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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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)

- Tenant (Energy consumer)
- TEM contract
- TEM operator (here: Landlord)
- Electricity provider
- Additional electricity

- PV-system
- Surplus electricity
- Investment
- Grid
- Tenant electricity premium
- Feed-in tariff
- Money
- Electricity
- Contract

Motivation – Tenant electricity model – Method – Results - Discussion
The tenant electricity model (TEM)

\[ \Delta \text{Cost}_{el,\text{tenant}} = \text{Cost}_{el,\text{old}} - \text{Cost}_{el,TEM} \]

Motivation – Tenant electricity model – Method – Results – Discussion

\[ NPV = -\text{Inv} + acf \]
\[ acf = (c_{\text{TEM}} \cdot e_{\text{TEM}} - c_{\text{Provider}} \cdot e_{\text{grid}}) \cdot CRF \]
The tenant electricity model (TEM)

- **Tenant** (Energy consumer)
- **Battery**
- **PV-system**
- **EVs**
- **mCHP**
- **Boiler**
- **Grid**
- **Surplus electricity**
- **Investment** (EEG)
- **TEM contract**
- **TEM operator** (here: Landlord)
- **Additional electricity**
- **Money**
- **Electricity**
- **Contract**
- **Heat**

**Motivation**
- Tenant electricity model

**Method**
- Investment (KWKG)
- Tenant electricity premium
- Feed-in tariff

**Results**
- Discussion
Motivation

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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

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

*Motivation – Tenant electricity model – Method – Results - Discussion*
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

![Graph showing the change in cost of energy and NPV over time.]
Results 2: Tenant-landlord relationship

- 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-capacity
- 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
Appendix
The model and parameters in detail

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

\[
C_{\text{inv}}^{l} = c_{\text{inv}}^{l,a=0} \cdot \text{cap}^l + \frac{c_{\text{inv}}^{l,a=ct} \cdot \text{cap}^l}{(1+i)^{ct_l}} - \frac{c_{\text{rem}}^{l,a=A} \cdot \text{cap}^l}{(1+i)^A}
\]

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

\[
c_{\text{PV,a}}^{direct} = c_{\text{tenant}}^{a} + c_{\text{TEP}}^{a} - c_{\text{EEG}}^{a} - \text{VAT} - c_{M&I}^{a}
\]

\[
c_{\text{CHP,a}}^{direct} = c_{\text{tenant}}^{a} + c_{\text{AGC}}^{a} + c_{\text{CHPP}}^{a} - c_{\text{EEG}}^{a} - \text{VAT} - c_{M&I}^{a}
\]

\[
c_{\text{grid,a}}^{direct} = c_{\text{tenant}}^{a} - c_{\text{landlord}}^{a}
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$cap < 10\,kW$  
$cap < 40\,kW$  
$cap < 100\,kW$  
$cap < 10\,kW$  
$cap < 40\,kW$  
$cap < 100\,kW$  
$cap < 50\,kW$  
$cap < 50\,kW$  
$cap < 50\,kW$
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<table>
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<th>PV capacity</th>
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<th>&lt; 40 kWp</th>
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<td>(EURct/kWh)</td>
<td>(EURct/kWh)</td>
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<td>Feed-in tariff</td>
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<td>10.61</td>
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<td>Tenant electricity premium</td>
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