

Willing to Pay?

Spatial Heterogeneity of e-Vehicle Charging Preferences in Germany

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FCN | Future Energy Consumer Needs and Behavior



1. Motivation E-Mobility as a focal point between energy and mobility transitions



Energy transition

- Reduce fossil fuel dependency and CO₂ emissions
- Smart home integration



Charging behavior

 Charging preferences of (future) consumer groups

Mobility transition

E-vehicle (EV) driving and charging behavior







1. Motivation Research Gap

Problem

In economics, electric vehicle (EV) charging spots – a spatial combination of parking and refueling – are rival goods.

- Better fit of EV charging supply to user expectations, needs, and behavior.
- Actual EV charging spot usage may differ from previously anticipated perceived usage.

Literature on single attributes of the charging process

Gap

 Charging speed, location, price; Hackbarth & Madlener
2013, 2016; Hidrue et al.
2011; Tanaka et al. 2014)

Gaps

- Charging behavior as a whole bundle
- Charging behavior with respect to the number of currently available charging spots.

What are the charging preferences and the willingness to pay according to the number of charging spots?

Solution

■ Percentage of EV drivers too small for field experiment → online experiment

Discrete choice experiment

 Measuring preferences for attributes indirectly by confronting respondents with hypothetical choice bundles



2. Methodology Discrete Choice Experiment

Introduction to respondents

"Assume that you regularly drive and charge an e-car. The range of the e-car is sufficient for your daily driving needs. Please imagine how and where you would like to charge the e-car's battery. Please assume that the two options are identical in all aspects not mentioned here, i.e. assume a generic e-car that is identical with respect to size, range, motor power etc."

ATTRIBUTES	Example of a Choice Card (full range of attributes). Repeated 12 times for each respondent.					
	Place of charging	At home	At work			
	Charging duration (full charge)	10 min	4 hours			
	Charging technology	Tethered charging (with cable)	Inductive charging (without cable)			
	Waiting time for available charging station	0 min	30 min			
	Share of renewables	50 %	25 %			
	Charging cost per month	200€	100€			
	CHOICE					
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2. Methodology Discrete Choice Experiment

- The number of both attributes and levels is limited so that respondents are not overburdened
- The design algorithm ensures that all levels appear on the same number of choice cards
- Individuals maximize their utility by choosing a particular charging solution
- Respondents are forced to consider tradeoffs between the attributes that define the two options A and B

		Overview of Attribute Levels					
ATTRIBUTES -	Place of charging	At home	At work	Roadside: Secondary			
	Charging duration (full charge)	10 min	10 min 30 min		8 hours		
	Charging technology	Tethered cha	arging (with cable)	Inductive charging (without cable)			
	Waiting time for available charging station	0 min	5 min	10 min	30 min		
	Share of renewables	25 %	50 %	75 %	100 %		
	Charging cost per month	50€	100€	150€	200€		
			Ύ				

LEVELS



2. Methodology Distribution of charging spots across Germany



- Does the number of existing charging spots affect the EV charging preferences?
- 2) Depending on the number of charging spots, what is the willingness to pay (WTP) for certain attributes of the EV charging process? For example, how much is 1 minute less in charging duration worth?

Following from that:

3) What are the implications for charging infrastructure policy and planning with consideration of the spread of charging infrastructure?

Source: ChargeMap.com (2019), own illustration, as of October 2019.



2. Methodology Matching the Data Sets



Number of charging spots

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3. Results Marginal effects

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Charging cost per month	Marginal e High Med 200 € -19 150 € -15 100 € -9 50 €	ffects in % dium Low Base	On average, a choice set with cost of €200 is selected 19% less often compared to a choice set with cost of €50.
Charging duration	8 h -10 4 h 30 min 10 min	-6 -1 Base	Hardly any difference between 10 and 30 min of charging duration.
Roadside: ma Charging location Roadside: by-p A At	in goal - roduct t work t home	7 -6 -4 Base	At-home-charging preferred to charging at work or roadside.
Share of renewables	100% 75% 50% 25%	4 3 2 Base	Higher share of renewables preferred.
Waiting time for available charging station	30 min 10 min Statis 5 min s 0 min	-3 tically not significant Base	30 min of waiting time are more relevant than 30 min of charging duration.
Charging technology Te	ductive thered	∎ 1 Base	Weak preference for inductive charging.
Number of charging spots 1 charging	ng spot	-0.3	

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3. Results Average Willingness to Pay (WTP) for 0-530 charging spots

Variable	WTP (€/month)
Charging duration (reduction of 1 min)	0.16
Waiting Time (reduction of 1 min)	0.82
Renewable share (increase by 1%)	0.42
Technology (inductive instead of cable)	8.37

Charging location	WTP (€/month)
At home	(base)
At work	-22.22
On the road side	-35.62
On the road main	-46.18

- For a reduction of 1 min in
 - charging time, consumers are willing to pay 0.16 €/month.
 - waiting time, consumers are willing to pay 0.82 €/month.
- Difference in WTP between 0% and 100% renewables is 100*0.42 € = 42 €/month.
- For inductive charging compared to cable charging, the WTP is 8.37 €/month.

Consumers are willing to pay 22.22 €/month more for charging at home, compared to charging at work.



3. Results Spatial heterogeneity in the WTP for charging location

- WTP relative to at-home charging
- Location is interacting with the number of charging spots
- Evidence for charging point awareness



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5. Conclusions and Policy Implications

Respondents prefer charging (in order of importance)

Future) V drivers

- at the lowest costs;
- with shorter charging durations;
- at home to at work to roadside;
- with a higher share of renewable energies;
- with lower waiting times;
- inductively to cable-charging.

Spatial heterogeneity reveals

Key Findings

- charging point awareness
- the more charging spots there are, the more respondents become indifferent between the attribute levels
- importance of respondents' dependability on finding a spot outside their homes
- reservation system enhances efficient charging point availability

Affordable (fast-) charging spots

- primarily at home (either on private properties or public charging spots in residential areas) or
- at work (i.e. in mixed-use areas)
- which can be booked in advance.

Policies aimed at individuals' tradeoffs between monetary incentives and convenience





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Appendix: 3. Results Average Willingness to Pay (WTP) for 0-530 charging spots

Detailed results in €/month

	Average	WTP subject to the number of charging spots <i>C</i>						CS
Variable	WTP for <i>CS</i> = 0,, 530	0	1	50	100	150	200	250
Charging duration (reduction by 1 min) * charging spots	0.16	0.16	~	~	~	0.15	~	~
Waiting time (reduction by 1 min) * charging spots	0.82	0.82	~	~	~	0.81	~	~
Renewable share (increase by 1%) * charging spots	0.42	0.40	0.40	0.42	0.43	0.45	0.47	0.48
Technology (inductive instead of cable) * charging spots	8.37	8.48	8.48	8.39	8.30	8.21	8.12	8.03
Charging location:								
At home	(base)	(base)	(base)	(base)	(base)	(base)	(base)	(base)
On the road (main goal) * charging spots	-46.18	-48.20	-48.16	-46.64	-45.07	-43.48	-41.88	-40.26
On the road (side activity) * charging spots	-35.62	-38.11	-38.06	-36.18	-34.24	-32.28	-30.30	-28.29
At work * charging spots	-22.22	-24.47	-24.44	-22.73	-20.92	-19.17	-17.36	-15.44

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