

Dynamic Electric Vehicle Charging Tariffs: A Preference Analysis of German Consumers

S. Präse¹ T. Schütte¹ H. Wetzel¹

¹Institute of Economics
University of Kassel

Enerday, Dresden, March 2026

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Motivation and Background I

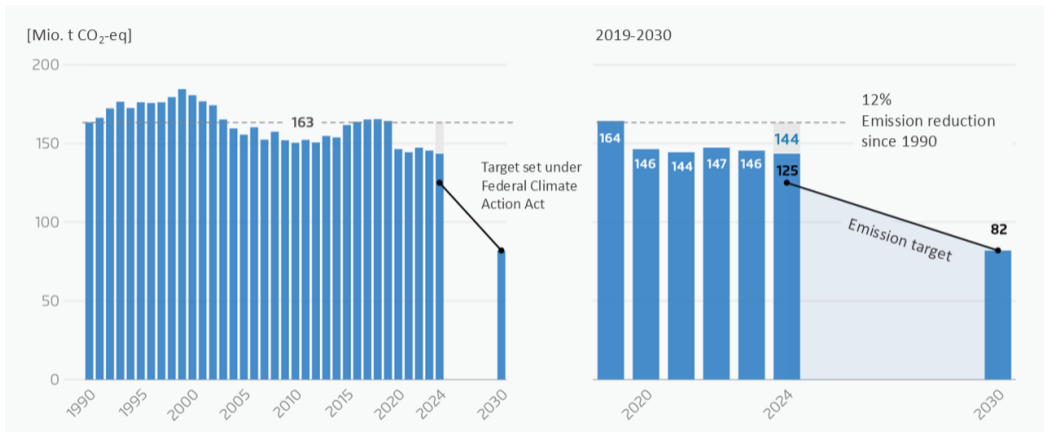
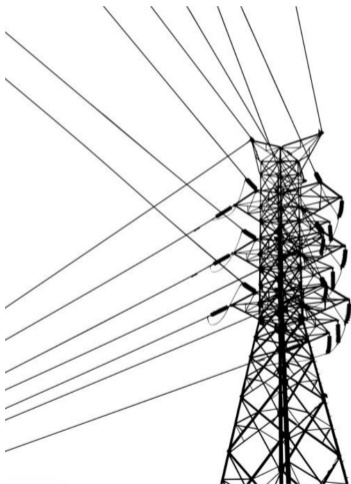


Figure 1: Development of greenhouse gas emissions in the transport sector in Germany (Agora, 2025)

Motivation and Background II



- Demand and supply must be balanced to ensure grid stability.
- Increased supply from renewable energy sources and growing EV adoption rates pose challenges to the power sector (e.g. increased intermittency, risk of grid congestion) (e.g. Huang et al. 2021).
- One way to address these challenges is to shift demand from peak hours to non-peak hours using price signals.
⇒ Dynamic electricity pricing

Motivation and Background III

- Existing literature finds a negative correlation between more dynamic properties of electricity tariffs and consumer acceptance (Dütschke and Paetz, 2013; Ruokamo et al., 2019; Schlereth et al., 2018).
- However, most of the existing literature studies dynamic electricity tariff options for household electricity (e.g., Von Loessl, 2023; Dutta and Mitra, 2017), with few studies on dynamic EV charging tariffs (e.g., Helferich et al., 2024).
- Household electricity consumption is very price inelastic, as shown in the EU (Csereklyei, 2020), Germany (Schulte and Heindl, 2017) and the US (Burke and Abayasekara, 2018).
- Recent findings suggest that EV charging price elasticity is more similar to gasoline price elasticity rather than that of household electricity consumption (Nehiba, 2024).

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Stated Choice Experiment

- **Sample:** Car owners and potential future car owners in Germany who are decision-makers in their household ($N = 7,150$) (Based on a representative sample).
- **Choice scenario:** (Future) Car owners assume that their (future) car is an EV and are asked to make a decision on a charging tariff. They receive identical baseline information to ensure a minimum level of affinity.

Choice scenario

- Imagine, that you can choose between dynamic charging tariffs for your EV.
- These tariffs have varying prices at varying times which are defined in advance and can be viewed in a mobile app.
- Thus, they offer savings potential but also the risk of additional costs compared to a flat tariff.



Figure 2: Example of changing prices over a day

Attributes and Levels

Table 1: Attributes and attribute levels

Attribute	Level
Most frequent low-price zone	12pm-2am; 2am-4am; 12am-2pm
Most frequent high-price zone	6am-8am; 6pm-8pm; 8pm-10pm
Number of price zones per day	3; 5; 7; 9
Fixed monthly costs	80 %; 90 %; 100 %; 110 % of the individual-specific charging costs
Maximum monthly savings	60 %; 70 %; 80 %; 90 % of the individual-specific variable charging costs
Maximum monthly additional costs	25 %; 50 %; 75 %; 100 % of the individual-specific variable charging costs

Sample Choice Set

Table 2: Sample choice set

Attributes	Option 1	Option 2	Option 3
Most frequent low-price zone	12pm-2am	2am-4am	2am-4am
Most frequent high-price zone	8pm-10pm	6am-8am	6am-8am
Number of price zones per day	3	7	5
Fixed monthly costs	63 €	76 €	50 €
Maximum monthly savings	12 €	18 €	14 €
Maximum monthly additional costs	20 €	5 €	10 €
I choose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Would you actually choose this tariff?		Yes <input type="checkbox"/>	No <input type="checkbox"/>

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Main model results: General preferences

Table 3: SML estimation results in a mixed logit model for the choice among three dynamic EV charging tariffs and an opt-out (1000 Halton draws, $N = 7,150$)

	Mean of the estimated parameter	Robust z-statistic	Std. dev. of the estimated parameter	Robust z-statistic
Monthly tariff costs	-4.969***	(-50.661)		
Most frequent low price zone (ref.: 12 am to 2 pm):				
2 am to 4 am	-0.080**	(-2.420)	0.915***	(20.982)
12 pm to 2 am	-0.080**	(-2.469)	0.932***	(21.895)
Most frequent high price zone (ref.: 6 pm to 8 pm):				
8 pm to 10 pm	-0.045*	(-1.803)	0.294***	(3.367)
6 am to 8 am	-0.017	(-0.663)	0.538***	(10.245)
Number of price zones per day	-0.051***	(-10.535)	0.130***	(16.357)
Potential monthly cost savings	-0.057	(-0.591)	0.917***	(3.637)
Potential monthly additional costs	-1.401***	(-30.109)	1.496***	(25.076)
No-choice option	-4.840***	(-33.129)	4.110***	(47.984)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Interaction model results: Car-related individual-specific characteristics

Table 4: SML estimation results in a mixed logit model with interaction terms between dynamic EV charging tariff attributes and car-related individual-specific characteristics (Interactions with control variables omitted for brevity, 1000 Halton draws, N = 7,150)

	Potential monthly cost savings		Potential monthly additional costs		No-choice option	
	Mean of the estimated Parameter	Robust z-statistic	Mean of the estimated Parameter	Robust z-statistic	Mean of the estimated Parameter	Robust z-statistic
Number of cars					0.252**	(2.022)
Owns exclusively gasoline cars			0.432*	(1.798)	-1.224***	(-2.883)
Owns exclusively EVs						
Owns both						
Annual mileage in km			-0.017***	(-3.548)		
Uses car for work					-0.386**	(-2.140)
Has EV charging tariff	1.376**	(2.331)			-1.059**	(-1.993)
Future car: Conventional						
Future car: EV	0.880***	(3.958)			-0.679***	(-3.668)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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Discussion

- We find that people show a general preference for dynamic electric vehicle charging tariffs.
 - ⇒ In contrast to results from the literature on tariffs for household electricity.
- Respondents prefer fewer daily price zones (changes).
 - ⇒ Respondents value lower perceived operating effort.
- The results suggest that respondents tend to value avoiding additional costs more than additional savings.
 - ⇒ Suggests the presence of loss aversion in our sample.
 - ⇒ Also suggests that peak pricing could have a larger potential than price reductions in shifting demand.
- People that have fewer (or no) cars, do not own an EV, already use an EV charging tariff, or intend to purchase an EV in the near future show stronger preferences for dynamic EV charging tariffs.
 - ⇒ Suggests that EV affinity increases the likelihood of adopting dynamic EV charging tariffs.

Comments and Questions (Thank you!)

Contact: simon.proese@uni-kassel.de

Appendix

Literature I

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Choice scenario

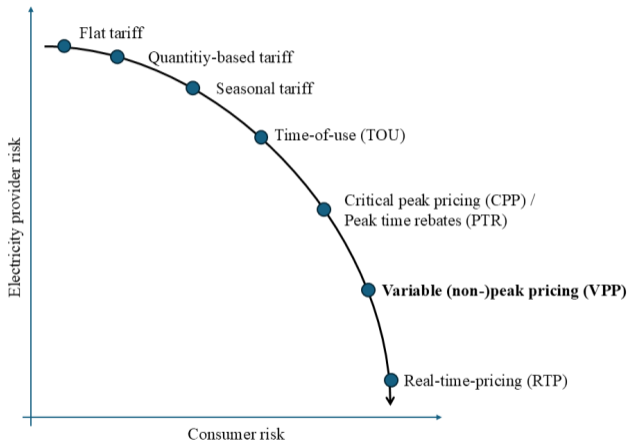


Figure A1: Classification of the tariff used in the stated choice experiment (Own illustration based on Dutta and Mitra, 2017; Dütschke et al., 2012)

Sample statistics (N=7,150)

	Mean/share	Std. Dev.	Min	Max	Germany ¹
Owens an electric vehicle ^b	0.07	0.26	0.00	1.00	
Number of cars in household	1.44	0.75	0.00	9.00	
Annual mileage of most used car (in km)	12333.43	8989.51	1000.00	65000.00	
Owens solar PV ^b	0.19	0.39	0.00	1.00	
Owens wallbox ^b	0.10	0.30	0.00	1.00	
Owens battery storage ^b	0.12	0.32	0.00	1.00	
Age					
18-29 ^b	0.15	0.35	0.00	1.00	0.18
30-39 ^b	0.19	0.39	0.00	1.00	0.18
40-49 ^b	0.19	0.39	0.00	1.00	0.16
50-59 ^b	0.23	0.42	0.00	1.00	0.22
60-75 ^b	0.25	0.43	0.00	1.00	0.26
Female ^b	0.48	0.50	0.00	1.00	0.50
High education ^b	0.45	0.50	0.00	1.00	0.39
East Germany ^b	0.16	0.37	0.00	1.00	0.16
Household size	2.34	1.08	1.00	6.00	
Household equivalized income	2233.94	1146.32	100.00	12500.00	
Urban ^b	0.79	0.41	0.00	1.00	

Binary variables are marked with ^b, all other variables are continuous. ¹Quotas used to ensure representativeness.

Interaction model results

Table 5: SML estimation results in a mixed logit model with interaction terms between dynamic EV charging tariff attributes and car-related individual-specific characteristics (Interactions with control variables omitted for brevity, 1000 Halton draws, $N = 7,150$)

	Potential monthly cost savings		Potential monthly additional costs		No-choice option	
	Mean of the estimated Parameter	Robust z-statistic	Mean of the estimated Parameter	Robust z-statistic	Mean of the estimated Parameter	Robust z-statistic
Number of cars	-0.070	(-0.441)	-0.000	(-0.003)	0.252**	(2.022)
Owns exclusively gasoline cars	-0.218	(-0.404)	0.432*	(1.798)	-1.224***	(-2.883)
Owns exclusively EVs	-0.102	(-0.153)	-0.080	(-0.258)	-0.808	(-1.492)
Owns both	0.476	(0.657)	0.313	(0.959)	-0.154	(-0.261)
Annual mileage in km	-0.011	(-0.983)	-0.017***	(-3.548)	0.002	(0.172)
Uses car for work	0.084	(0.378)	0.024	(0.242)	-0.386**	(-2.140)
Has EV charging tariff	1.376**	(2.331)	-0.115	(-0.409)	-1.059**	(-1.993)
Future car: Conventional	-0.043	(-0.147)	-0.061	(-0.471)	-0.218	(-0.931)
Future car: EV	0.880***	(3.958)	0.043	(0.439)	-0.679***	(-3.668)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Explanations before the Choice Experiment I

Below we come to a part of the survey that relates to charging the electric vehicle battery and vehicle power contracts. For this part of the survey, we ask you to imagine that your vehicle is now an electric vehicle.

Where can i charge my electric vehicle?

In the following, assume that your household has its own garage or parking space. Also assume that you have a power connection and a wallbox installed at this parking space, which you use to charge the electric vehicle.

How often do i need to charge my electric vehicle?

We have calculated a monthly charging time for you based on your information. Therefore, assume that you need to charge this electric vehicle for a total of [*individualized amount*] hours per month.

How is the electricity for the electric vehicle billed?

The electricity you use in your household in everyday life (e.g. for the fridge, washing machine or dishwasher) is known as “household electricity”, whereas the electricity you use to charge your electric vehicle is known as “vehicle electricity”. Assume below that the vehicle electricity is billed separately from your household electricity. There are so-called “electric vehicle charging tariffs” for this.

Explanations before the Choice Experiment II

What are electric vehicle charging tariffs?

An electric vehicle charging tariff is a special electricity tariff for electric vehicles. Electricity costs in electric vehicle charging tariffs are generally lower than in household electricity tariffs. With a conventional electric vehicle charging tariff, you charge the battery of your household's electric vehicle at the wallbox at your parking space at the maximum available charging speed at all times. This means that it always takes the same amount of time to charge the battery from 0% to 100% in a conventional electric vehicle charging tariff. Conventional electric vehicle charging tariffs are currently the standard. In the future, however, there will be new types of electric vehicle charging tariffs, such as dynamic electric vehicle charging tariffs.

Dynamic electric vehicle tariffs have three price zones: standard, low, and high. This means that the price of electricity for electric vehicles can sometimes be more expensive and sometimes cheaper throughout the day. Depending on the dynamic electric vehicle tariff, these price zones can occur with varying frequency, meaning that the price of electricity can change at different times throughout the day.

The price zones for all days of the current contract year can be viewed at any time via an app. This allows you to plan in advance when you want to charge your household's electric car. The image on the left shows an example of a day with few price zones, while the image on the right shows a day with many price zones. In a dynamic electric vehicle tariff, the number of price zones can vary from day to day. [Next page]

Explanations before the Choice Experiment III



Figure A2: Example of a day with little price variation

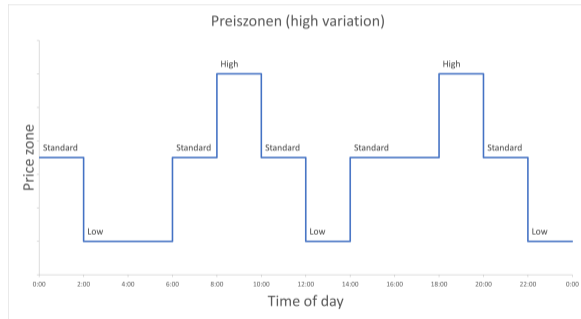


Figure A3: Example of a day with much price variation

Attribute Descriptions I

Most common period with low price zone

Low-price zones can occur several times a day and at any time of day. This property specifies the hours during which a low-price zone occurs **most frequently** in the respective contract.

Most common period with high price zone

High-price zones can occur several times a day and at any time of day. This property specifies the hours during which a high-price zone occurs **most frequently** in the respective contract.

Number of price zones per day

The tariffs differ in the number of price zones per day. This feature indicates how many price zones (low, standard, high) occur on average per day. The image on the left shows an example of a day with few price zones, while the image on the right shows a day with many price zones.

Attribute Descriptions II

Monthly tariff costs

The monthly costs indicate how much you pay per month when using the tariff if you charge your household's electric vehicle exclusively in the standard price zone.

Potential monthly cost savings

By charging your household's electric vehicle during low-price periods, you can reduce your monthly costs under your respective electricity vehicle charging tariff. You can save up to the amount shown each month, depending on how much you actually charge during low-price periods.

Potential monthly additional costs

Charging your household's electric vehicle in high-price zones can increase your monthly costs in the respective electric vehicle charging tariff. Depending on how much you actually charge in high-price zones, you may incur additional monthly costs up to the specified amount.

Choice Scenario I

Now suppose you need to sign a dynamic electric vehicle charging tariff.

Now take a close look at all three dynamic electric vehicle charging tariffs on the following pages and select your preferred dynamic electric vehicle charging tariff on each page. Please always assume that only the three dynamic electric vehicle charging tariffs shown are available for selection and that they do not differ in other characteristics, such as the associated devices that need to be installed or customer service, but are identical.

Please make each selection as if you were actually signing a dynamic electric vehicle charging tariff. The results of this study will be used to advise providers on the design of these electric vehicle charging tariffs. Your decisions could therefore have an impact on the design of future electric vehicle charging tariffs.

[Next page (Choice sets)]

Choice Scenario II

Above each choice set:

Assume that you charge **[individualized monthly charging time in hours]** hours per month.

Let us begin with the first choice. Which of the following electric vehicle charging tariffs would you choose?

Assume that the tariffs shown are the only ones available. Make your choices under the assumption that your annual mileage is the same as today.

[... Choice set 1 - 6 ...]

Under each choice set:

Would you choose the chosen tariff if it was offered to you in reality? [Yes / No]

Screenshot of the Experiment (in German)

1 von 6

Nehmen Sie an, dass Sie pro Monat **19 Stunden** laden.

Beginnen wir nun mit der ersten Auswahl. Für welchen der folgenden drei Autostromverträge würden Sie sich am ehesten entscheiden?

Treffen Sie jede Entscheidung unter der Annahme, dass sich Ihre jährliche Fahrleistung nicht ändert.

Attribut: (für weitere Informationen bitte klicken/tippen)	Vertrag A	Vertrag B	Vertrag C
Häufigster Zeitraum Niedrigpreiszone 	02 bis 04 Uhr	02 bis 04 Uhr	00 bis 02 Uhr
Häufigster Zeitraum Hochpreiszone 	20 bis 22 Uhr	18 bis 20 Uhr	06 bis 08 Uhr
Anzahl Preiszonen pro Tag 	9	3	3
Monatliche Kosten 	56 Euro	74 Euro	62 Euro
Mögliche monatliche Einsparung 	12 Euro	18 Euro	16 Euro
Mögliche monatliche zusätzliche Kosten 	5 Euro	15 Euro	5 Euro
Ihre Auswahl:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Wenn Ihnen dieser Vertrag in der Realität angeboten würde, würden Sie diesen Vertrag dann wirklich abschließen?

- Nein
 Ja

Calculation of individualized attributes

- Number of charging cycles required per month

$$X = [(stated\ annual\ mileage) / 12) / (range\ of\ corresponding\ car\ class)]$$

- Charging time per charging cycle

$$Y = [(average\ amount\ of\ energy\ required\ per\ full\ charge\ in\ kWh) / 11\ kW]$$

- **Monthly charging costs**

$$Z = [Base\ costs + [(X) * (Energy\ required\ per\ full\ charge) * (Average\ working\ price\ in\ Euro/kWh)]]$$