V2G: Measuring Electric Vehicle Drivers’ Willingness to Co-Create Flexibility for Smart Grids

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* presenter
Strong growth in fluctuating renewables leads to search for new forms of flexibility

Installed PV Capacity in Bavaria [MW]

- 0.1%*
- 10%
- +55% p.a.

2002: 0
2004: 1000
2006: 2000
2008: 4000
2010: 8000
2012: 12000

Germany, August 2015: >50% of electricity from PV & wind in certain hours

http://www.agora-energiewende.de/en/topics/-agothem-/Produkt/produkt/76/Agorameter/

http://www.energieatlas.bayern.de/thema_sonne/photovoltaik/daten.html

*) Per cent of Bavarian power supply
Providing Flexibility in the Electricity Market

Old style

New style

The Prosumer

Flexibility?
Vehicle-to-grid (V2G)

– An interesting source of flexibility for the electric grid in future
– Flexibility can be valorized on the balancing power market but also for flexibility services for the grid (e.g. balance energy) or microgrids.
– Currently not feasible in many cases due to technical and regulatory reasons.
– But are electric vehicle drivers willing to „do“ V2G?

http://www.amsterdamvehicle2grid.nl
Research Questions

Research objective: Investigating electric vehicle drivers’ willingness to provide flexibility

1. To what extent are electric vehicle drivers’ willing to co-create flexibility?
2. Are there differences to other technology domains?
Data and sample

- N=301 people in Switzerland
- Target population: People owning electric car or interested in purchasing in the next 3 years
- Recruiting via B2C online panel (including nearly 70’000 consumers) of a leading Swiss market research agency
- Data collection January 2017
# Methodological Approach:
## Choice-Based Conjoint Analysis

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly electricity cost</td>
<td>50 CHF, 70 CHF, 90 CHF, 110 CHF</td>
</tr>
<tr>
<td>Use of flexibility</td>
<td>Super Flex, Flex Medium, Flex Light, No Flex</td>
</tr>
<tr>
<td>Electricity Mix (for remaining demand)</td>
<td>100% Unknown Origin, 100% Nuclear, 100% Hydro, 100% Solar</td>
</tr>
<tr>
<td>Contract duration</td>
<td>4 Years, 2 Years, 1 Year, Can be cancelled anytime</td>
</tr>
</tbody>
</table>

Specific attribute levels for “use of flexibility“
Business models for distributed flexibility need to strike a balance between interests of suppliers and prosumers.
Online choice experiment: Which electricity contract would you choose?

<table>
<thead>
<tr>
<th>Stromkosten pro Monat</th>
<th>Nutzung der Flexibilität</th>
<th>Strommix</th>
<th>Vertragsdauer</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 CHF</td>
<td>No Flex</td>
<td>100% Wasserstrom</td>
<td>Jederzeit kündbar</td>
</tr>
<tr>
<td>50 CHF</td>
<td>Super Flex</td>
<td>100% Atomstrom</td>
<td>1 Jahr</td>
</tr>
<tr>
<td>90 CHF</td>
<td>Flex Medium</td>
<td>100% Unzertifizierter Graustrom</td>
<td>2 Jahre</td>
</tr>
<tr>
<td>70 CHF</td>
<td>Flex Light</td>
<td>100% Solarstrom</td>
<td>4 Jahre</td>
</tr>
</tbody>
</table>

- No Flex: Kein Zugriff des Energieversorgers auf Ihre Fahrzeugbatterie
- Super Flex: Garantiert Ladezustand 40%; unlimitierte Anzahl Entladezyklen/24 h
- Flex Medium: Garantiert Ladezustand 60%; max. 3 Entladezyklen/24 h
- Flex Light: Garantiert Ladezustand 80%; max. 1 Entladezyklus/24 h

0% - 100%
Results: WTCC of electric vehicle drivers

Study 2: Electric vehicles (N=300)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly power costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110 CHF</td>
<td>-57.8</td>
<td>50.9</td>
</tr>
<tr>
<td>90 CHF</td>
<td>-5.4</td>
<td>19.0</td>
</tr>
<tr>
<td>70 CHF</td>
<td>26.0</td>
<td>24.2</td>
</tr>
<tr>
<td>50 CHF</td>
<td>37.2</td>
<td>43.4</td>
</tr>
<tr>
<td>Use of flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SuperFlex</td>
<td>-44.0</td>
<td>20.8</td>
</tr>
<tr>
<td>FlexMedium</td>
<td>-4.8</td>
<td>18.5</td>
</tr>
<tr>
<td>FlexLight</td>
<td>21.4</td>
<td>15.4</td>
</tr>
<tr>
<td>NoFlex</td>
<td>27.5</td>
<td>33.6</td>
</tr>
<tr>
<td>Power mix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown origin</td>
<td>-89.1</td>
<td>54.2</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-74.8</td>
<td>51.2</td>
</tr>
<tr>
<td>Hydro</td>
<td>73.8</td>
<td>52.9</td>
</tr>
<tr>
<td>Solar</td>
<td>90.1</td>
<td>58.0</td>
</tr>
<tr>
<td>Contract duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 years</td>
<td>-28.8</td>
<td>23.6</td>
</tr>
<tr>
<td>2 years</td>
<td>-1.4</td>
<td>17.3</td>
</tr>
<tr>
<td>1 year</td>
<td>4.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Cancel anytime</td>
<td>25.4</td>
<td>39.3</td>
</tr>
</tbody>
</table>
Required flexibility premium

Electric Vehicles (N=300)

- NoFlex: 0.00 CHF
- FlexLight: 3.85 CHF
- FlexMedium: 20.40 CHF
- SuperFlex: 45.16 CHF
Comparing three technology areas

1) Electric Vehicles

2) Heat Pumps

3) PV + Battery
Data and sample

- Parallel survey in three technology areas (N= ca. 300 each)
- Target population: People owning electric car/heat pump/PV+battery or interested in purchasing in the next 3 years
- Recruiting via B2C online panel (including nearly 70’000 consumers) of a leading Swiss market research agency
- Data collection January 2017
<table>
<thead>
<tr>
<th>Electric Cars</th>
<th>Super Flex</th>
<th>Flex Medium</th>
<th>Flex Light</th>
<th>No Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaranteed charging level 40%; Unlimited amount of discharging cycles per 24 h</td>
<td>Guaranteed charging level 60%; max. 3 discharging cycles per 24 h</td>
<td>Guaranteed charging level 80%; max. 1 discharging cycle per 24 h</td>
<td>No access of utility on battery</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heat Pump</th>
<th>Super Flex</th>
<th>Flex Medium</th>
<th>Flex Light</th>
<th>No Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaranteed room temperature 16°; 5 min. hot shower per day</td>
<td>Guaranteed room temperature 18°; 10 min. hot shower per day</td>
<td>Guaranteed room temperature 20°; 15 min. hot shower per day</td>
<td>Guaranteed room temperature 22°; Unlimited hot shower per day</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PV+Battery</th>
<th>Super Flex</th>
<th>Flex Medium</th>
<th>Flex Light</th>
<th>No Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td>30% PV Self-Consumption; consumption data transmitted and used for forecasting</td>
<td>45% PV Self-Consumption; consumption data transmitted</td>
<td>60% PV Self-Consumption; only data on battery charging level transmitted</td>
<td>75% PV Self-Consumption; no data transmitted</td>
<td></td>
</tr>
</tbody>
</table>
**Results:** Comparison of part-worth utilities for attribute „Use of flexibility“

<table>
<thead>
<tr>
<th></th>
<th>SuperFlex (N=301)</th>
<th>MediumFlex (N=301)</th>
<th>LightFlex (N=301)</th>
<th>NoFlex (N=301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV and Battery</td>
<td>-14.9</td>
<td>-7.5</td>
<td>6.8</td>
<td>15.6</td>
</tr>
<tr>
<td>Heat Pumps</td>
<td>-129.7</td>
<td>-32.6</td>
<td>49.8</td>
<td>112.6</td>
</tr>
<tr>
<td>Electric Vehicles</td>
<td>-44.0</td>
<td>-4.8</td>
<td>21.4</td>
<td>27.5</td>
</tr>
</tbody>
</table>

Implicit Discomfort Cost (WTCC): 3.85-20.40 CHF/month
Conclusions

– Electric vehicle drivers are an **interesting target segment** for distributed flexibility provision

– **Compensation** required in the range of 3.85 to 45.16 CHF per month for electric vehicle drivers

– To our knowledge, this is the **first study** systematically investigating prosumers’ willingness to co-create flexibility across three technology areas (N=902)

– There is some **willingness to co-create flexibility** in exchange for more favorable electricity tariffs

– Some forms of flexibility provision imply a higher **cost of discomfort** than others (e.g. heat vs. EV battery)
Limitations and further research

- Limited comparability across the studies
- We have yet to look into explanations for differences in willingness to co-create flexibility (e.g. sociodemographic, psychographic factors).
- Quantification of the provided flexibility would be an interesting add to a new study
- Replication in other countries would be interesting. 😊
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Thank you!