BUSINESS MODELS USING THE FLEXIBILITY OF HEAT PUMPS – A DISCOURSE
Project „HPsmart in existing buildings“

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Heat Pumps are Flexible!
What to Do With This Flexibility?
WPsmart Project
Kick-Off Workshop: “Businessmodels HP in SG”

- Flexibility Contracting!
  - A third party operates the heat pump and offers benefits to the endcustomer
Selected Objectives by Actor

... Opportunities for Heat Pumps

Offering services to the electric grid:

- Provision of reserve power: Revenues are generated through the provision of capacity and energy at the reserve markets.
- Reduction of grid fees: If the heat pump offers the possibility to be shut down by the grid operator it is considered as an interruptible load leading to reduced grid fees.
- Reduction of concession fees: If it is possible to operate heat pumps in a high-tariff/low-tariff scheme a reduction of concession payments can be achieved.

Offering services to the balance group:

- Optimised electricity purchase: Operation of the heat pump based on the forecasted electricity price at the spot market. Thereby reducing electricity buying costs.
- Reducing the need for balancing energy: Possibility to reduce/counteract forecasting errors within a balancing group leading to a reduced need for balancing energy.

Offering services to heat and electricity customers:

- Increasing self-consumption of onsite generated PV electricity with improved controls.
- Increasing efficiency: Reduced electricity consumption of the heat pump system due to improved controls using forecasts and operational data.
Analyses of Business Models

Methodology

Quantitative analyses
• Estimation of potential revenue

Qualitative analyses
• Business model canvas
• Techno-economic analyses
Quantitative Analyses
Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP electricity tariff (work only)</td>
<td>19</td>
<td>ct/kWh</td>
</tr>
<tr>
<td>Feed-in tariff for PV (EEG 1.1.2015, roof mounted private)</td>
<td>12.3</td>
<td>ct/kWh</td>
</tr>
</tbody>
</table>

Technical assumptions:

- Building type: Single Family House
- EL. Energy production of a 5kWp PV: 5000 kWh/a
- El. Nominal power of HP: 2.5 kWel
- Nominal operational hours: 2500 h/a
- Electricity consumed by HP: 6250 kWh/a
- Electricity costs for HP: 1250 EUR/a
Quantitative Analyses

Estimated Annual Revenue for 1kW\textsubscript{el} of HP

Year of Marketdata: 2015
Quantitative Analyses

Estimated Annual Revenue for 1kW_{el} of HP

Year of Marketdata: 2015
Discussion

Onsite Business Models

Efficiency increase of 5-20% using predictive controls
→ Expected to emerge soon

Self-consumption increase 10-40%
PV self-consumption driven by regulations
→ Already present in the market

Year of Marketdata: 2015
Discussion
Grid Business Models (German regulatory conditions)

Year of Marketdata: 2015

Grid fees can be reduced up to 80% if HP can be blocked for 100% of electricity.

Reduced concession fees during low load hours.
Electricity Price for Households in Germany
28.89 ct/kWh in 2016

- Tax: 6.63 ct/kWh
- Renewable Subsidies (EEG): 6.35 ct/kWh
- Concession fee: 1.66 ct/kWh
- Grid fees and billing: 7.07 ct/kWh
- Other: 0.86 ct/kWh
- Generation and sales: 6.1 ct/kWh

Source: BDEW
Electricity Price for Households in Germany
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Source: BDEW
Discussion
Balance Group Business Models

Year of Marketdata: 2015

- Reserve Markets
- Balance Group
- Onsite
- Grid

Low share at end customer price
Low prices at spot market
BUT also low complexity
Low risk
Time scales 1h (day-ahead)

Looks attractive but is none trivial: Will be investigated in more detail in future work.
Discussion
Reserve Markets

Year of Marketdata: 2015

Revenue does not seem to justify technical stress to HP
Avoid frequent switching by pooling
Price drop in market prices
Long tenders

Few hours where negative and positive tertiary reserve has been called (ca. 240 hours and ca. 400 hours)
Discussion
Price development and risk

Year of Marketdata: 2013
**Summary**

**Revenue Estimation**

- **Reserve Markets:** Technically challenging and negative price development
- **Balance Group:** Spotmarket low risk, low gain – Balancing energy attractive → needs more detailed investigations
- **Onsite:** Regulatory driven, simple to realise but not so smart from the point of the power system
- **Grid:** State of the art, although the flexibility is poorly used, strongly regulatory driven
What is needed to realise the models?

Results of Business Model Canvas

- Value proposition, revenue streams and customer segments differ by business model
- Communication, algorithms and controls are key resources for all business models
- Forecasting, market acting, controlling HPs are key activities
- Technology providers, system planners are most important partners
- Communication, algorithms and controls, loss of efficiency, billing and market participation are main costs
## Attractiveness of Different Options

### Techno-economic Analysis

<table>
<thead>
<tr>
<th></th>
<th>Purchase</th>
<th>Grid services and balance group management</th>
<th>Renewables and Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spot market</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td>Timescales suitable for HP</td>
<td>Suitable for HP, though frequent switching has to be avoided</td>
<td>Suitable for HP, frequent cycling needs to be avoided</td>
</tr>
<tr>
<td>Costs</td>
<td>Communication technology, pool management, market participation fees, efficiency losses</td>
<td>Communication technology, pool management, market participation fees, prequalification, efficiency losses</td>
<td>Communication and controls, Energy management, efficiency losses</td>
</tr>
<tr>
<td>Revenue</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>Risk &amp; Complexity</td>
<td>low</td>
<td>medium</td>
<td>low</td>
</tr>
<tr>
<td>Attractiveness</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th><strong>SR NEG</strong></th>
<th><strong>SR POS</strong></th>
<th><strong>TR NEG</strong></th>
<th><strong>TR POS</strong></th>
<th><strong>Reduced Grid Fees</strong></th>
<th><strong>PV self-consumption</strong></th>
<th><strong>Efficiency</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>PR</td>
<td>Danger of frequent switching if not taken care of by pool management</td>
<td>Suitable for HP, though frequent switching has to be avoided</td>
<td></td>
<td>suitable already today</td>
<td></td>
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<td></td>
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</tbody>
</table>

*Note: Colors indicate the level of attractiveness: good (green), moderate (yellow), poor (red).*
Heat pumps and smart grids:


More Information?

References

**PV Self-consumption:**


**Energy Demand Modelling:**


**Changes in load profile and technology models:**

**DSM:**