Chair of Marketing and Consumer Research
TUM School of Management
Technical University of Munich

Customer-focused business models for battery storage systems – A choice experiment in Germany

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Energy storage systems

Relevance

Balance the intermittency of renewables

Facilitate the **further integration** of electricity from renewables

Sources: Hoppmann et al., 2014; Kairies et al., 2016

Research aim

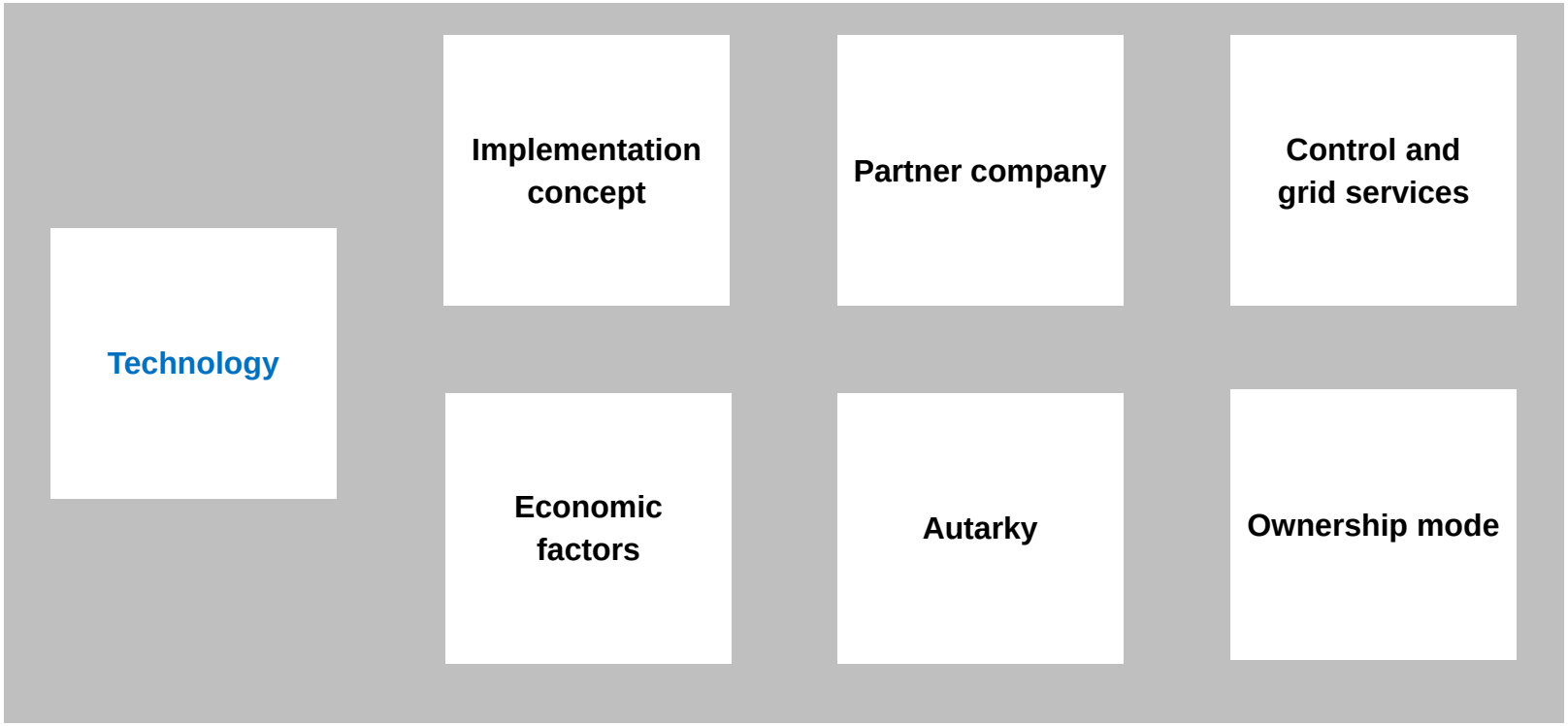
- An **increasing demand** for battery storage systems shows that consumers are willing to invest although prices are high.

- Most of the literature analyzes **technical aspects** of storage systems, **neglecting** the **role of consumers**.

This study aims at examining consumer preferences and business models for battery storage systems.

Framework

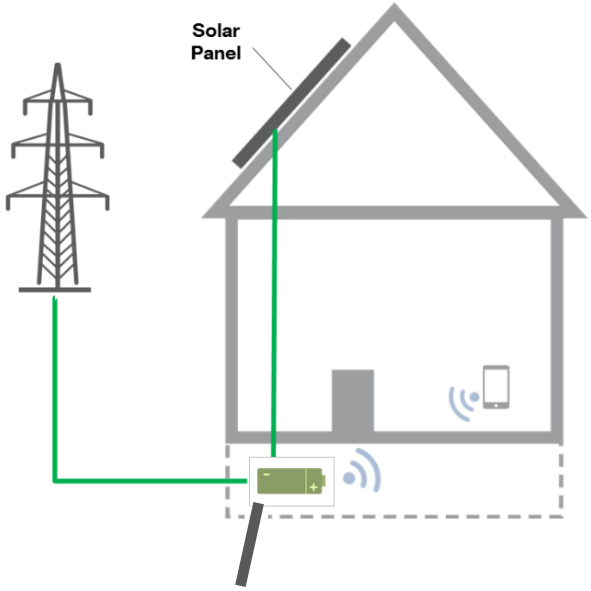
for analyzing consumer preferences for battery storage systems



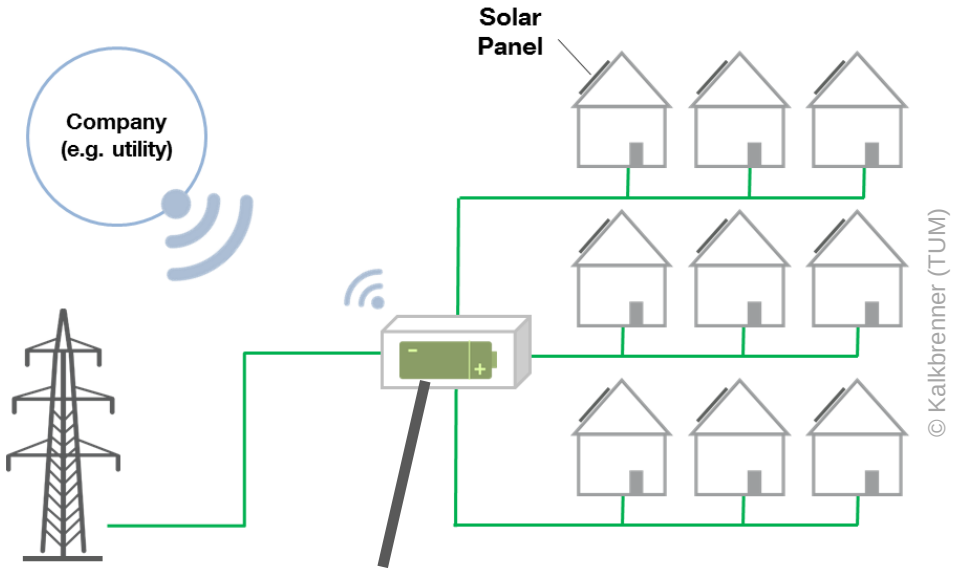
Framework adapted from Walker & Cass (2007)

Battery storage systems

Residential vs. community solution



Residential battery storage system

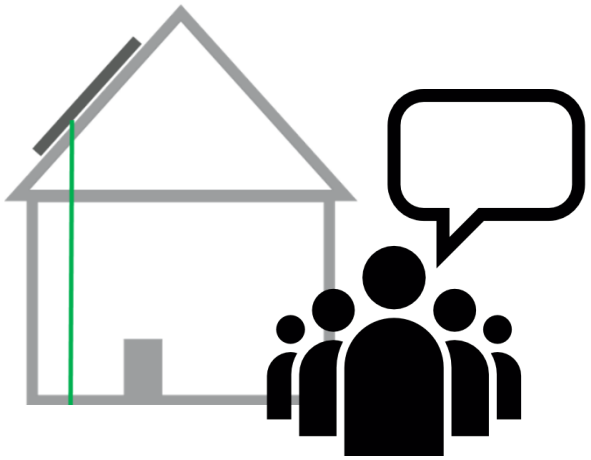


Community battery storage system

Data

- **Online survey** conducted in Germany in 2016

- **Sample**
  - N=837
  - Target population
    - owners of photovoltaic systems (n=753)
    - citizens that are interested in photovoltaic systems and battery systems (n=84)



Icon made by OCHA from www.flaticon.com

Methods

- **Choice Experiment**
  - fractional factorial design
  - two equal-sized blocks
  - each respondent was allocated one block with 8 scenarios
  - unbalanced design, due to constraints

- **Model**
  - effects coding
  - mixed logit
  - data analysis: Stata 13 (mixlogit, wtp)

Choice Experiment

Overview of the attributes & attribute levels (I/II)

Attribute	Levels	
Location of the storage system	In your house (*Residential storage*) In your residential area (*Community storage*)	
Cost *	6.000€ one-time payment 9.000€ one-time payment 12.000€ one-time payment 15.000€ one-time payment	45€ per month for 10 years 65€ per month for 10 years 85€ per month for 10 years 110€ per month for 10 years
Amortization period *(only for one-time payment)*	None 6 years 12 years 18 years	
Right of use	Ownership (=one-time investment) Right of use (=monthly payment)	

* Interest rate: 3.1% (Graebig et al. 2014)

Choice Experiment

Overview of the attributes & attribute levels (II/II)

Attribute	Levels
Average rate of self-sufficiency in electricity production	25% 50% 75% 100%
Control & provision of services for the electricity grid	Own control Own control by default External control by default External control by partner companies
Partner companies (e.g. for main-tenance and control)	Nationwide electricity supplier Regionally based electricity supplier Regionally based energy cooperative Battery operator

* Interest rate: 3.1% (Graebig et al. 2014)

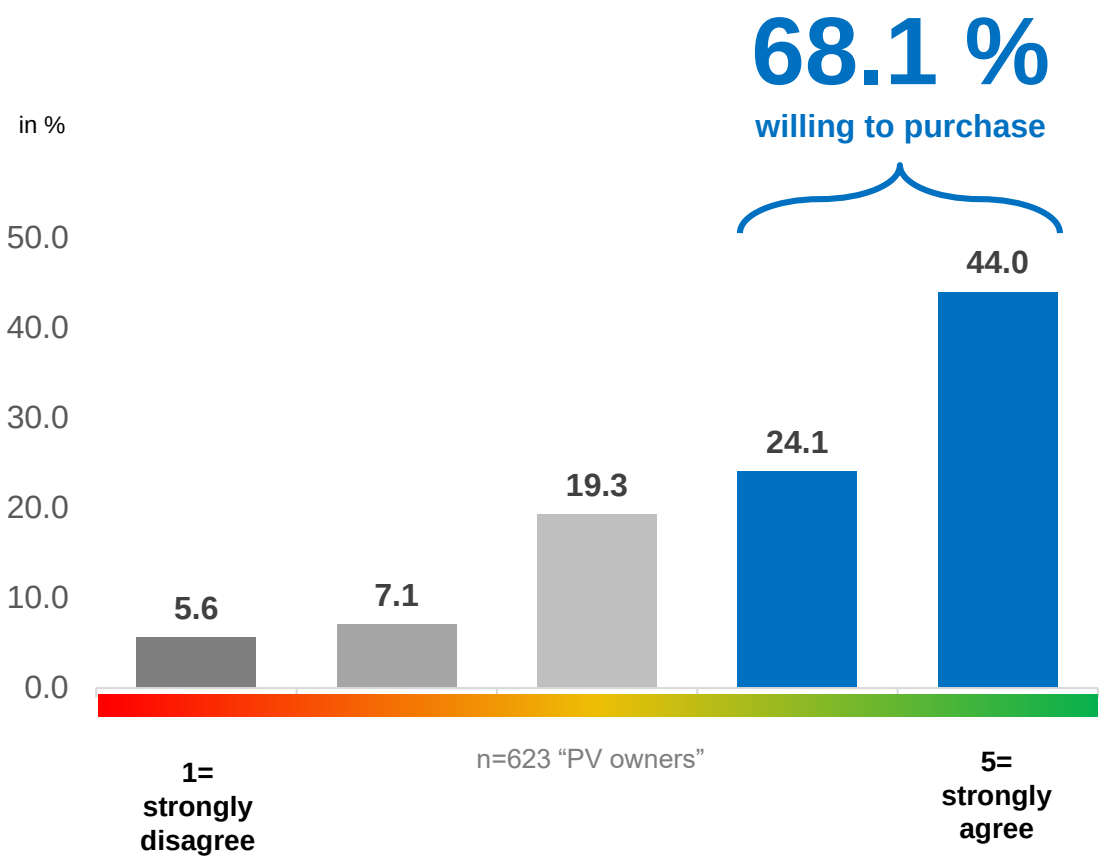
Choice Experiment

Example of a choice set

	Option A	Option B	Option C	Option D
Location of the storage system	In your house	In your house	In your residential area	*I don't choose any of the displayed options.*
Costs and Right of use	12.000 € one-time payment	6.000 € one-time payment	85€ per month for 10 years	
	Ownership	Ownership	Right of use	
Amortization period	18 Years	6 Years	-	
Average rate of self-sufficiency	100%	25%	75%	
Control & provision of services for grid	Own control by default	External control by default	External control by default	
Partner companies (e.g. maintenance and control)	Nationwide electricity supplier	Battery operator	Regional electricity supplier	
I choose:	☐	☐	☐	☐

Results

High interest in purchasing a storage system



*I will buy a residential battery storage system or participate in a community battery system as soon as the price is appropriate.**

* adopted from Wu et al., 2015

Results

Mixed logit parameter estimates

Preliminary results

Variable	Coef.		Std. Err.	Coef.		Std. Err.
Mean Estimates				*SD estimates*		
None-option	-0.7684	***	0.0880			
Cost (*Euro, NPV*)	-0.0002	***	0.0000			
Community storage system	-0.0360		0.0476	0.6994	***	0.0385
Ownership	1.22535	***	0.0649	0.7904	***	0.0578
Payback period	-0.1671	***	0.0103	0.1718	***	0.0089
50% autarky	-0.0858		0.0562	0.2700	**	0.0943
75% autarky	0.2967	***	0.0574	0.5502	***	0.0822
100% autarky	0.8835	***	0.0573	0.8453	***	0.0586
Own control	0.1807	**	0.0527	0.0342		0.1166
Own control by default	0.2343	**	0.0683	0.2727	*	0.1065
External control by default	-0.2326	***	0.0470	0.0322		0.0639
Nationwide electricity supplier	-0.3496	***	0.0500	0.2437	**	0.0903
Regional electricity supplier	0.1730	**	0.0525	0.2283	*	0.0948
Regional energy cooperative	0.1611	**	0.0588	0.1616		0.1285

Notes: * p<0.05, **p < 0.01, ***p < 0.001.
Number of observations = 26752;
LR chi2(12) = 1 755.93; Log likelihood = -7207.74;
Prob > chi2 = 0.0000

Results

Willingness to pay estimates

Preliminary results

	Willingness to pay (in Euro)
Location (Reference: in your house)	
Community storage system	-225.9 (ns)
Ownership mode (Reference: use rights)	
Ownership	7,690.4
Payback period (per year)	-1,048.8
Autarky (Reference: 25% autarky)	
50% autarky	-538.8 (ns)
75% autarky	1,861.9
100% autarky	5,544.8
Control (Reference: External control)	
Own control	1,133.8
Own control by default	1,470.3
External control by default	-1,460.0
Partner Company (Reference: Specialized battery operator)	
Nationwide electricity supplier	-2,193.8
Regional electricity supplier	1,085.5
Regional energy cooperative	1,010.9

ns: not statistically significant

Conclusion

- We find a high **interest** in purchasing storage systems.
- **Economic factors** and high levels of **autarky** warrant emphasis as attributes.
- A potential market for **residential and community** storage concepts exists.

- Support for business models that use storage systems as a means to **contribute to grid operation** is given.
- End-users in Germany **value control** but are **willing to relinquish** it to support the grid if they can decide when.
- **Opportunities** exist for providers with **regional ties** and **new entrants.**

The study's results can assist in creating customer-focused business models, diffusing storage systems, and assessing potential for technologies and policy instruments.

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