Karlsruher Institut für Technologie

Institut für Industriebetriebslehre
und Industrielle Produktion

Effects of the tenants electricity law on energy system layout and landlord-tenant relationship in a multi-family building in Germany

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INSTITUTE FOR INDUSTRIAL PRODUCTION (IIP)
Chair of Energy Economics (Prof. Dr. W. Fichtner)

Agenda

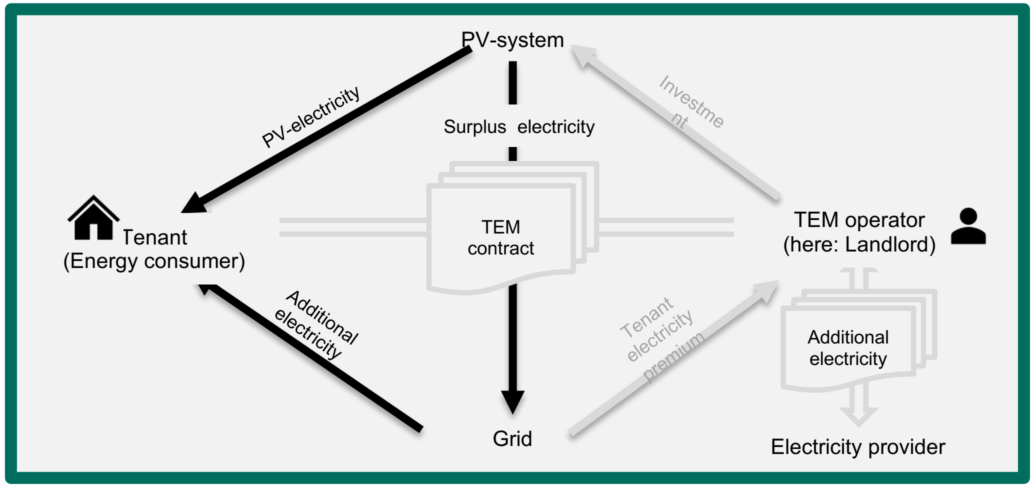
- Motivation and the tenant electricity model (TEM)
- Research question and methodology
- Profitability of the TEM
- Synergetic effects for tenants and landlords
- Influence of electric vehicles
- Discussion of assumptions and findings
- Conclusion/outlook

Motivation

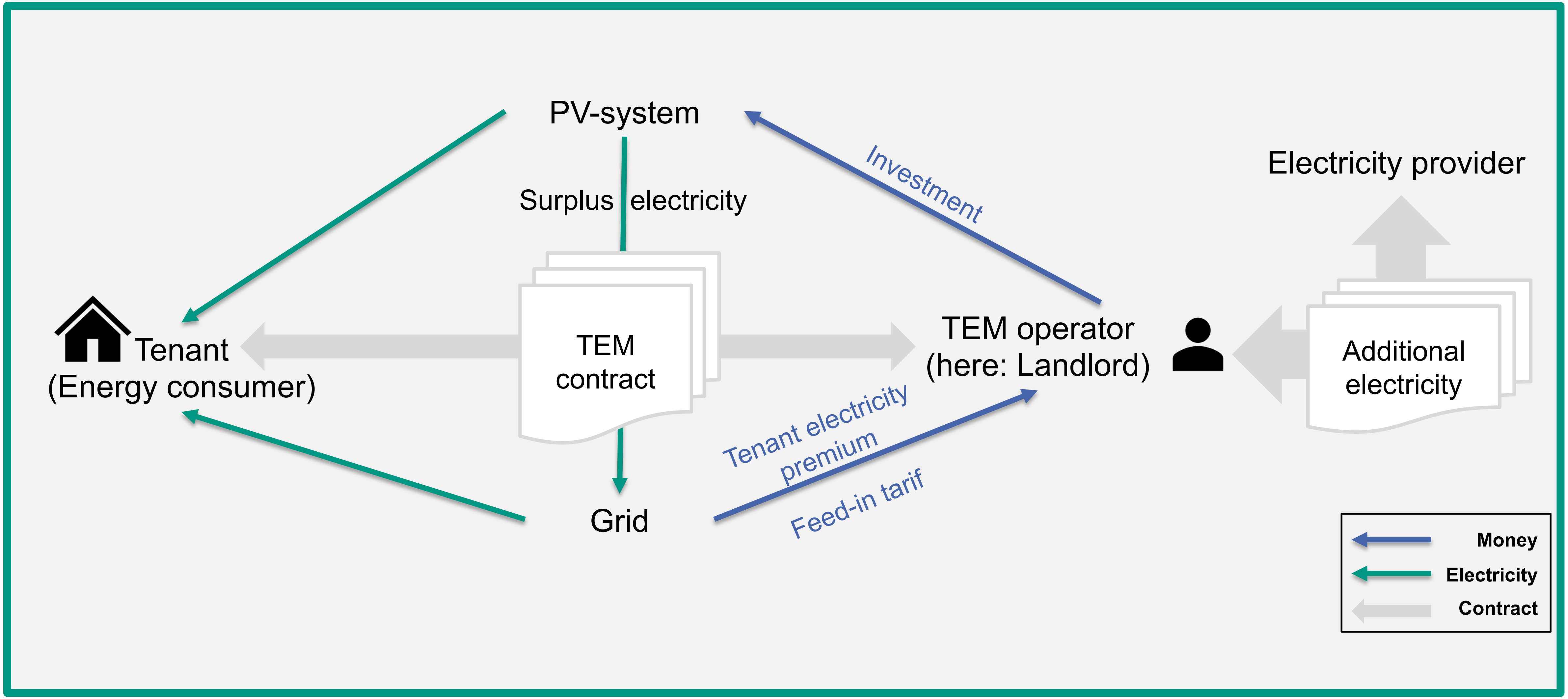
- Building sector accounts for a high share of emissions in Germany
- Building stock of multi-family buildings (MFB) in particular
- Energy transition depends on the landlords willingness to invest, tenant-landlord-dilemma
- New demand through electric vehicles (EVs)

- ***How to integrate MFBs in the energy transition process?***

- 2017, newly introduced legislation: ***The tenants electricity law***
  - Financial aid for PV-systems
  - Financial aid for CHP-systems



The tenant electricity model (TEM)



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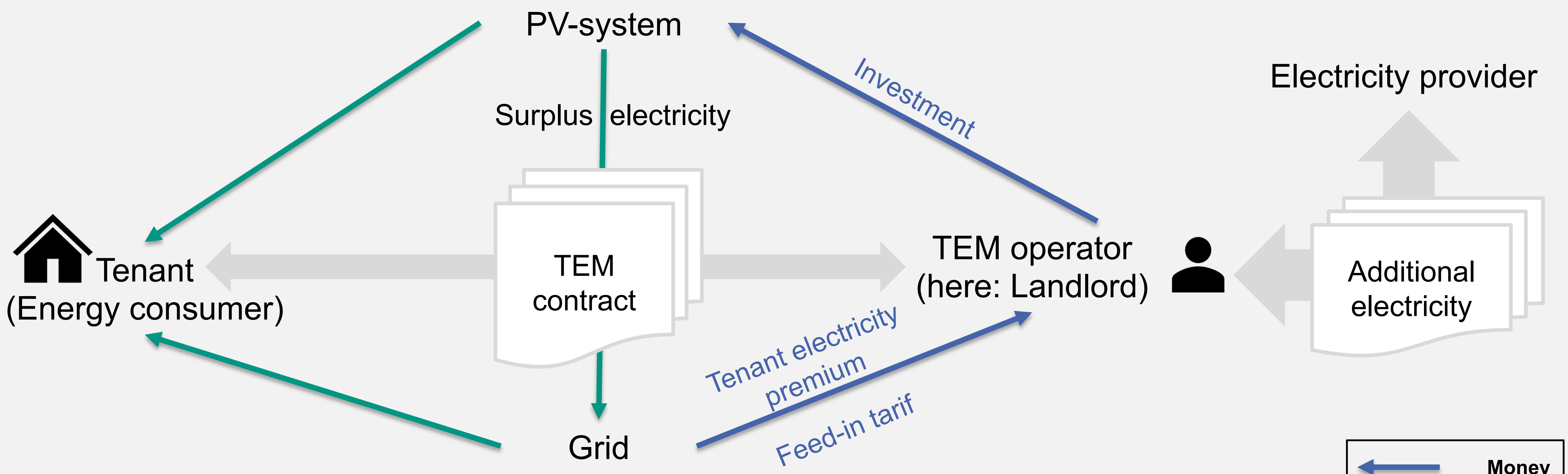

$$\Delta Cost_{el,tenant} = Cost_{el,old} - Cost_{(el,TEM)}$$

$$NPV = -Inv + acf$$

$$acf = \left(c_{\mathrm{TEM}} \cdot el_{TEM} - c_{Provider} \cdot el_{grid}\right) \cdot CRF$$

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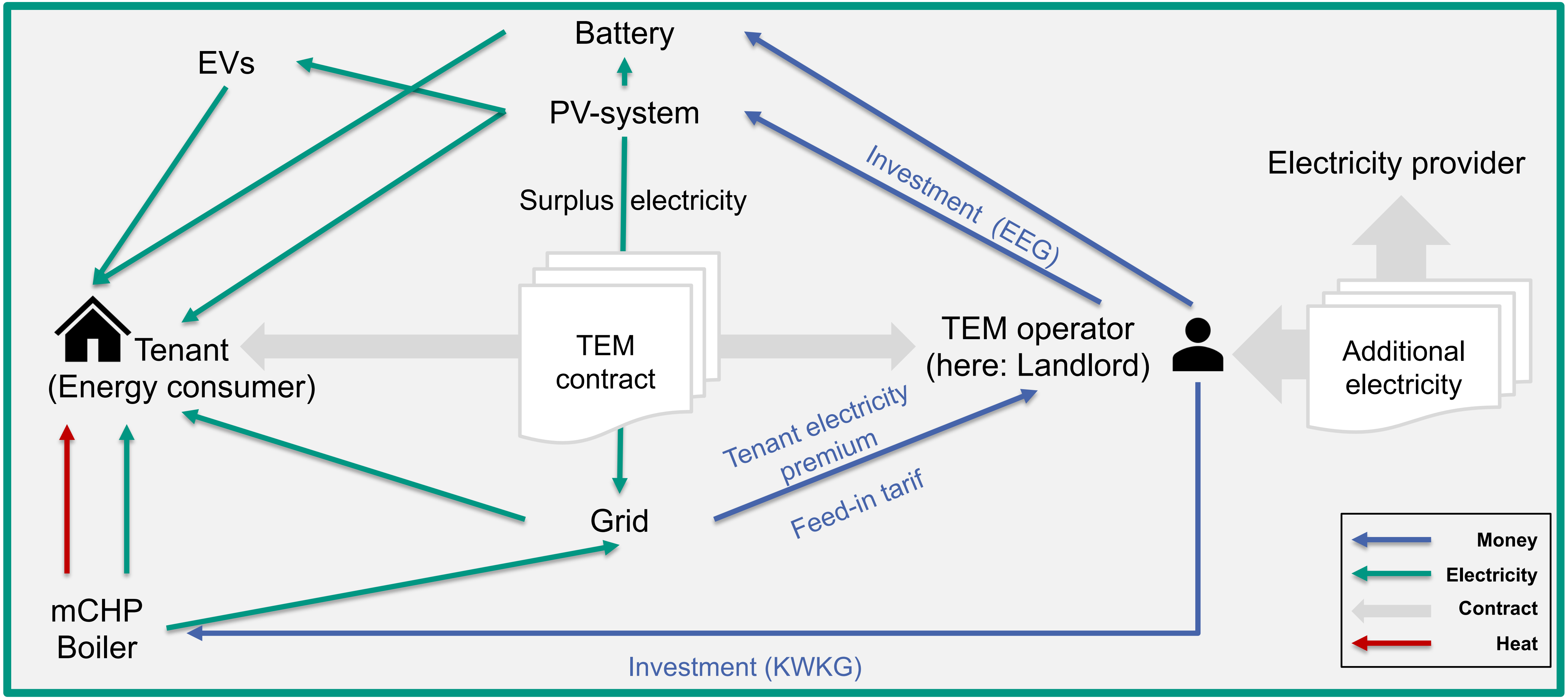

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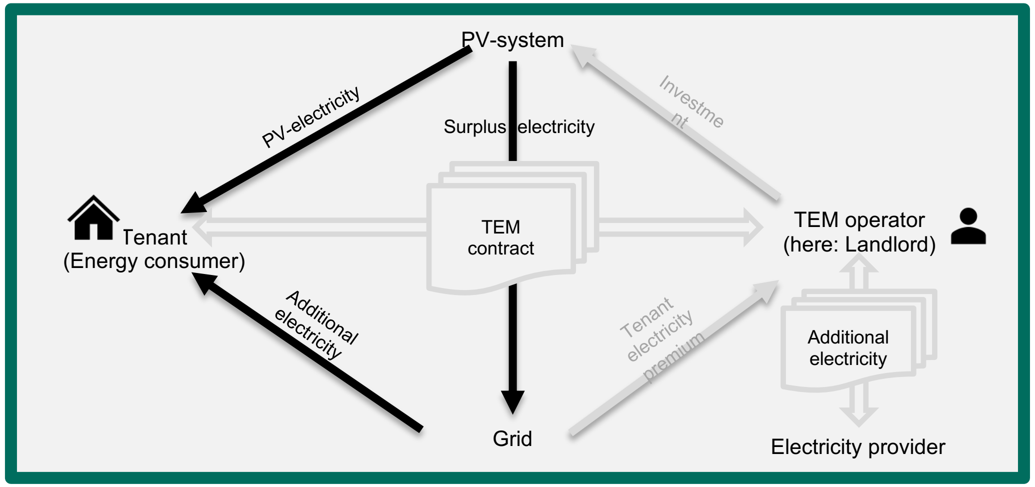
Research gap:

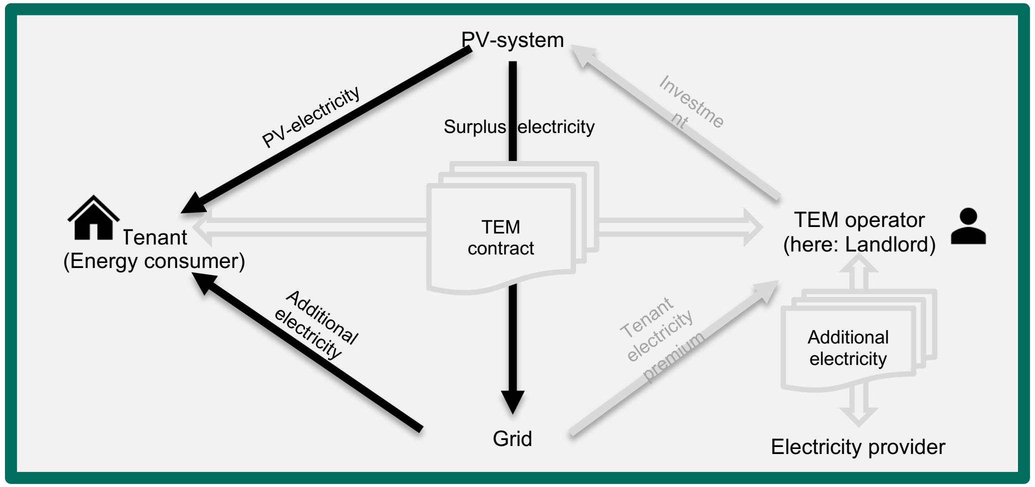
- No consideration of the German TEL

- No proper assessment of the energy system in MFBs considering electricity, heating and electric vehicles



Research question

- **Q1:** How does the TEL influence the optimal sizing and operation of an energy system in a MFB?
- **Q2:** How does the TEL influence the tenant-landlord relationship?
- **Q3:** How do EVs and different charging strategies influence the profitability of a TEM and the layout of an energy system?

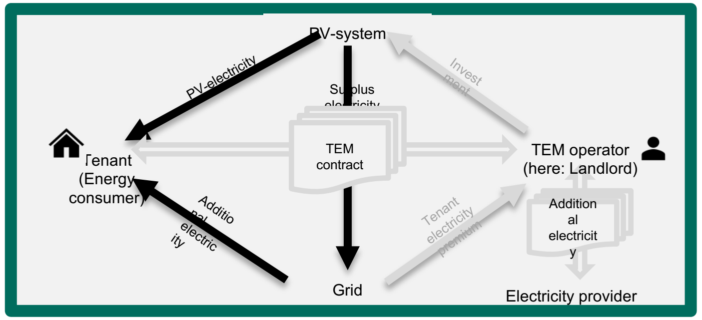


Tenant electricity law (TEL) model

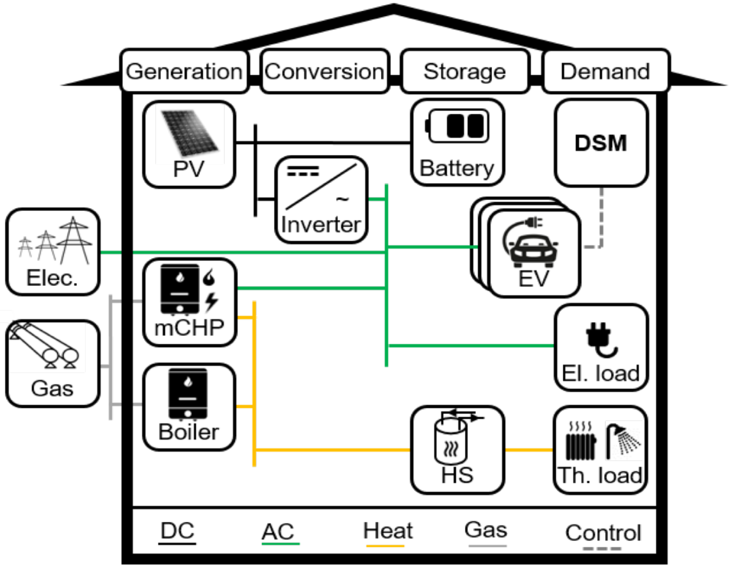
Input profiles

- Irradiation
- Heat demand
- Electricity demand
- EV-driving

Economic framework tenant electricity law



Karlsruhe, 10 units, 38 occupants, 1978



- MILP (Kleinebrahm, 2018)
- Heat and electricity
- Electric vehicles (EVs)
- One year in hourly resolution
- Maximize NPV

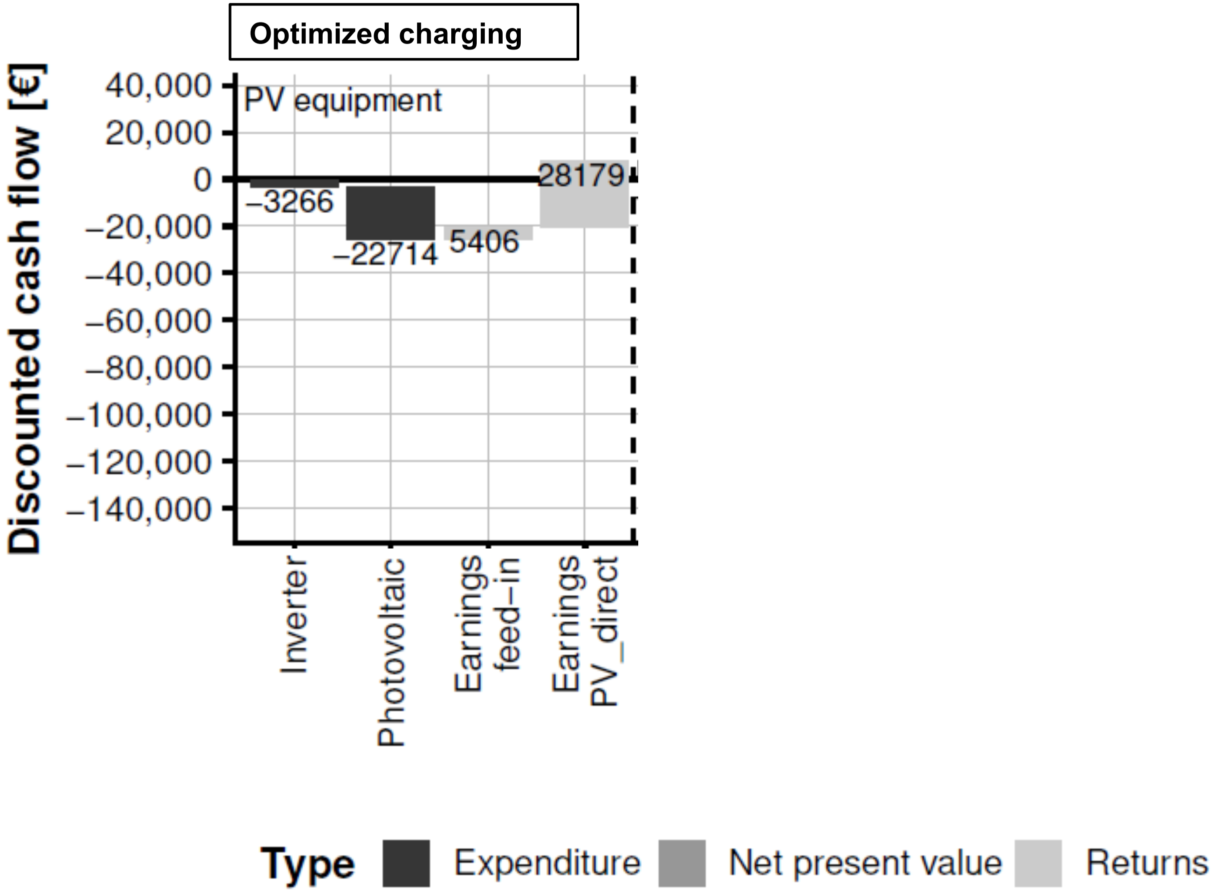
Output

- Technology choice
- Technology investment
- Dispatch profile (CHP, Battery, EV-Charging,…)
- NPV (Landlord)
- Energy cost savings (Tenant)

- **Increase energy demand:** Increase Number of EVs (0-6)
- **Increase electric flexibility:** Fast charging vs. Optimized charging

Results 1: Discounted cash flow

- PV-system profitable by itself
- Highest cash flow through CHP-unit
- Complementary production peaks of CHP-unit and PV-system
- In none of the cases, a battery storage system is installed



Results 2: Tenant-landlord relationship

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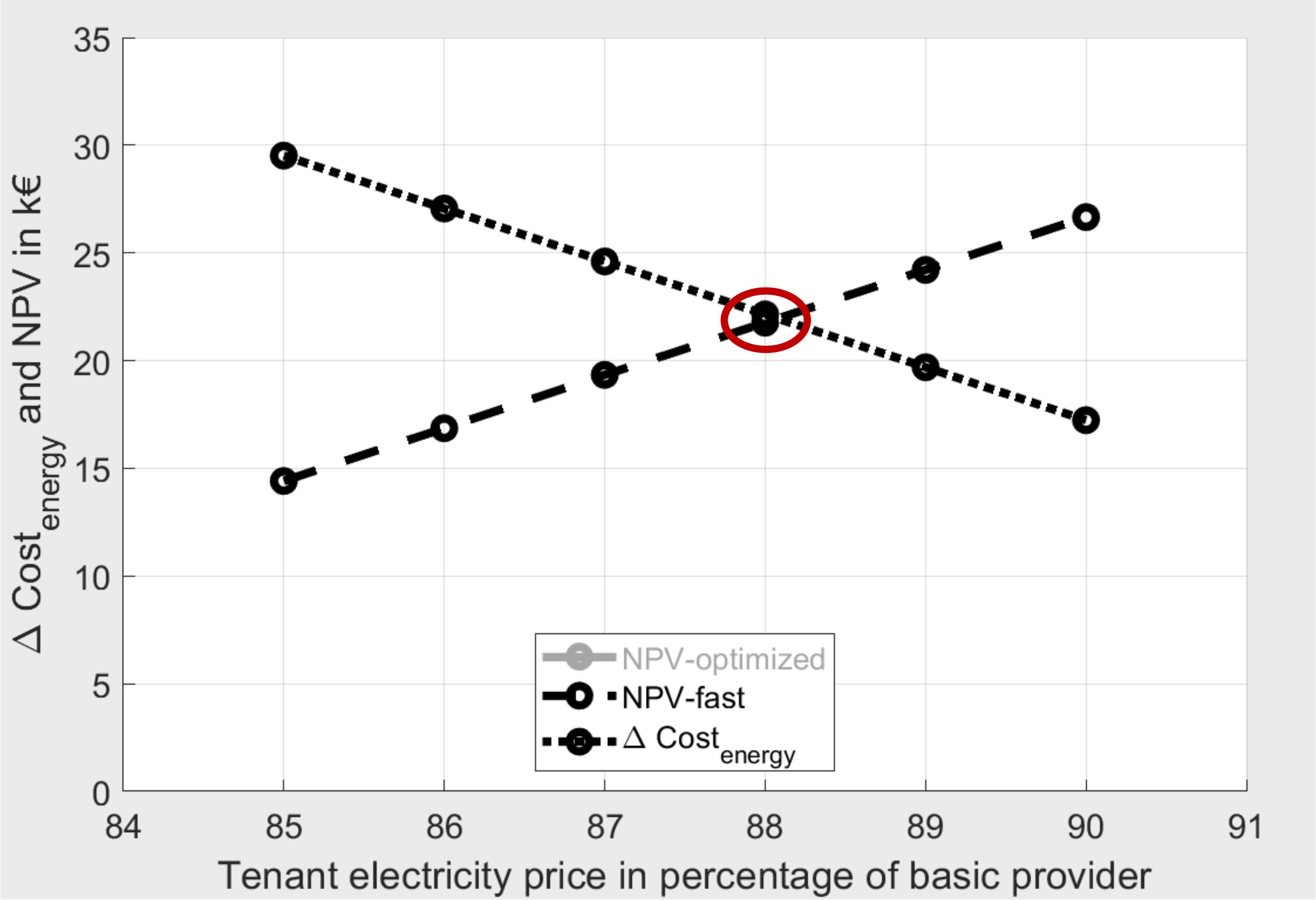

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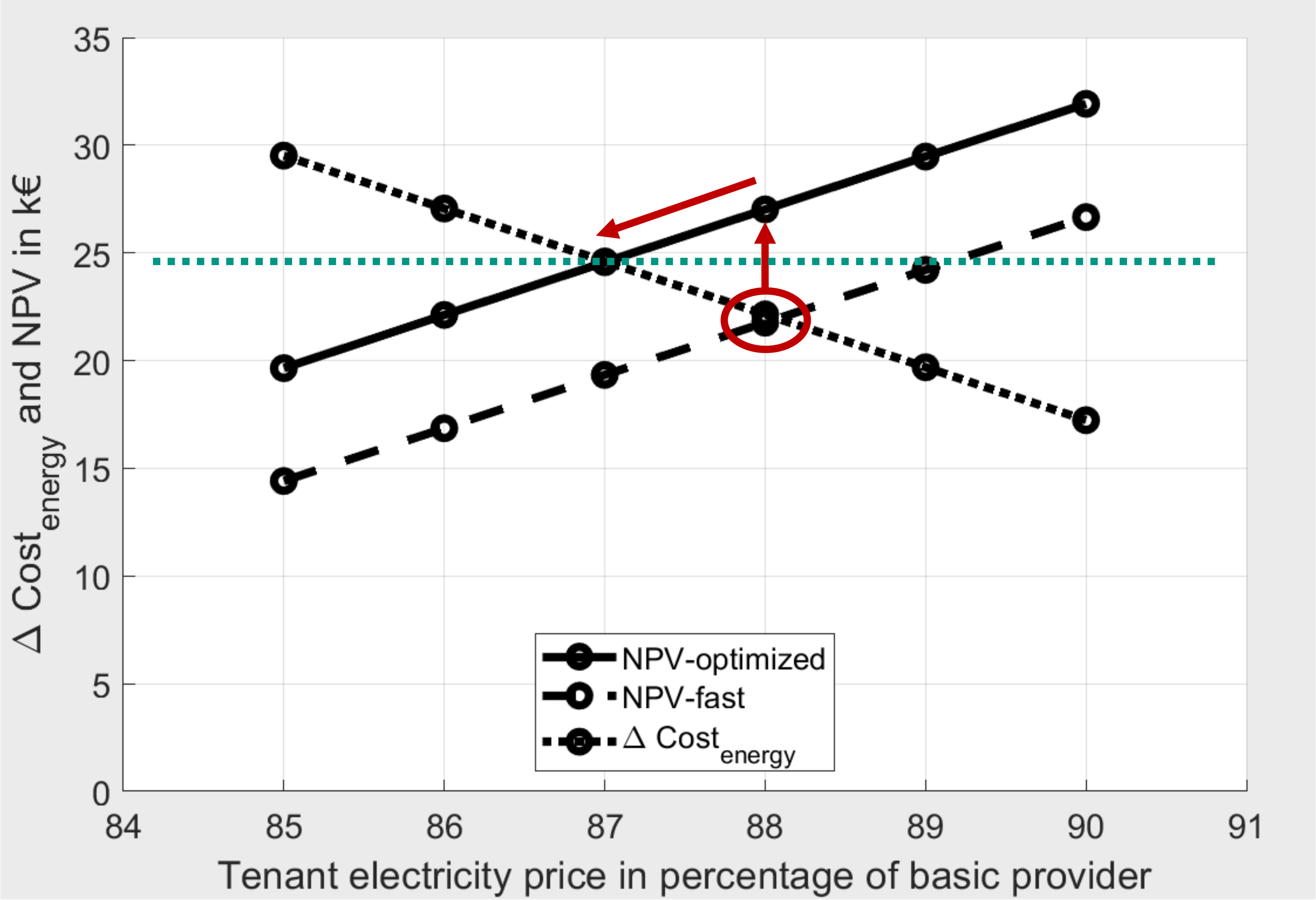
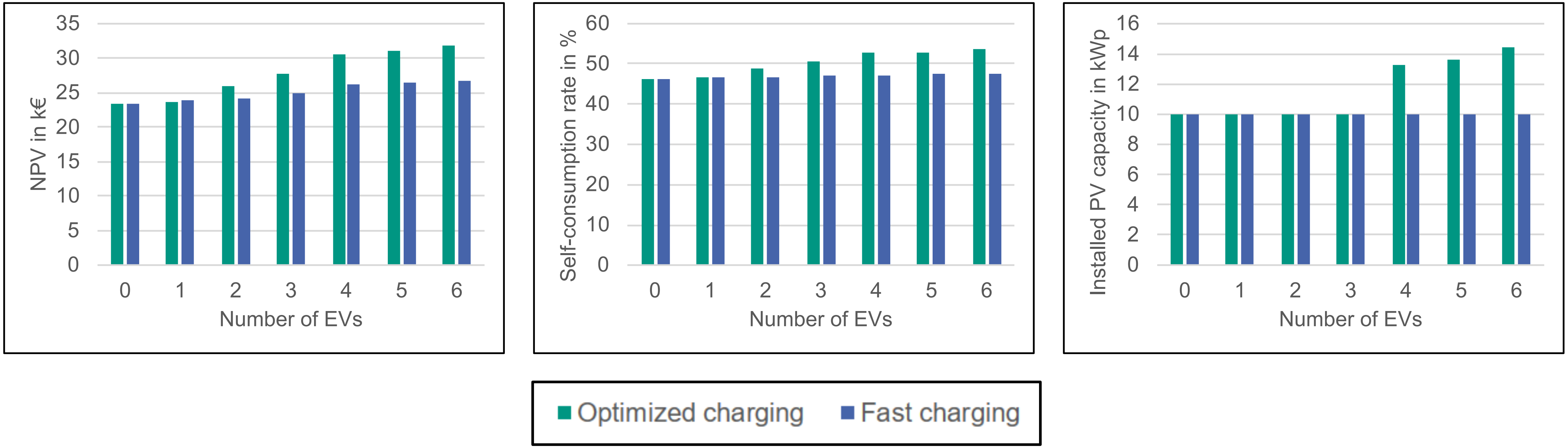


- A symbiotic relationship between tenants and landlord
- Adopting to an optimized charging regime and lowering the tenant electricity price increases the economic profit for both parties

Results 3: Influence of electric vehicles



- Number of EVs increases the electricity demand, the self-consumption rate and the NPV
- Optimized charging strategy has stronger effect on NPV
- PV-capacity depends on feed-in tariff

Discussion

Findings

- Profitability is driven by the CHP-unit
- Heat demand constraints CHP-unit expansion
- Additional flexible electricity demand is better answered by additional PV-capacitiy
- Financial risk for buying electricity from the grid is low
- Financial risk for oversizing the PV-system is high
- Still low number of 434 registered TEM since 2017, 9.74 MW installed capacity

Assumptions

- Perfect foresight
- One representative year
- Existing EV-charging infrastructure
- All tenants participate in the TEM
- Higher bargaining power of landlords for commodity price

Conclusion

- TEMs can be profitably implemented
- CHP-capacity mostly heat driven
- Synergy between CHP-unit and PV-system
- Higher demand through EVs increase profitability
- Flexibly charging increase profitability further
- New symbiotic relationship between tenant and landlord

Outlook

- Extend study to different building types
  - Different heating demand
  - Different driving profiles
  - Different PV-Potential
- Include heat pump technologies
- Include renovation measures?
- Extend financial evaluation?
  - Different tax regime for landlords

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Appendix

The model and parameters in detail

$$\max NPV, NPV = -\sum_{l \in L} C_{inv}^{l} + \sum_{a=0}^{A} \frac{acf^{a}}{(1+i)^{a}} \tag{1}$$

$$C_{inv}^{l} = c_{inv}^{l,a=0} \cdot cap^{l} + \frac{c_{inv}^{l,a=clt^{l}} \cdot cap^{l}}{(1+i)^{clt^{l}}} - \frac{clt_{rem}^{l}}{clt^{l}} \cdot \frac{c_{inv}^{l,a=A} \cdot cap^{l}}{(1+i)^{A}} \tag{2}$$

$$acf^{a} = \sum_{l=1}^{L} -c_{O\&M}^{l} \cdot cap^{l} + \sum_{t=1}^{8760} (P_{direct}^{t,l} \cdot c_{direct}^{l,a} + P_{feedin}^{t,l} \cdot c_{feedin}^{l} - P_{el,prod}^{t,CHP} \cdot \frac{c_{el,prod}^{CHP,a}}{\eta^{l}}) \tag{3}$$

$$c_{direct}^{PV,a} = c_{tenant}^{a} + c_{TEP} - c_{EEG}^{a} - VAT - c_{M\&I}^{a} \tag{4}$$

$$c_{direct}^{CHP,a} = c_{tenant}^{a} + c_{AGC}^{a} + c_{CHPP} - c_{EEG}^{a} - VAT - c_{M\&I}^{a} \tag{5}$$

$$c_{direct}^{grid,a} = c_{tenant}^{a} - c_{landlord}^{a} \tag{6}$$

Parameter	Unit	Value
$c_{el,basic}$	$€\backslash kWh$	0.2946
$c_{el,landlord}$	$€\backslash kWh$	0.2551
$c_{el,tenant,ref}$	$€\backslash kWh$	0.2858
c_{EEG}	$€\backslash kWh$	0.1134
c_{gas}	$€\backslash kWh_{el}$	0.066
$c_{inv}^{PV,a=0}$	$€\backslash kW_p$	1350
$c_{inv}^{inverter}$	$€\backslash kW$	250
c_{inv}^{CHP}	$€\backslash kW_{el}$	5000
$c_{inv}^{battery,a=0}$	$€\backslash kW_{el}$	600
c_{inv}^{boiler}	$€\backslash kW_{th}$	175
A	*years*	20

Parameter	Unit	Value	
i	%	4	
r_{el}	%	2	
c_{TEP}	$€\backslash kWh$	0.037	$cap < 10kW$
c_{TEP}	$€\backslash kWh$	0.0337	$cap < 40kW$
c_{TEP}	$€\backslash kWh$	0.0211	$cap < 100kW$
c_{feedin}^{PV}	$€\backslash kWh$	0.122	$cap < 10kW$
c_{feedin}^{PV}	$€\backslash kWh$	0.1187	$cap < 40kW$
c_{feedin}^{PV}	$€\backslash kWh$	0.1061	$cap < 100kW$
c_{CHPP}	$€\backslash kWh$	0.04	$cap < 50kW_{el}$
c_{AGC}	$€\backslash kWh$	0.001	$cap < 50kW_{el}$
c_{feedin}^{CHP}	$€\backslash kWh$	0.11826	$cap < 50kW_{el}$

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PV capacity	< 10 kWp	< 40 kWp	< 100 kWp
	(EURct/kWh)	(EURct/kWh)	(EURct/kWh)
Feed-in tariff	12.2	11.87	10.61
Tenant electricity premium	3.7	3.37	2.11