Willing to Pay?

Spatial Heterogeneity of e-Vehicle Charging Preferences in Germany

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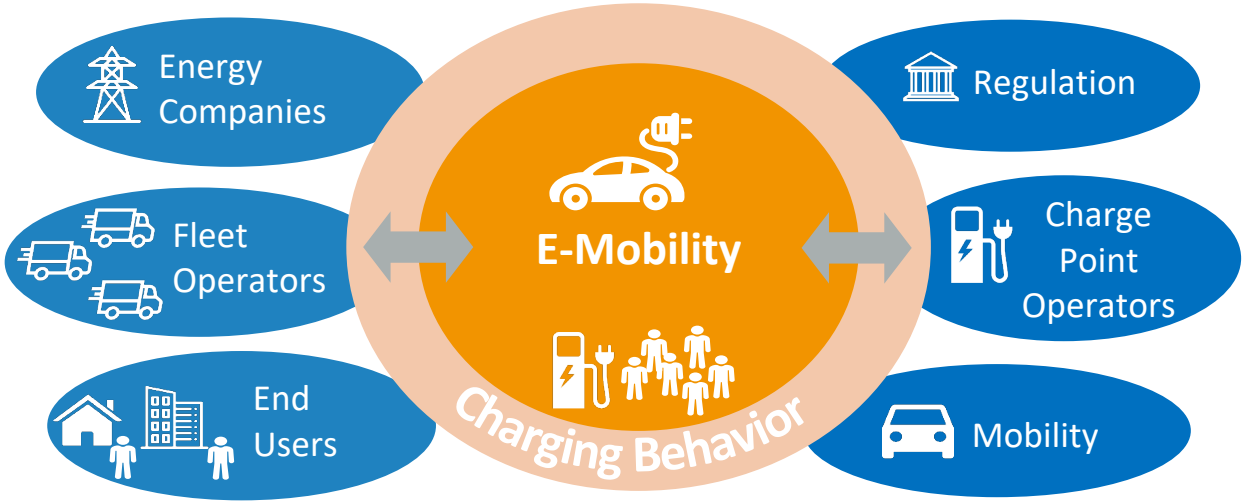
E-MOBILITY AS A FOCAL POINT BETWEEN ENERGY AND MOBILITY TRANSITIONS

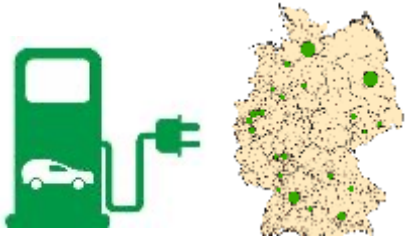


Mobility transition

- E-vehicle (EV) driving and charging behavior

Charging behavior

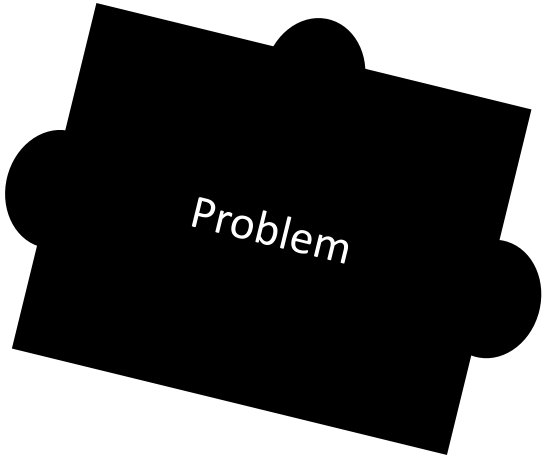
- Electric vehicle charging preferences of (future) consumer groups & their willingness to pay



Energy transition

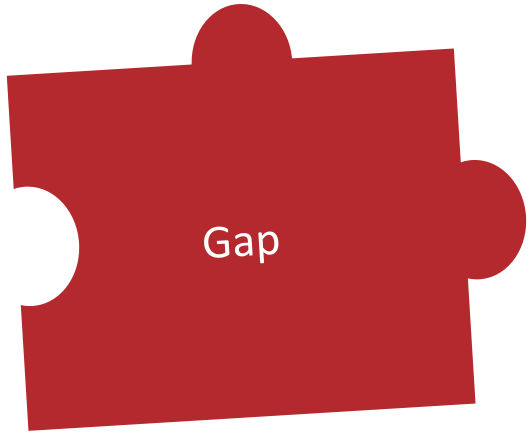
- Reduce fossil fuel dependency and CO_2 emissions
- Smart home integration

RESEARCH GAP



In economics, charging spots – a spatial combination of parking and refueling – are rival goods.

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



Effects of charging design on preferences

- Effects of charging design (duration, location, price) on preferences = Charging behavior as a whole bundle.

  ✓ Done in previous paper

- Here: Effects of charging availability (number of charging spots on preferences

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

- 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

DISCRETE CHOICE EXPERIMENT

“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.“

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 €
	○ **OPTION A**	○ **OPTION B**

ATTRIBUTES

LEVELS

CHOICE

DISCRETE CHOICE EXPERIMENT

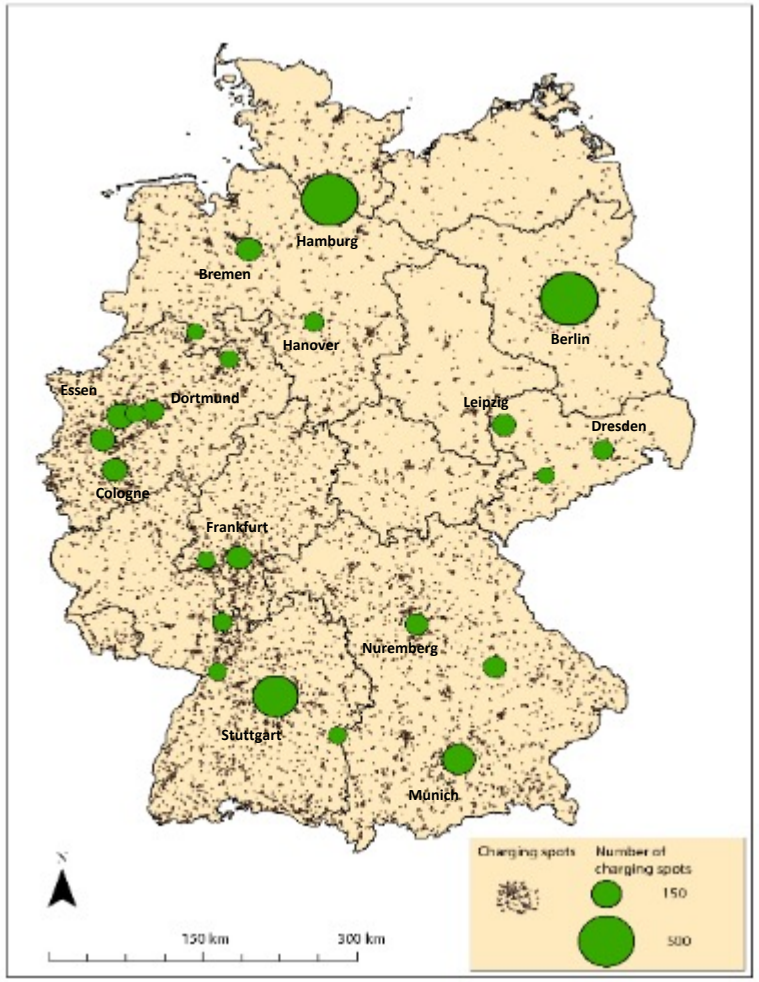
- Respondents are forced to consider tradeoffs between the attributes that define the two options A and B
- The number of both attributes and levels is limited so that respondents are not overburdened
- The design algorithm ensures that all levels appear on the same number of choice cards
- Individuals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

Overview of Attribute Levels				
Place of charging	At home	At work	Roadside: Primary	Roadside: Secondary
Charging duration (full charge)	10 min	30 min	4 hours	8 hours
Charging technology	Tethered charging (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 €

ATTRIBUTES

LEVELS

DISTRIBUTION OF CHARGING SPOTS ACROSS GERMANY



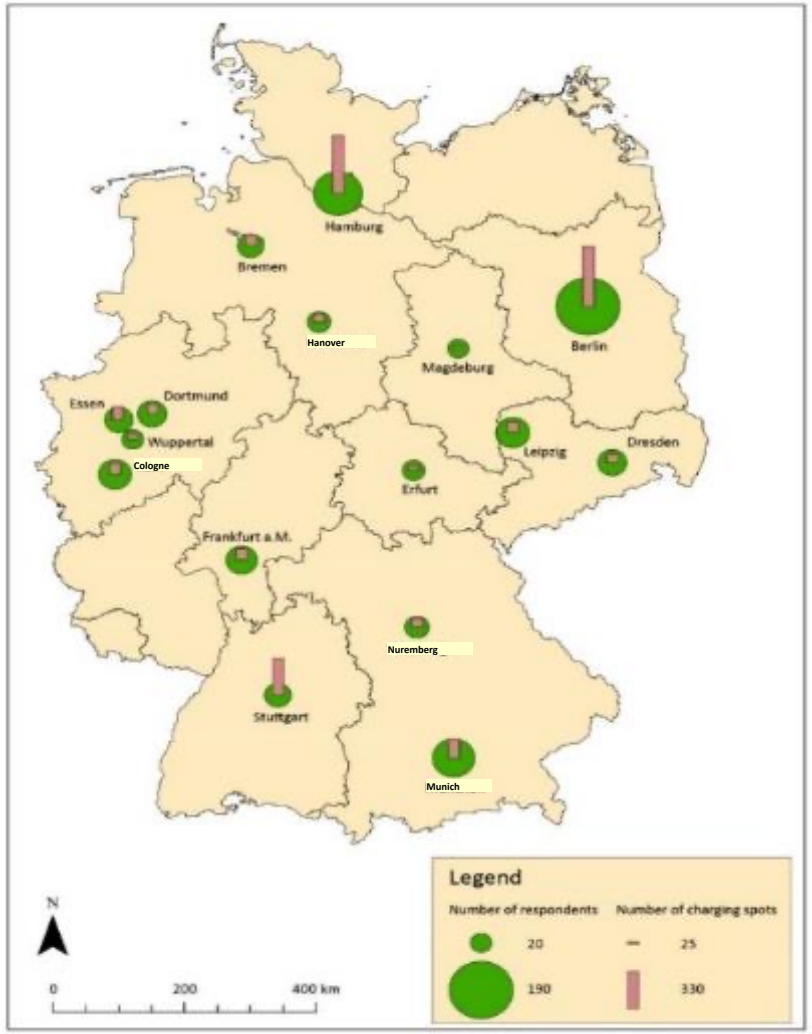
1) Does the number of existing charging spots affect the EV charging preferences?
2) Depending on the number of charging spots, what is the willingness to pay (WTP) for certain attributes of the EV charging process? For example, how much is 1 minute less in charging duration worth?

Following from that:

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

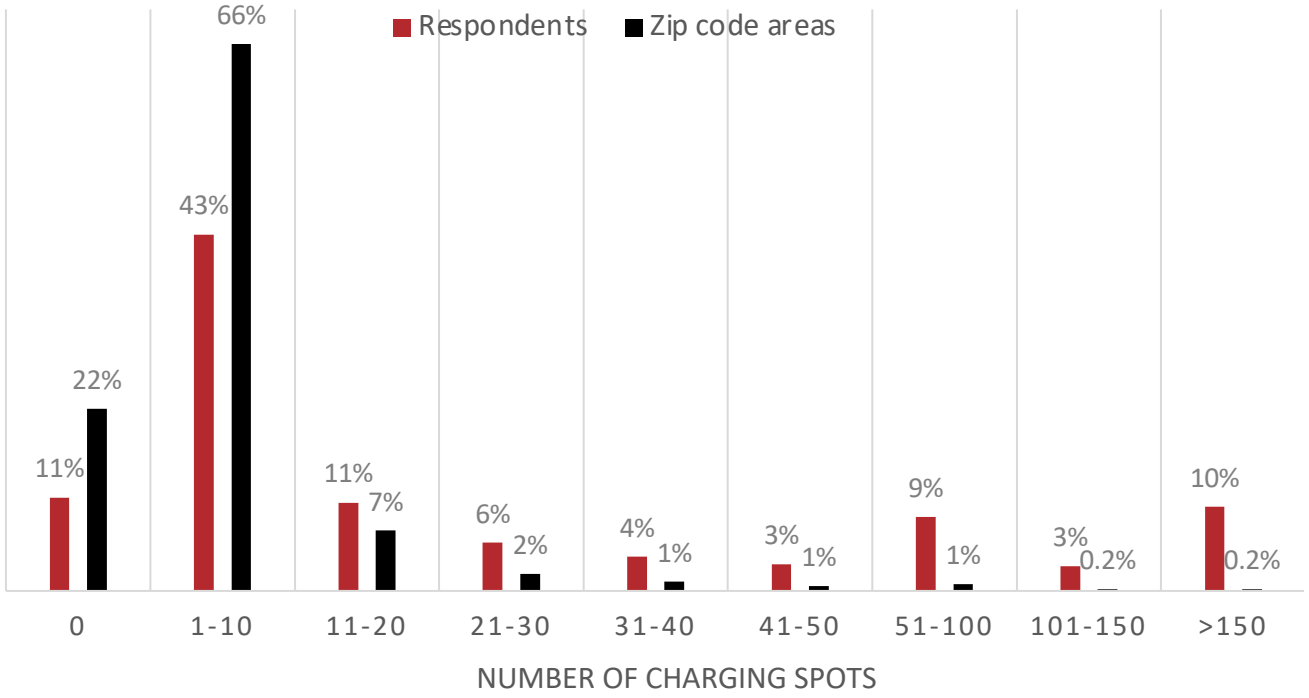
Source: ChargeMap.com (2019), own illustration, as of October 2019.

MATCHING THE DATA SETS

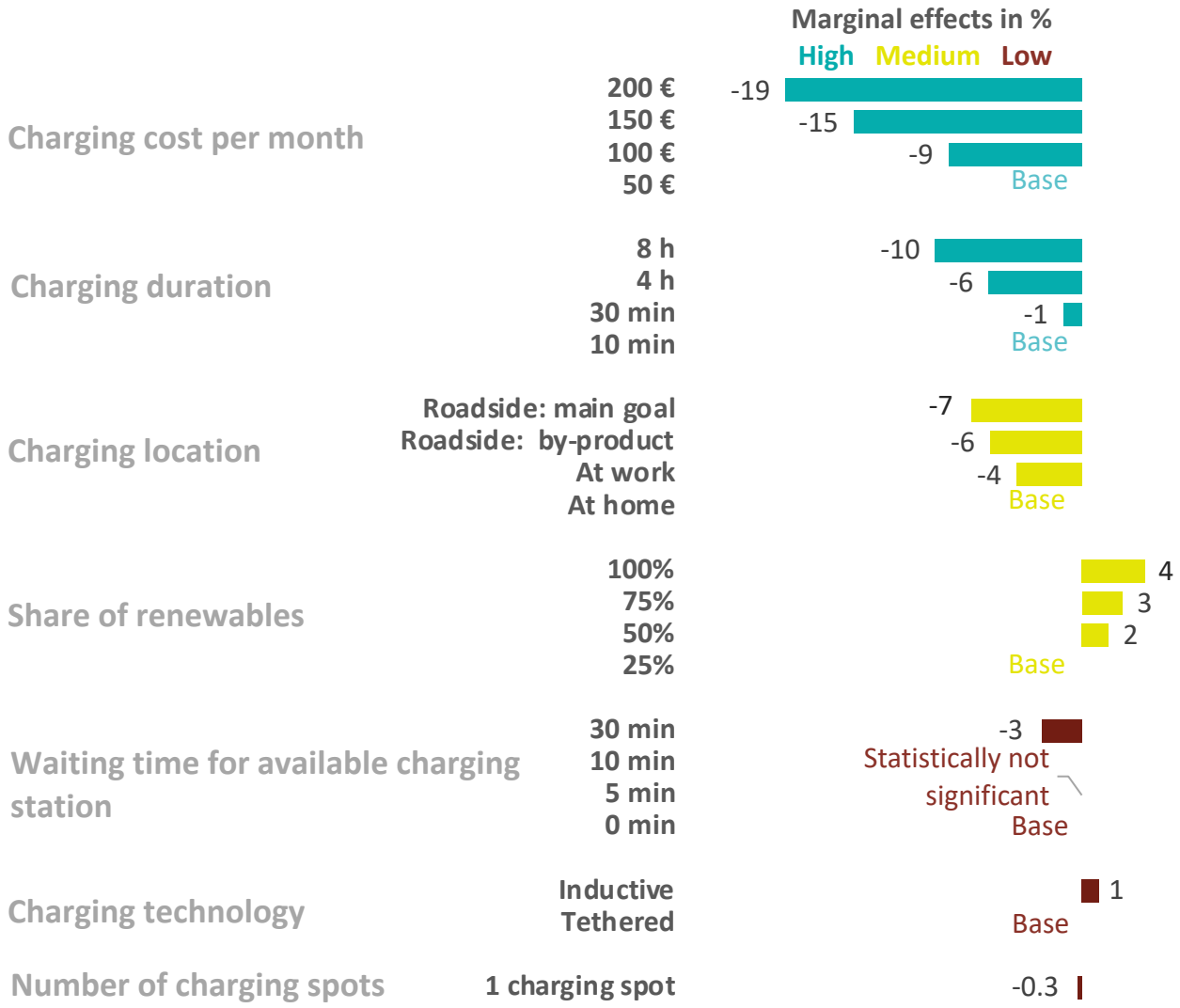


Allocation of charging spots and respondents across Germany (as of October 2019)

Representative sample, *N* = 4.101



MARGINAL EFFECTS



On average, a choice set with cost of €200 is selected 19% less often compared to a choice set with cost of €50.

Hardly any difference between 10 and 30 min of charging duration.

At-home-charging preferred to charging at work or roadside.

Higher share of renewables preferred.

30 min of waiting time are more relevant than 30 min of charging duration.

Weak preference for inductive charging.

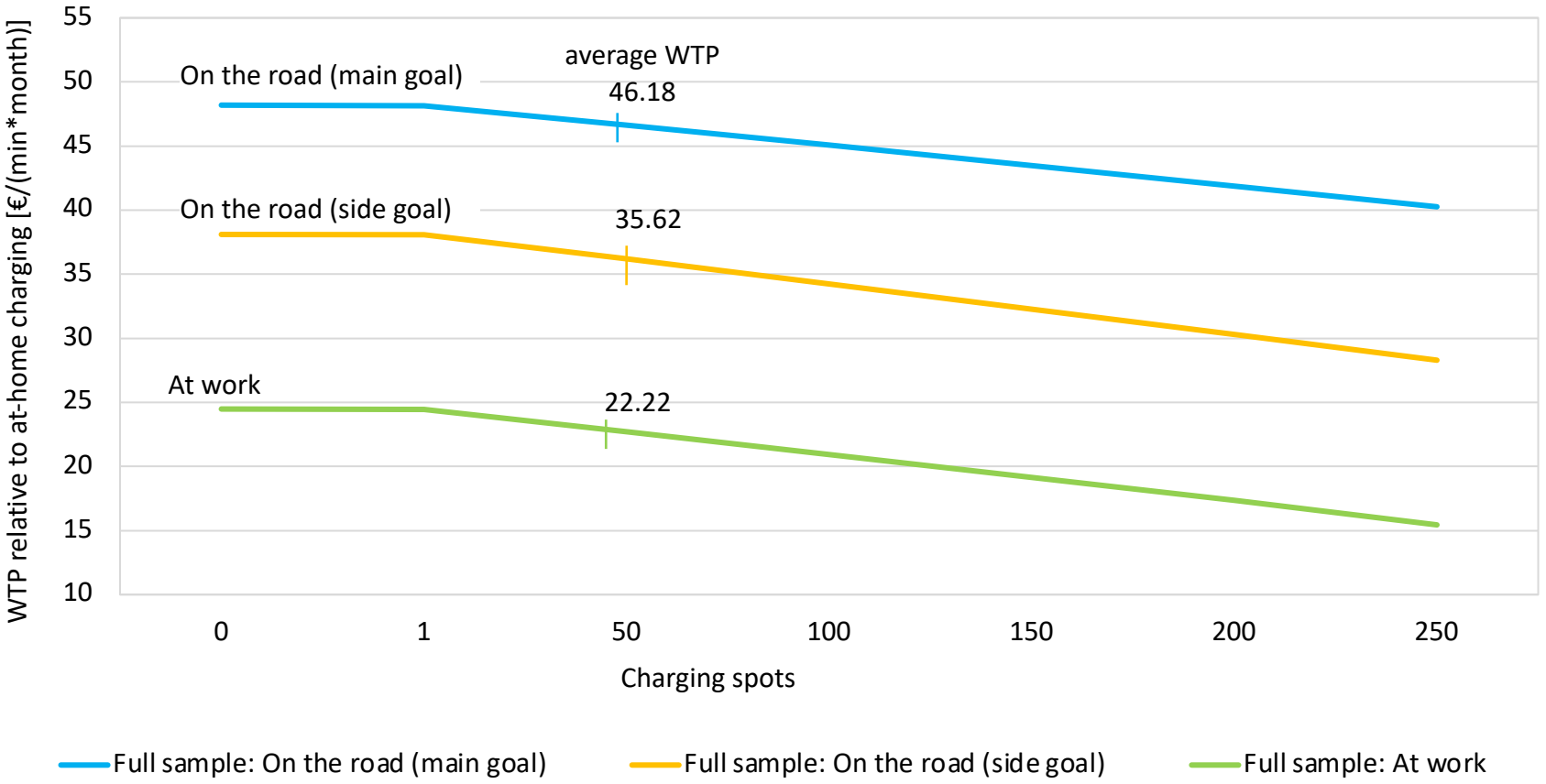
AVERAGE WILLINGNESS TO PAY FOR 0-530 CHARGING SPOTS

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

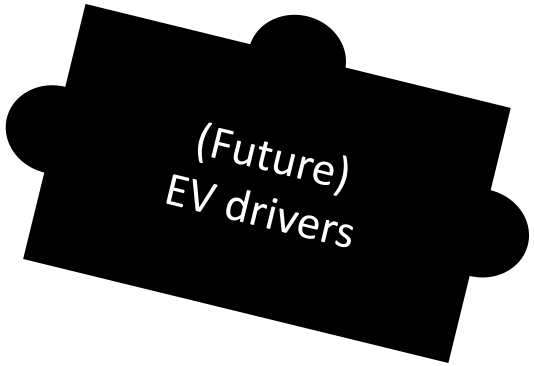
- **FOR A REDUCTION OF 1 MIN IN**
  - charging time, consumers are willing to pay 0.16 €/month.
  - waiting time, consumers are willing to pay 0.82 €/month.
- **DIFFERENCE IN WTP BETWEEN 0% AND 100% RENEWABLES IS 100*0.42 € = 42 €/MONTH.**
- **FOR INDUCTIVE CHARGING COMPARED TO CABLE CHARGING, THE WTP IS 8.37 €/MONTH.**
- **CONSUMERS ARE WILLING TO PAY 22.22 €/MONTH MORE FOR CHARGING AT HOME, COMPARED TO CHARGING AT WORK.**

WILLINGNESS TO PAY RELATIVE TO AT-HOME CHARGING



1. **Location is interacting with the number of charging spots**
2. **Spatial heterogeneity in the Willingness to Pay for charging location**
3. **Evidence for charging point awareness**

CONCLUSIONS AND POLICY IMPLICATIONS



Respondents prefer charging (in order of importance)

- 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

- 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.

Key takeaway: Policies aimed at individuals' tradeoffs between monetary incentives and convenience.

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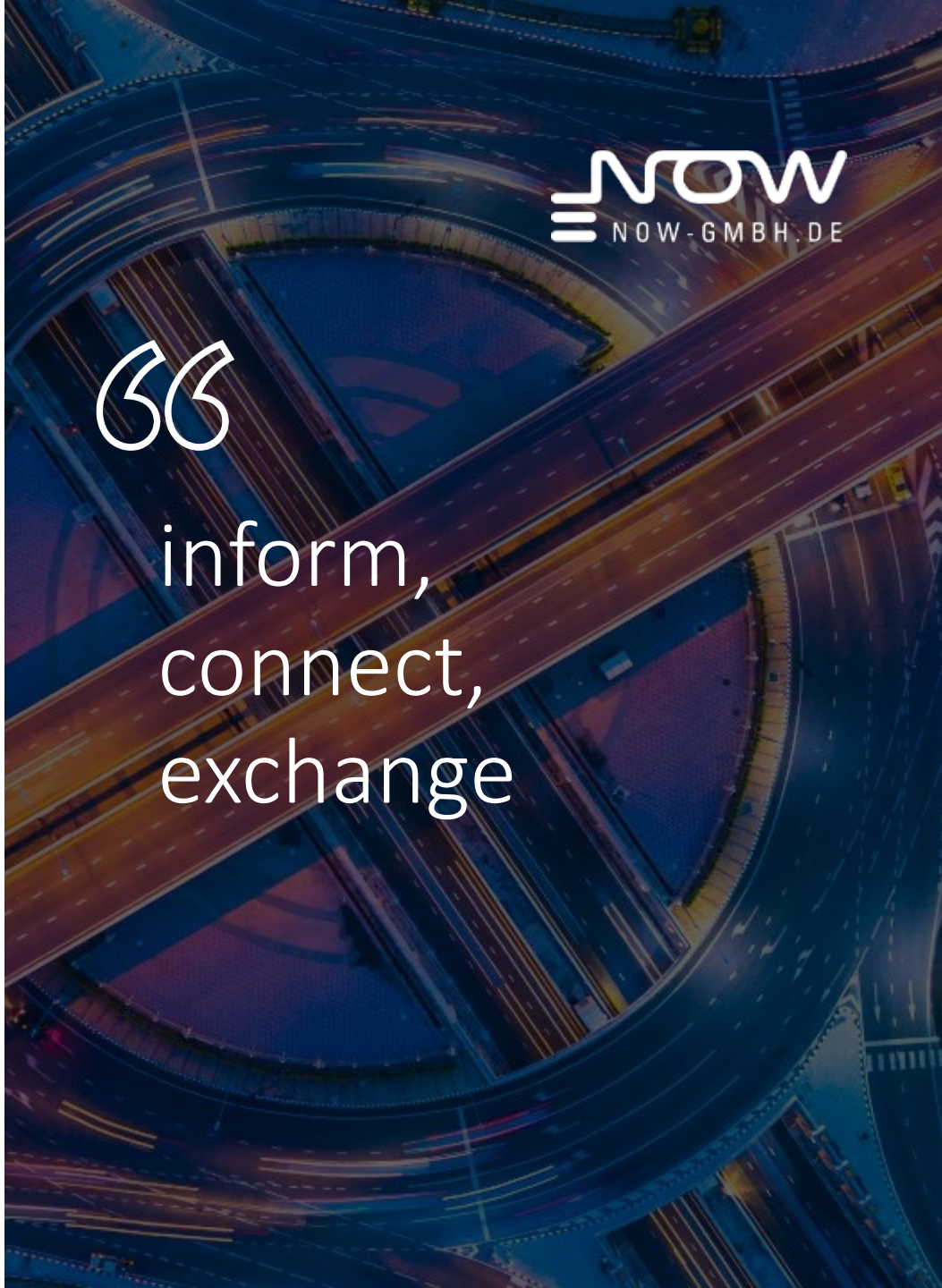

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APPENDIX: 3. RESULTS

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

Detailed results in €/month

Variable	Average WTP for $CS = 0, \dots, 530$	WTP subject to the number of charging spots CS						
		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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