Current development on the German day-ahead spot market: curse or blessing for the utilization of flexibility by households?

Judith Stute, Matthias Kühnbach - 7th AIEE Energy Symposium, Session 11, 15.12.2022 16:00 – 17:30

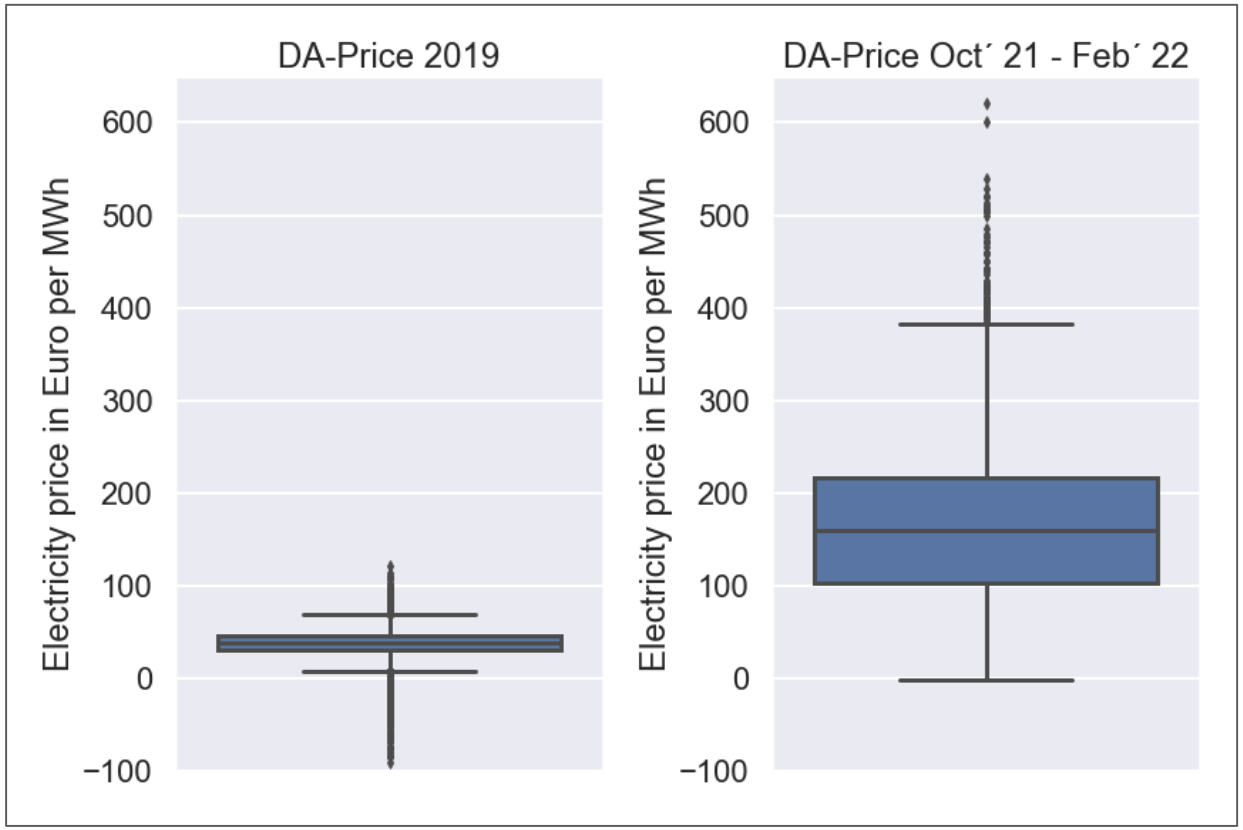
01

Motivation & Research Questions

Motivation & Research Questions

Motivation - Current development on the day-ahead spot market in Germany

- **Day-ahead spot market prices in Germany did rise sharply from 2019 to 2022.**
- **Development has an impact on household electricity prices.**
- **Dynamic electricity tariffs based on the day-ahead spot market price are already available in Germany.**



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Motivation & Research Questions

Research Questions

1. What are the effects of the changes in the spot market for the economic attractiveness of using a home energy management system combined with dynamic electricity tariffs for household customers?

2. What does this mean for flexibility deployment of different technology assets in households (electric vehicles, heat pumps, battery storage systems)?

02

Method

Method

Model for flexibility usage in buildings - Overview

Model-based mapping of technology assets

Option a:

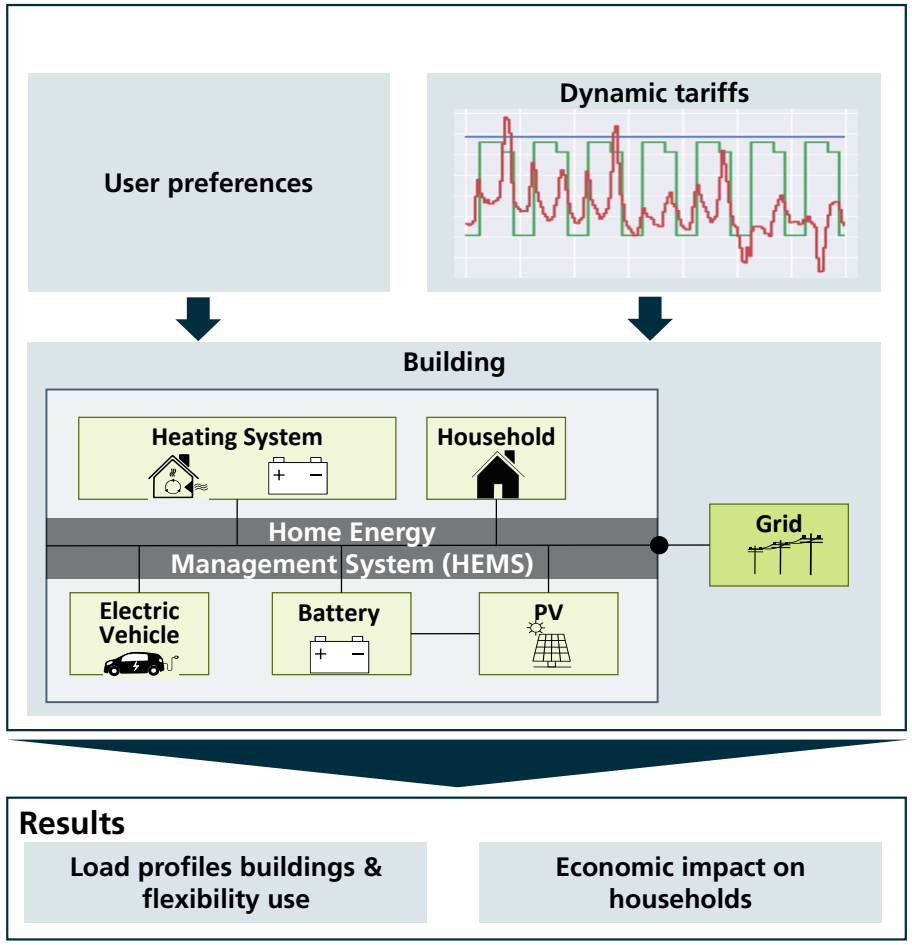
inflexible operation of heat pumps, electric vehicles and battery storage systems

representation of the status quo → simulation model

Option b:

flexible operation of heat pumps, electric vehicles and battery storage systems

using a home energy management system (HEMS) → MILP optimization model

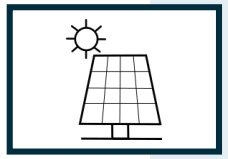


03

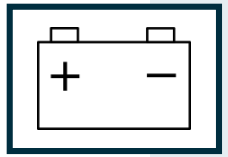
Case Study

Case Study
Households

316 measured household load profiles with socio-demographic data



Installed power by annual household power consumption



Usable battery capacity by annual household power consumption

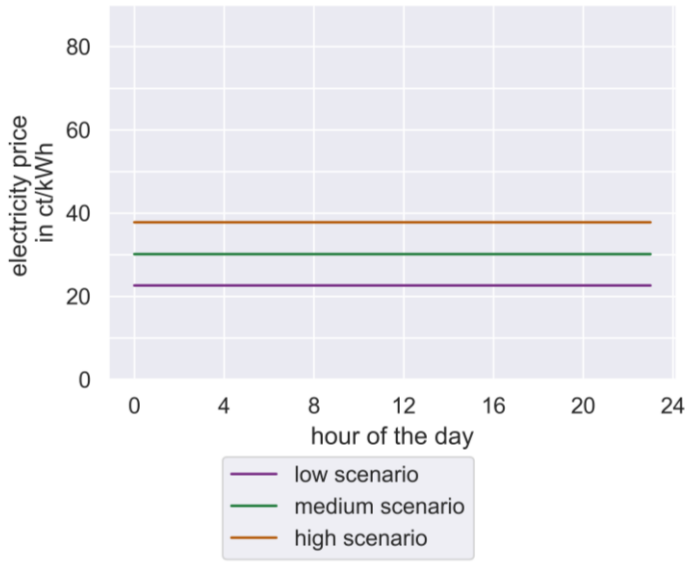
Charging capacity: 11 kW
Assignement of driving/stopping profile to household via socio-demographic data

Dimensioning of heat pump size via living space and heat demand of households

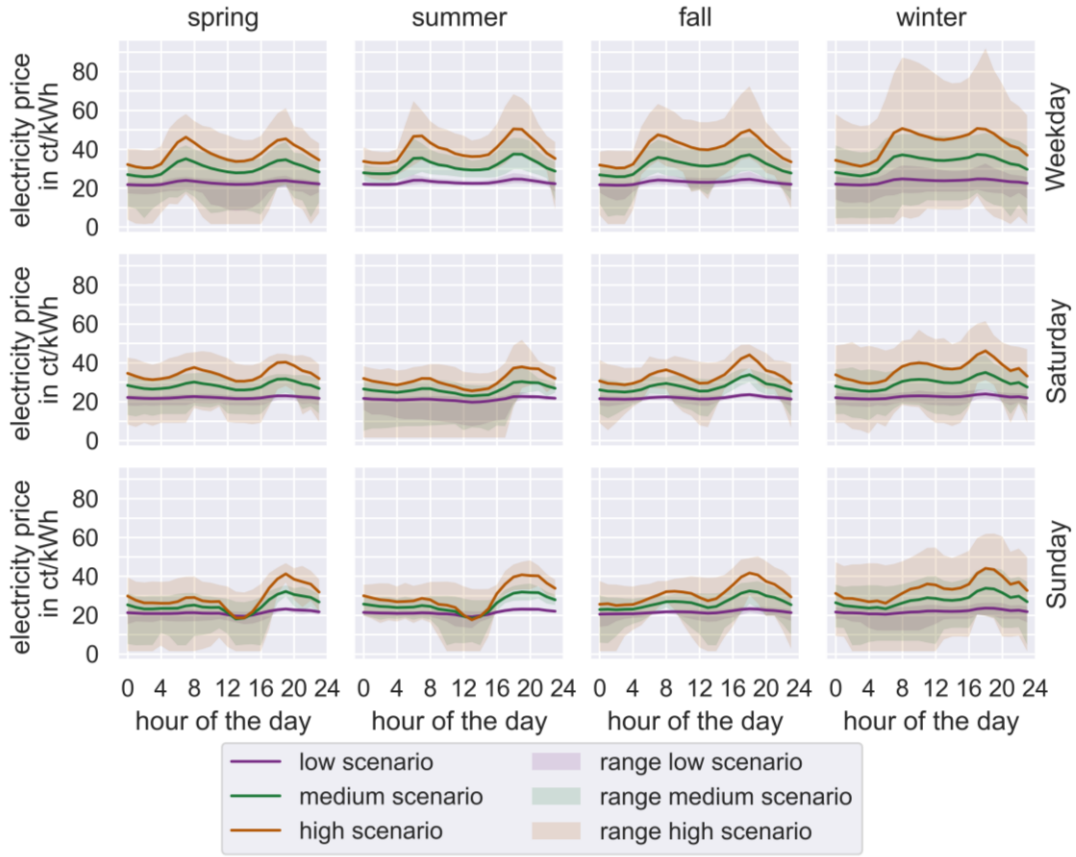
Case Study

Electricity tariffs considered

Static tariff



Dynamic tariff



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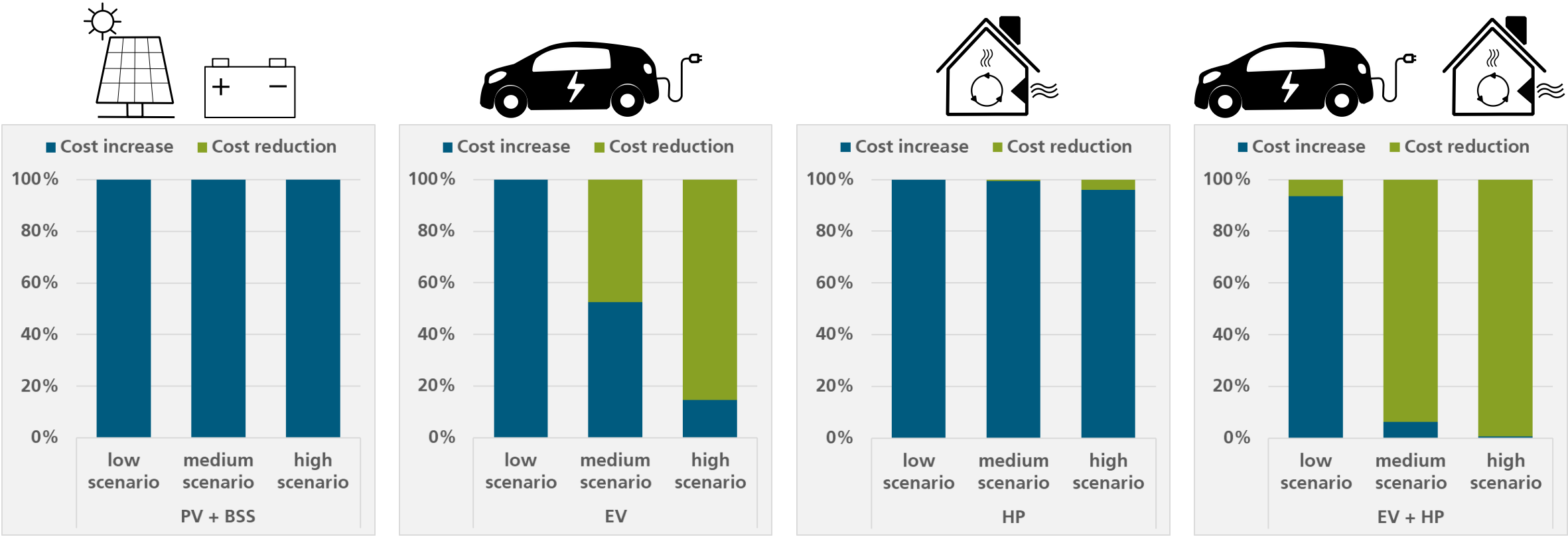
04

Results

Results

Economic effects on households - Overview

Cost inrease vs. cost reduction for households considering electricity purchase costs, metering point operation costs and invest in HEMS



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Results

Economic effects on households - Overview

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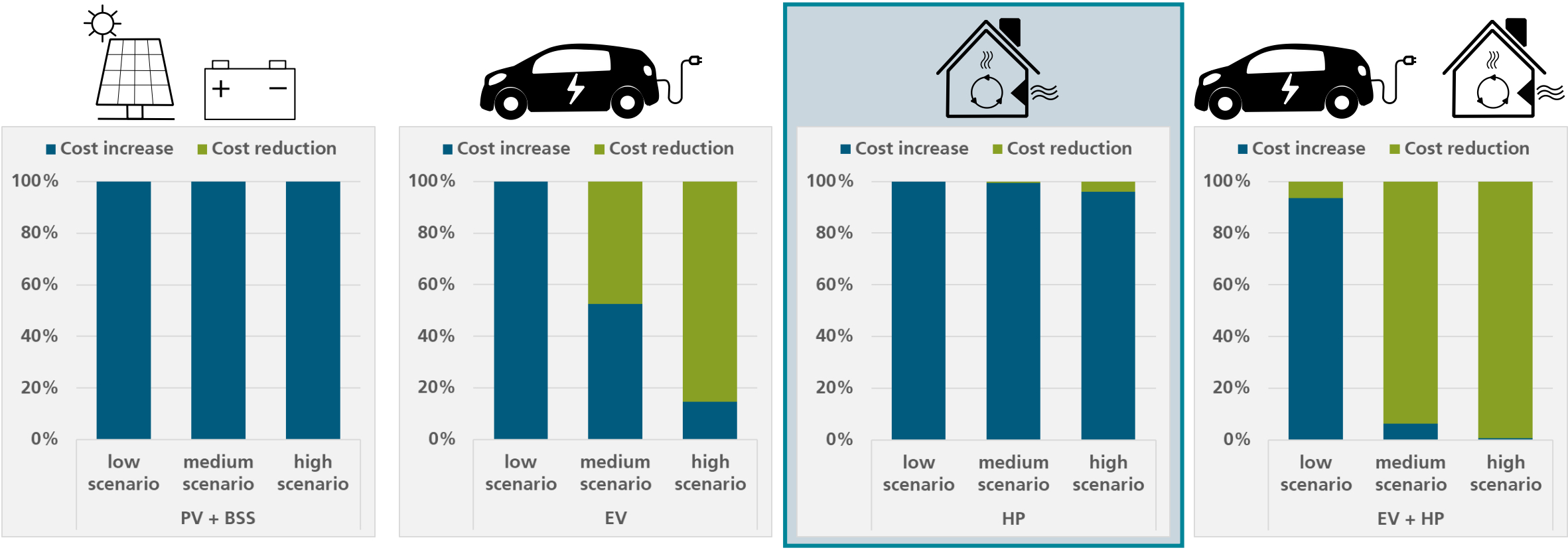

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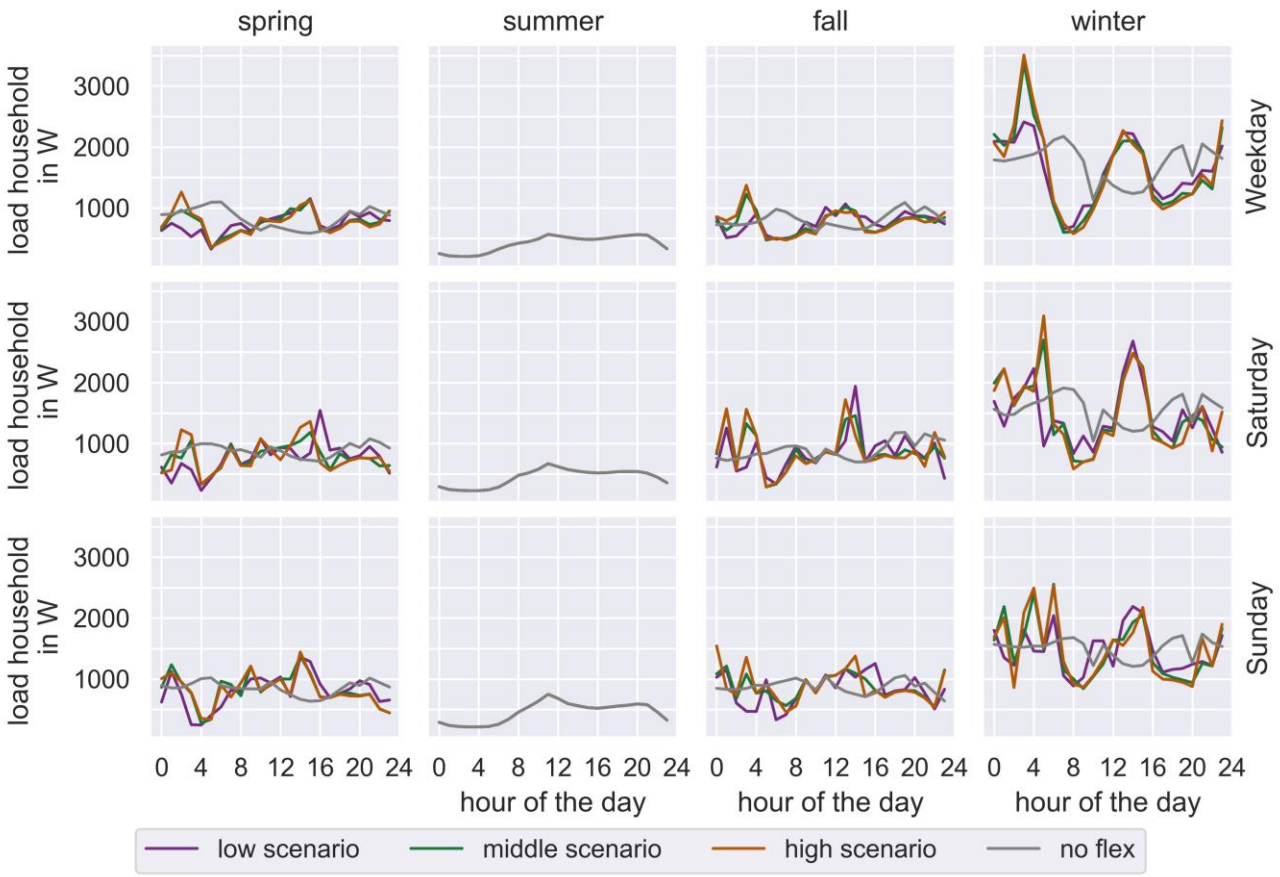
Results

Deep dive – Households with heat pump systems

Average aggregated household load curves by season and type day

Heat pump

- In winter:
  - newly emerging load peaks in the early morning hours and in the afternoon
- In spring and fall:
  - shift to low price hours in the early morning and in the afternoon
  - Shift into early morning hours is smaller in the low scenario → relationshop between price difference, temperature-dependent COP and temperature-dependent supply temperature



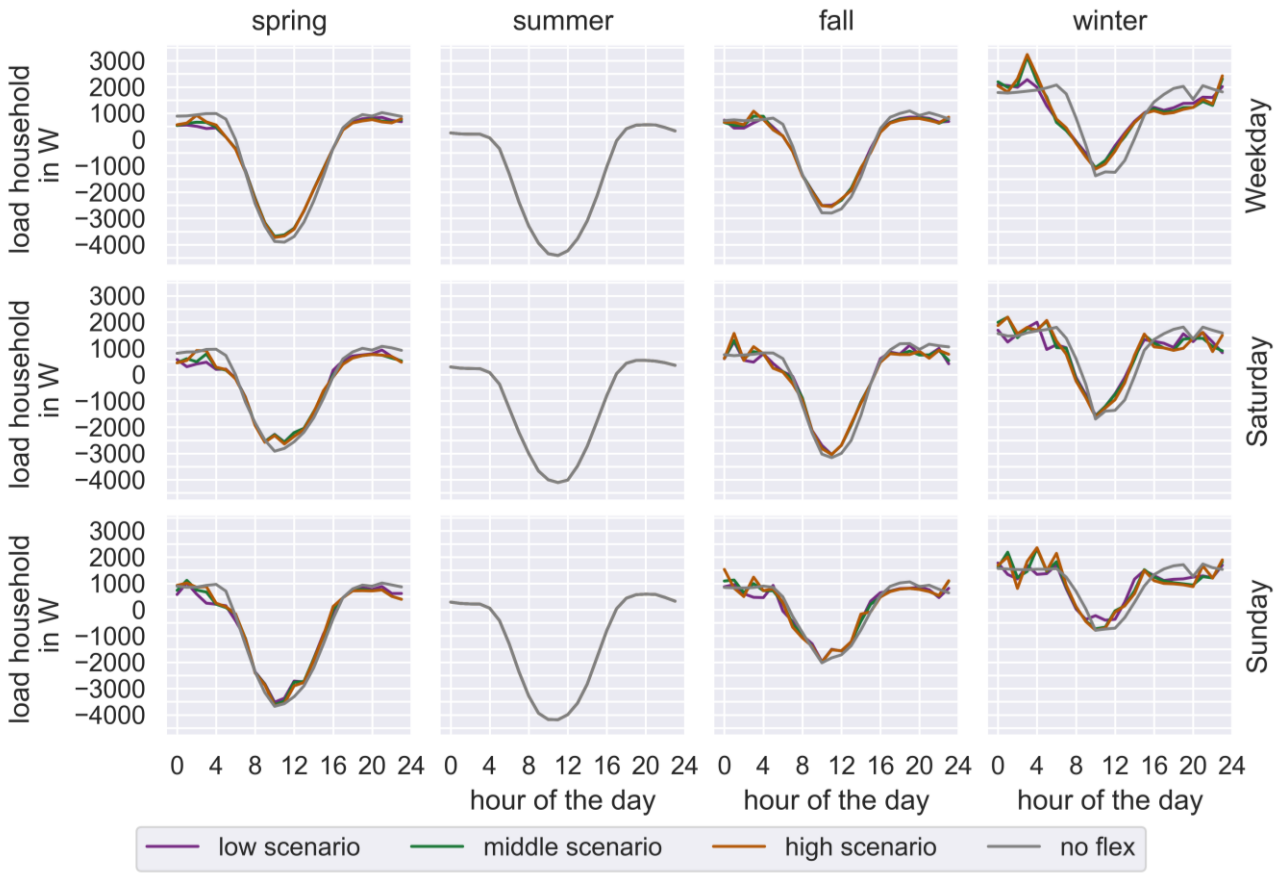
Results

Deep dive – Households with heat pump systems

Average aggregated household load curves by season and type day

Heat pump + PV system

- In general:
  - load shifting to times with PV generation
  - Lower increase in peak loads than in households without PV system
- In winter:
  - Stronger orientation to electricity prices due to lower PV generation



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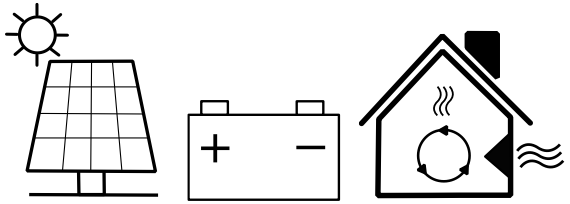
Results

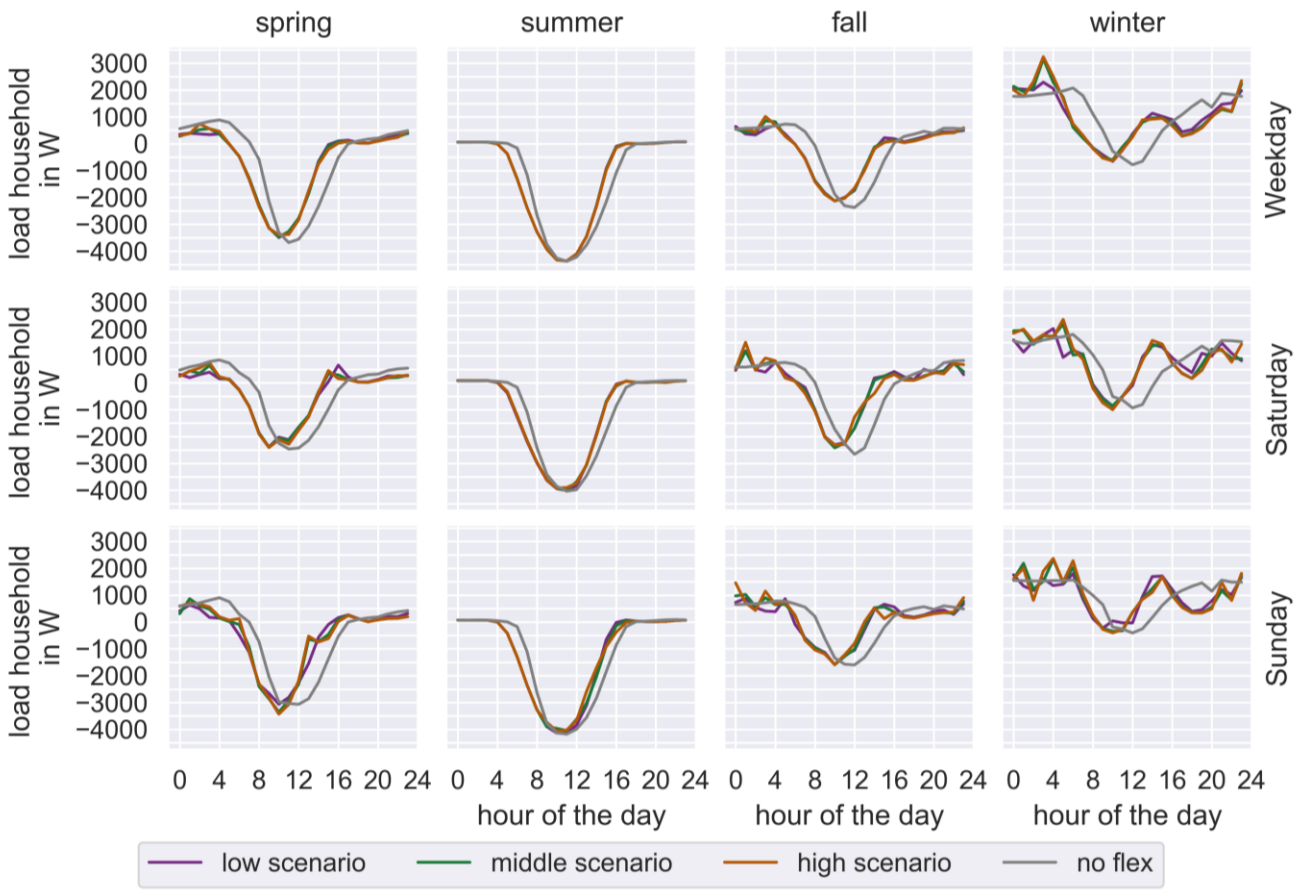
Deep dive – Households with heat pump systems



Average aggregated household load curves by season and type day

Heat pump + PV system + battery storage system

- In general:
  - Similar effects as for household with only heat pump and PV system
- In winter:
  - Stronger orientation to electricity prices due to lower PV generation and usage of energy from PV system for battery



Results

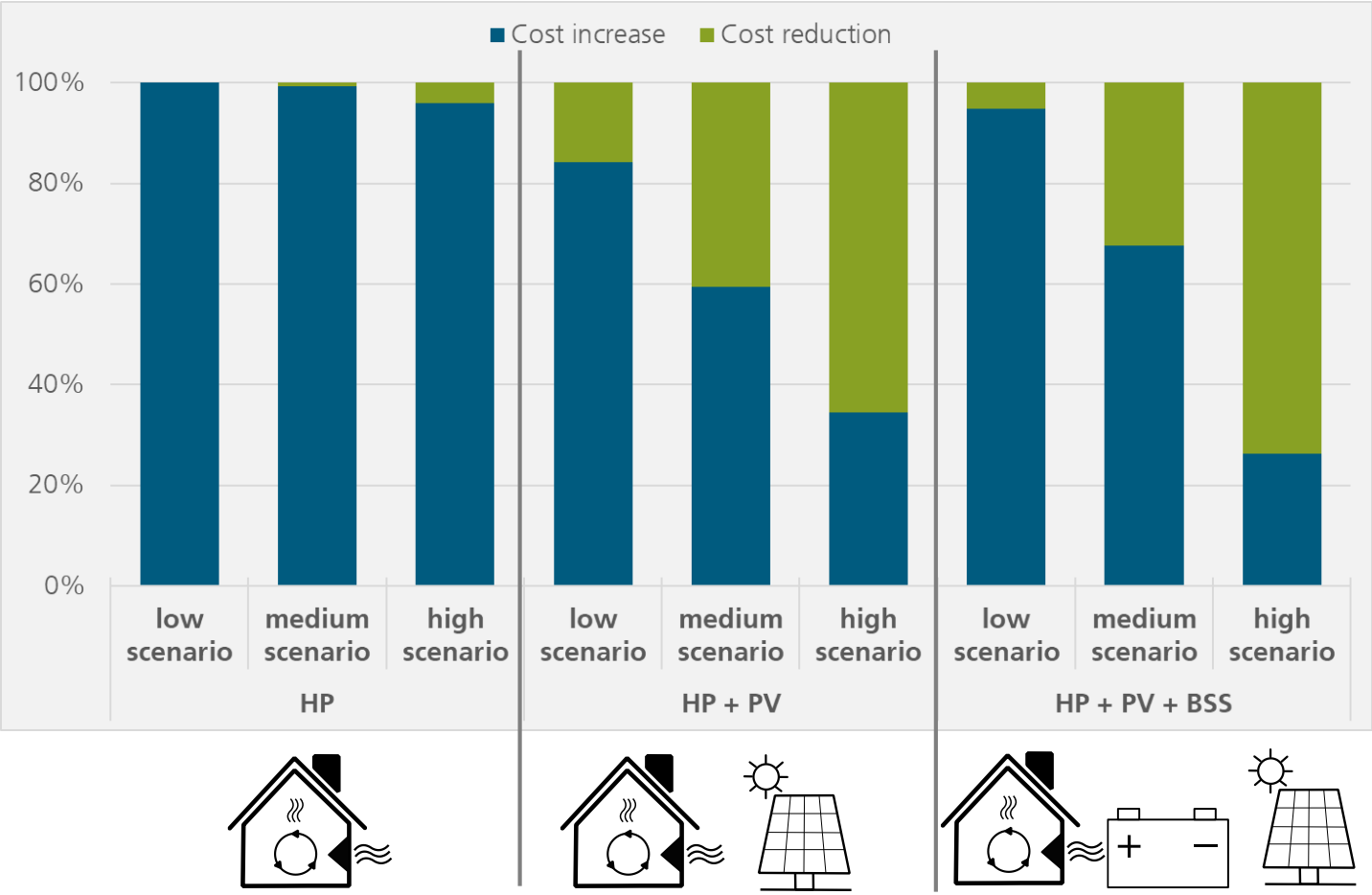
Deep dive – Households with heat pump systems

Economic effects – incl. metering point operation costs and invest HEMS for dynamic tariff utilzation

Metering point operation costs: 7.50 €/m

Invest HEMS: 167 €/yr.

- No cost reduction for households with only heat pump in low scenario
- Cost reduction can be seen in the majority of cases for households with additional PV system or battery storage system in high scenario
- Combination of the utilization of HEMS for dynamic tariffs and increasing self-consumption



05

Summary, Discussion and Outlook

Summary, Discussion and Outlook

Summary

1 **What are the effects of the changes in the spot market for the economic attractiveness of using a home energy management system combined with dynamic electricity tariffs for household customers?**

Dynamic tariffs in combination with a HEMS can lead to cost reduction for household's electricity bills

- Effect is highest for households with an electric vehicle and a heat pump
- Costs savings (unit rate) need to be high enough to compensate for invest in HEMS and metering point operation costs
- Cost savings for households with a heat pump can be increased with PV system and battery storage system → combination of utilization of dynamic tariffs and increase in self-consumption

The higher the price scenario and price spread, the more attractive using dynamic tariffs in combination with a HEMS

Summary, Discussion and Outlook

Summary

2 **What does this mean for flexibility deployment of different technology assets in households (electric vehicles, heat pumps, battery storage systems)?**

Focus on heat pumps:

- For households with heat pumps we see an increase in peak load in the early morning hours and in the afternoon, especially in winter

- Slight increase in peak load in the morning hours for households with heat pump, PV system and battery storage system

Summary, Discussion and Outlook

Discussion & Outlook

Discussion & Outlook

Brine/water heat pumps with no outside temperature-dependent COP might cause higher peak loads in low price times

Analyze the effect of dynamic tariffs for households with heat pumps and PV systems or battery storage systems further by comparing it to the case of households with HEMS but static tariff

Analyze the results deeper for electric vehicles and battery storage systems

Investigate the effects on power distribution networks and grid expansion considerations

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