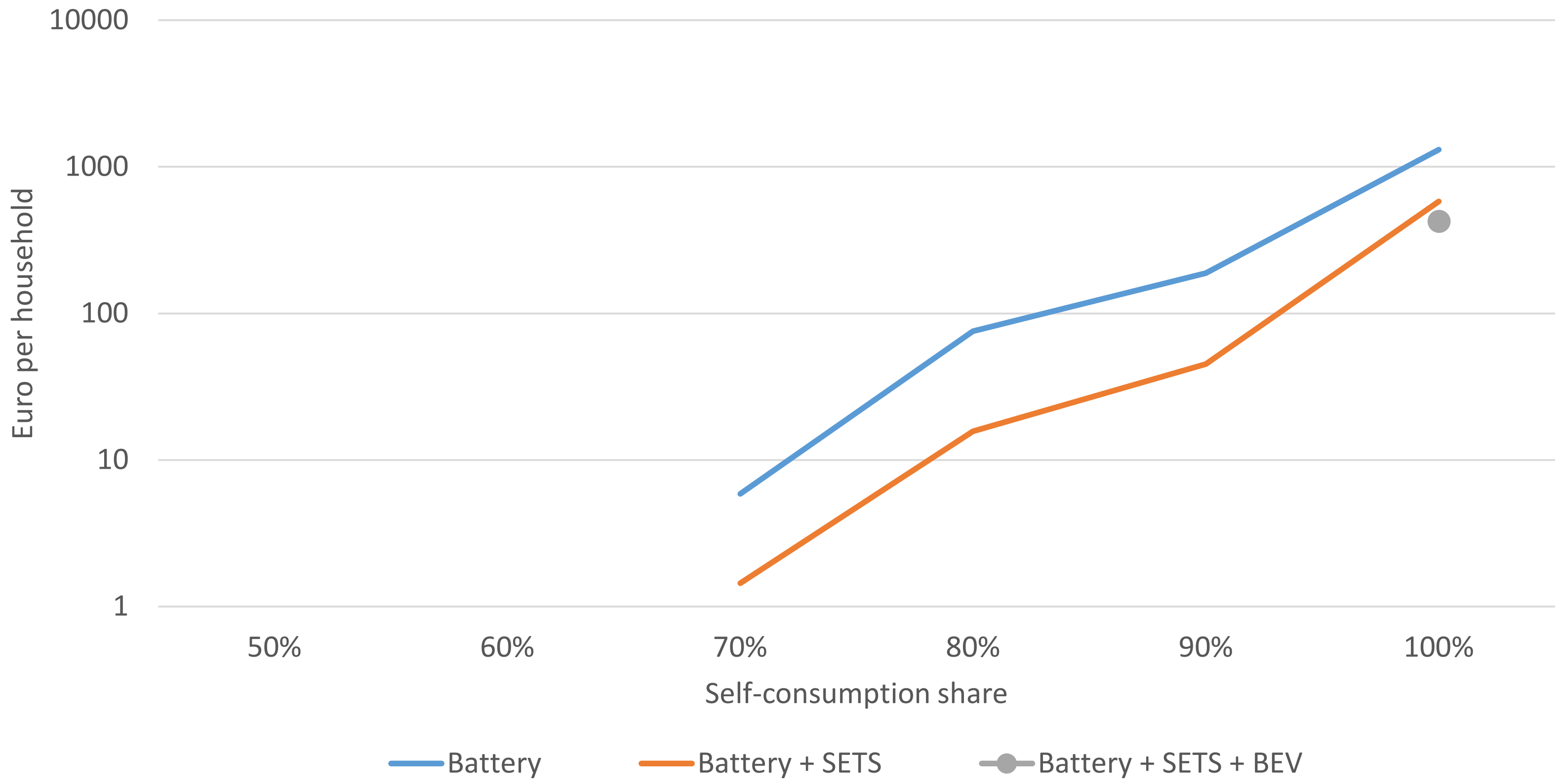
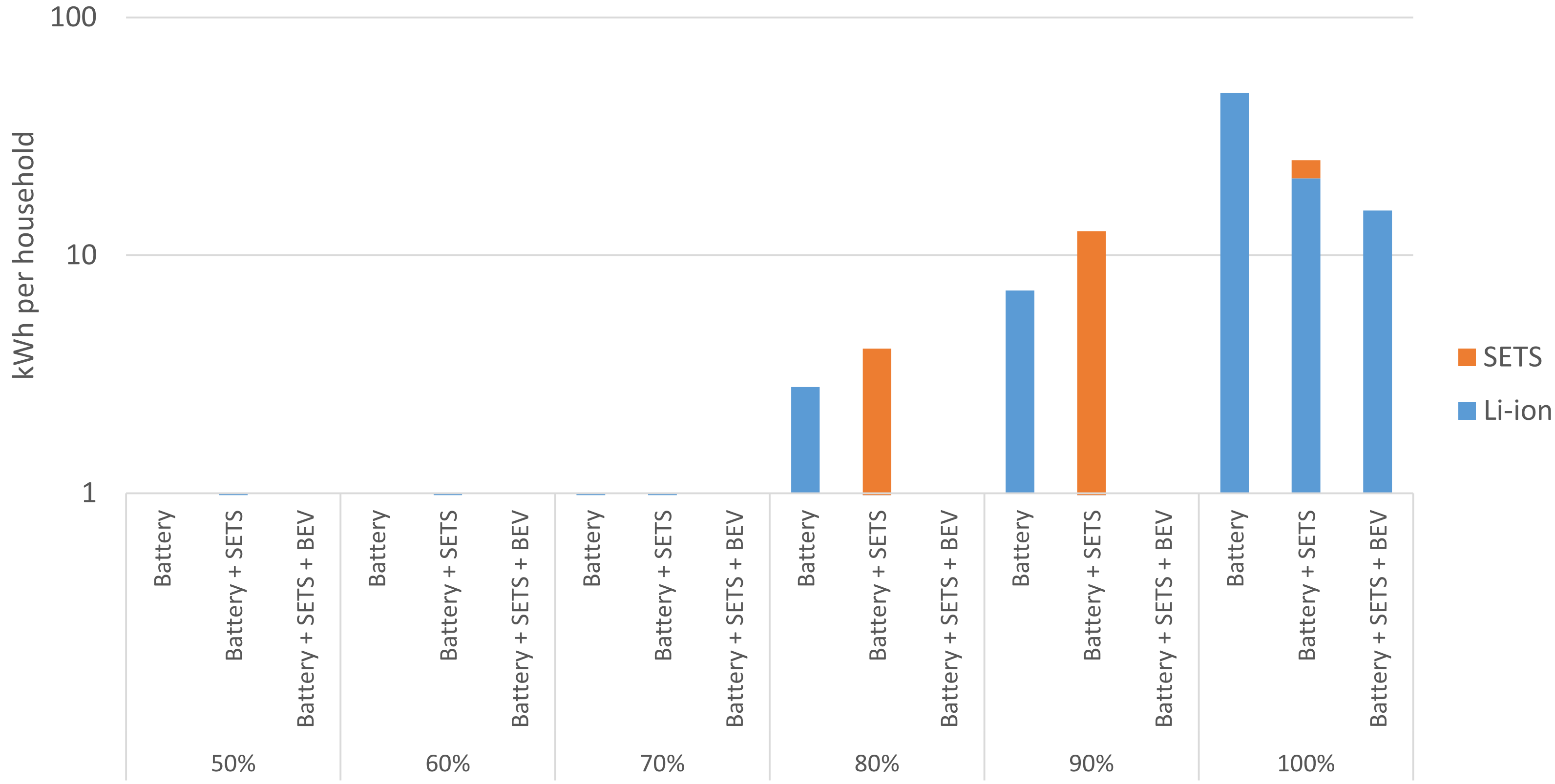
Sensitivity: 50% smaller PV installations
System costs, related to prosumager households



→ Higher "natural" self-consumption, much lower cost increases

→ Smaller benefits of SETS and BEV

4 Sensitivity: 50% smaller PV installations
Investments into storage (energy) per prosumager household



→ Much lower energy storage capacity required

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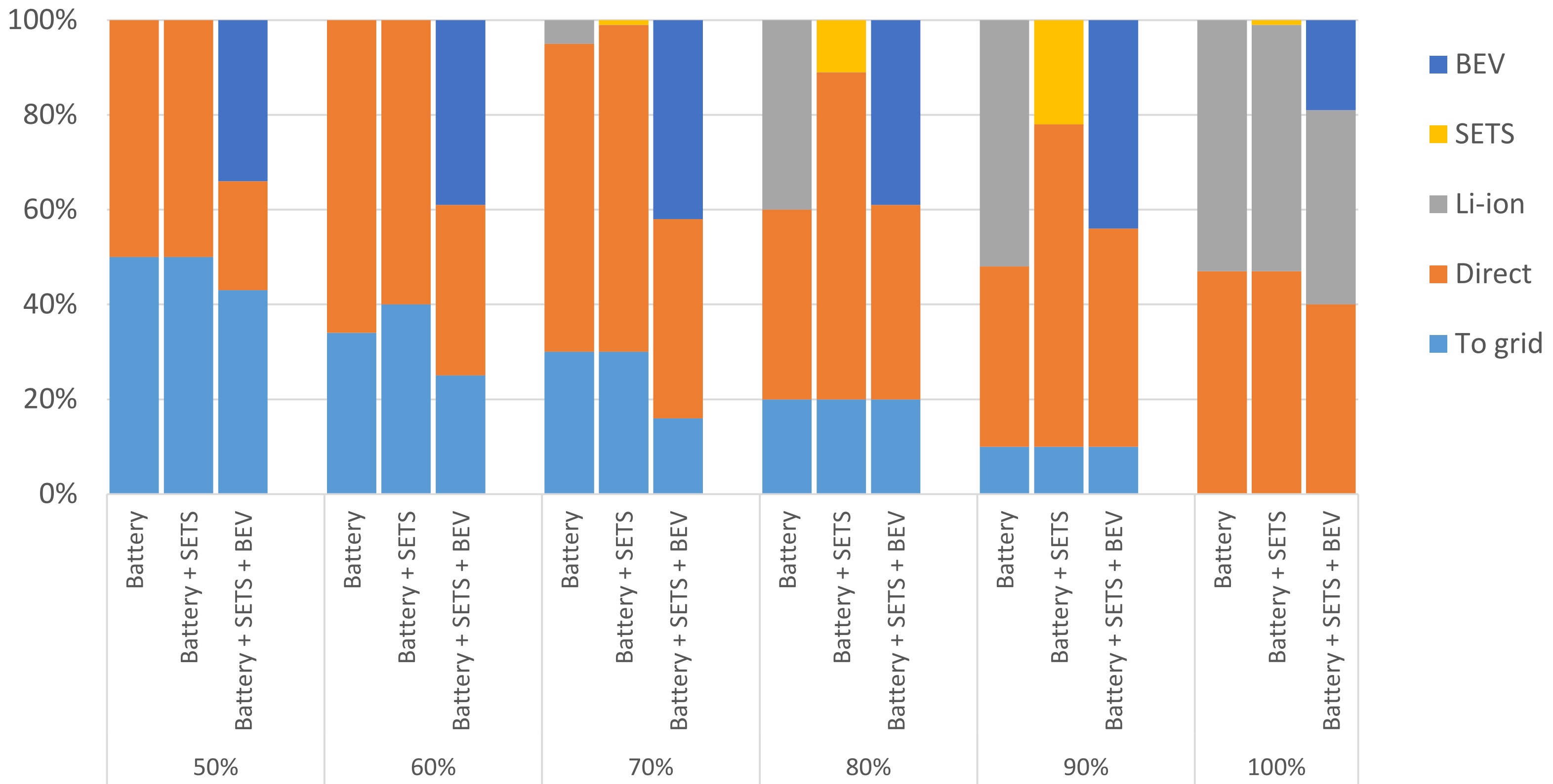
Sensitivity: 50% smaller PV installations
Shares of prosumagers‘ PV generation used for different options



→ Larger role for direct use of PV electricity

→ Less use of batteries and SETS

Prosumage: a growing niche

- Growth depends on consumer attitudes, technology cost and regulatory framework
- Here: no assessment if prosumage is desirable or not

Potential role of electric heating and electric mobility

- Batteries can increase self-consumption shares only to some extent
- SETS and BEV facilitate higher (cheaper) self-consumption shares
- Despite restrictions related to time profiles of heating and mobility demand

(Preliminary) conclusions

- If households aim to achive higher self-consumption, increased sector coupling is likely (and desirable)
- Policy / regulation: avoid distortions at sector borders

Future research

- Exploration of different BEV profiles
- Other sector coupling options: hybrid / direct electric heating
- Further investigation of alternative PV sizing
- Impacts on overall generation portfolio, RES shares, and CO_2 emissions
- Explicit consideration of regulatory environment
- Prosumage may help to unlock demand-side flexibility potentials
  → only „own“ electricity and no aggregator involved
- Complementary research: desirable amount of various sector coupling strategies in long-term decarbonization scenarios

Thank you for listening

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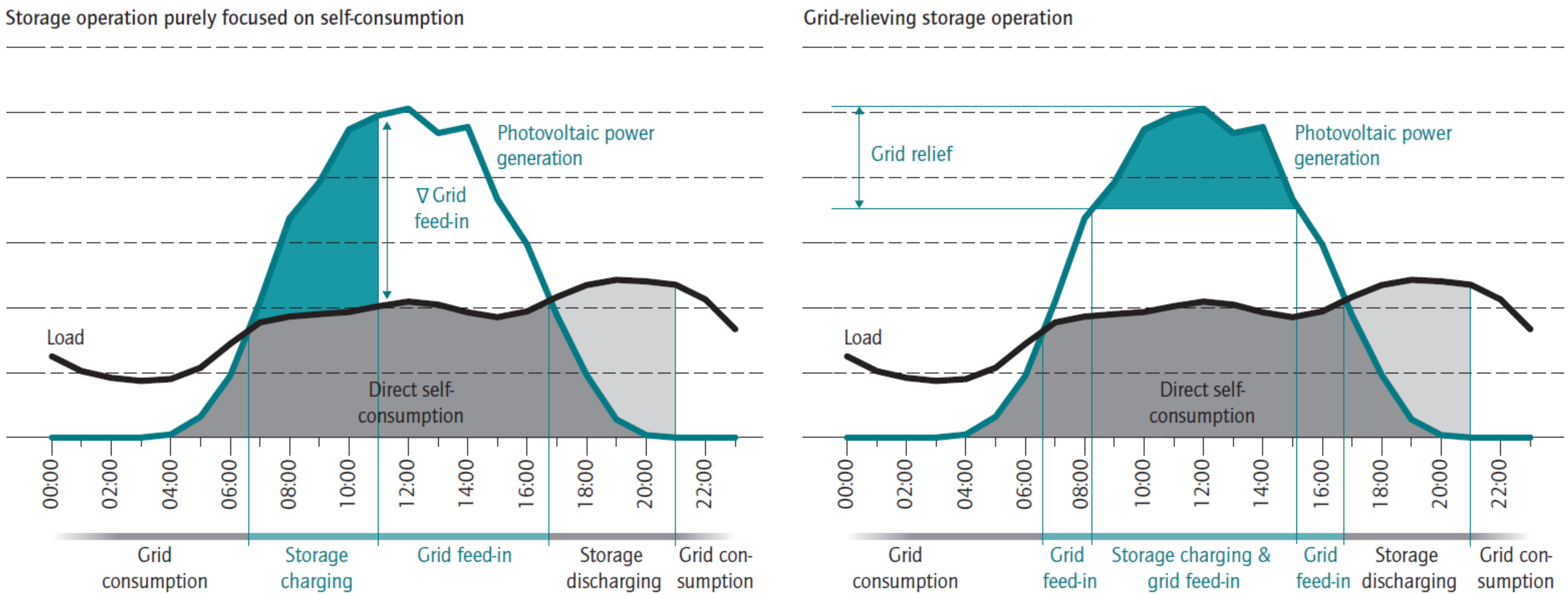
Backup: distribution grid relief



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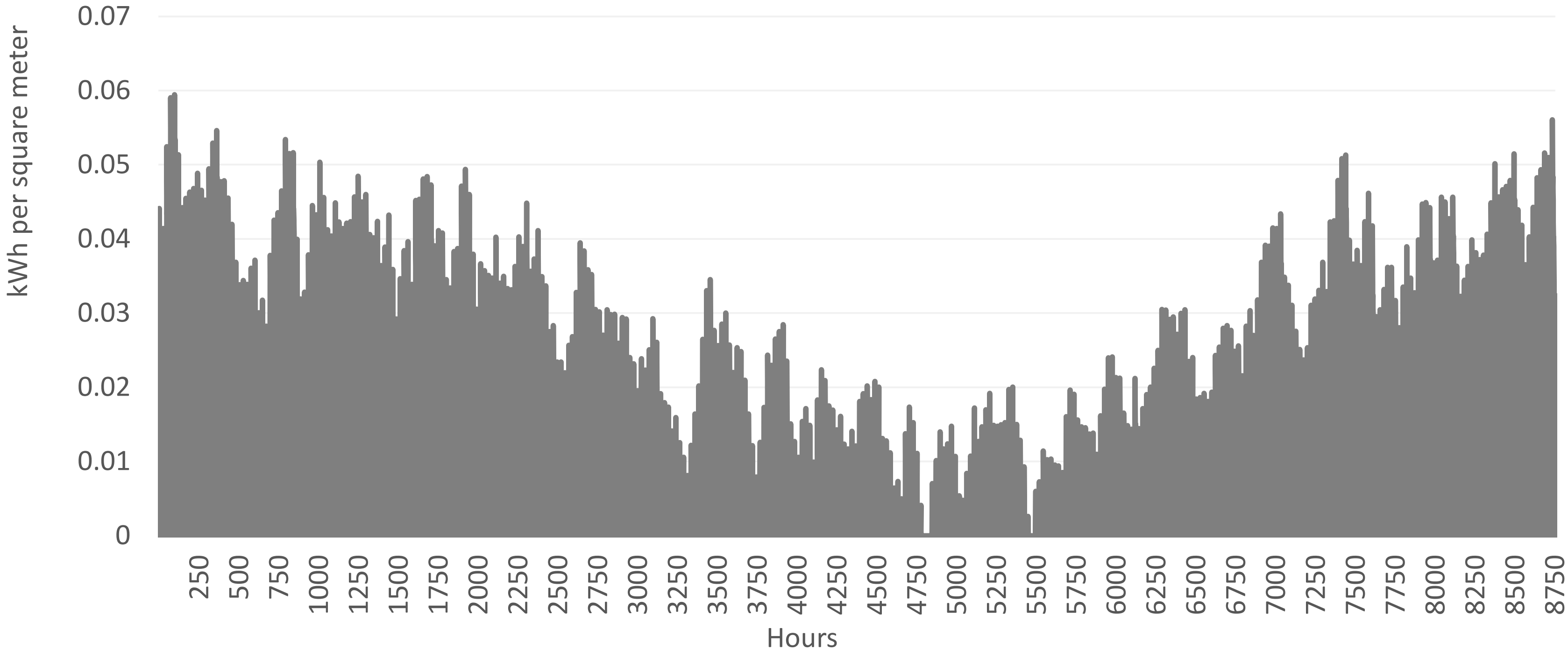
Backup: hourly heat demand profiles



- Taken from European Horizon 2020 research project RealValue
- Derived from dynamic simulations with RWTH building model
- 12 building archetypes; here we pick one-family houses with medium energy demand