

SMART
CHARGING

Consumer Preferences for BEV Smart Charging Programs

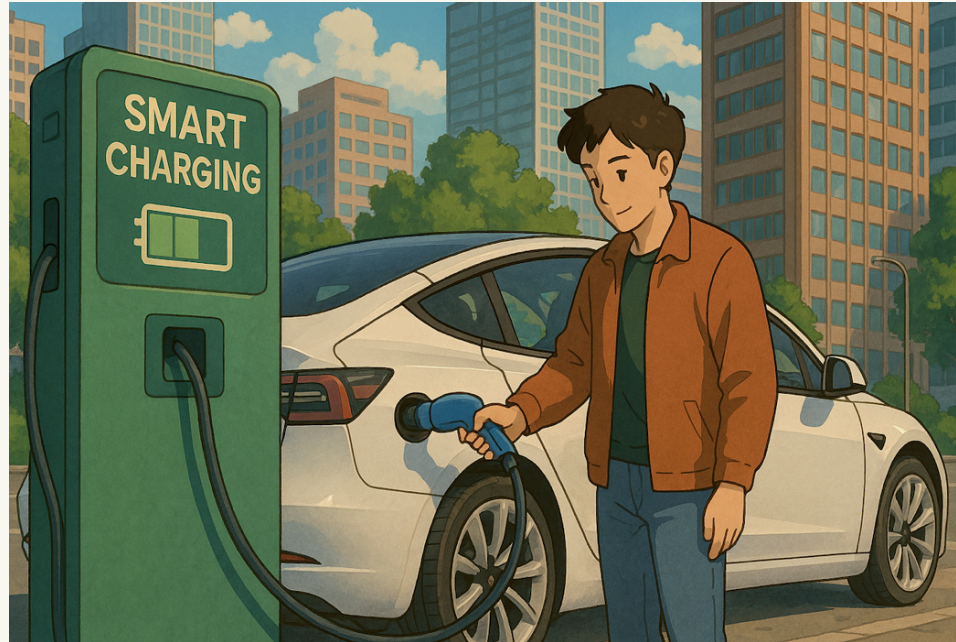
DQE Part II 2025

Pingfan Hu



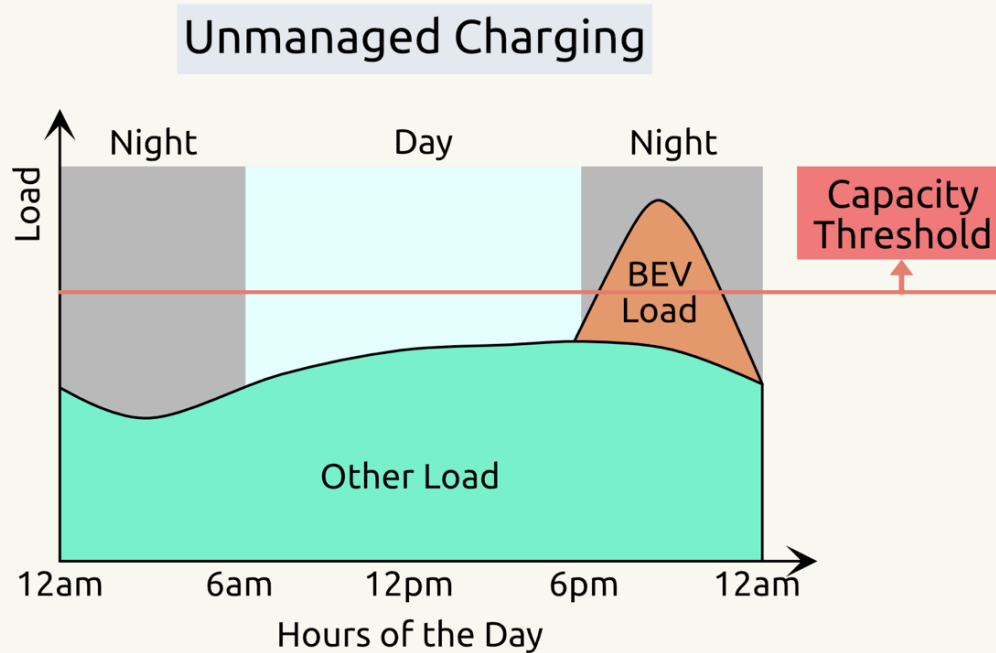
Introduction

- **Unmanaged** BEV charging generates CO_2 and other pollution.
- **Managed** charging is cheaper and environmentally friendly.
- **Smart** charging: Supplier-Managed Charging (SMC) and Vehicle-to-Grid (V2G).



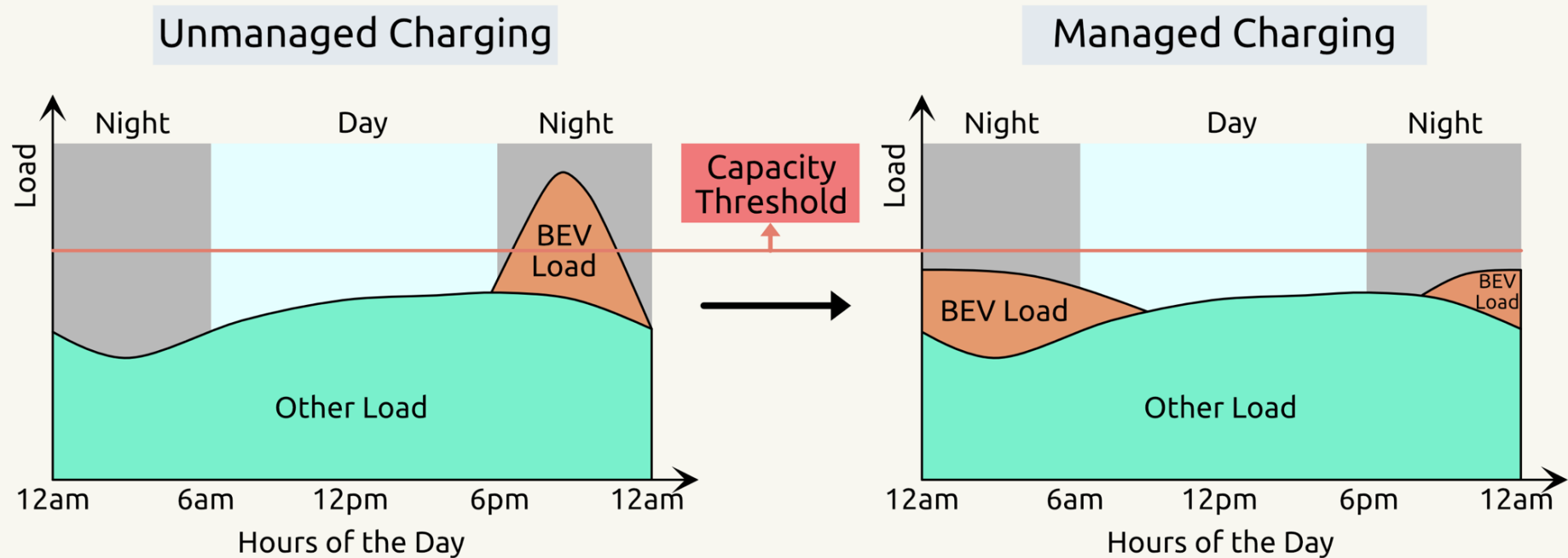
SMC - Supplier Managed Charging

- SMC smooths out overnight EV charging demand.
- Electricity demand is controlled below capacity threshold.
- It saves money and reduces pollution.



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Managed charging avoids overload caused by BEV charging.

V2G - Vehicle-to-Grid

Non-V2G (Single Direction)

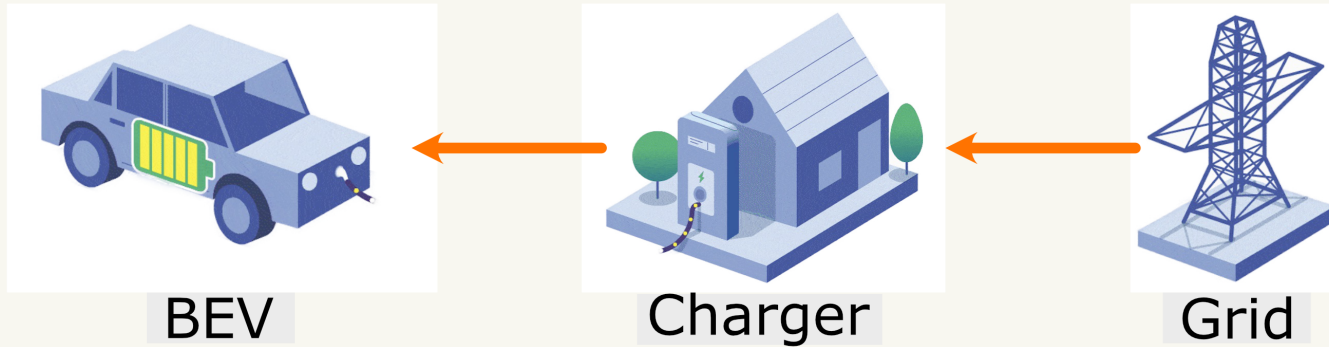
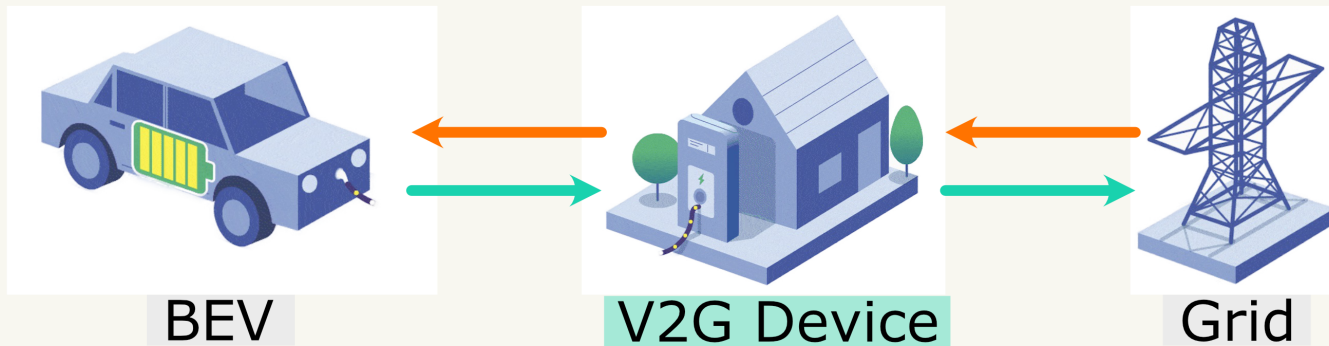


Figure Source: wri.org

V2G (Bi-direction)



In a V2G event, BEVs can charge the grid when necessary. BEVs are charged back eventually. Owners earn money.

Literature Review

1. A study by Wong et al. (2023) examined **incentives** affect the EV owners' acceptance, **but EV ownership is only 19%**.
2. A study by Philip and Whitehead (2024) found **range anxiety** matters, **but EV ownership is only 1.28%**.
3. Another study by Huang et al. (2021) indicates the importance of **fast charging**, **but the sample size is only 157**.

None of them have demographics data to study **heterogeneity**.

We need high EV ownership & large sample size, and consider heterogeneity.

Research Questions

1. **Sensitivity:** How do changes in smart charging program features influence BEV owners' **willingness** to opt in?
2. **Market Share:** Under what **conditions** will BEV owners be more willing to opt in to smart charging programs?

Conjoint survey to collect BEV owners' willingness.

Multinomial logit model for utility simulations.

Survey Design with formr

Survey Components

1. Conjoint Questions:

- a. Monetary Incentives
- b. Charging Limitations
- c. Flexibility

2. Demographic Questions:

- a. BEV Ownership & Usage
- b. Personal & Household Info

Conjoint Attributes Sample

No.	Attributes	Range
1	Enrollment Cash	\$50 to \$300
2	Monthly Cash	\$2 to \$20
3	Monthly Override	0 to 5
4	Min Battery	20% to 40%
5	Guaranteed Battery	60% to 80%

Conjoint Question Explained

A Sample Conjoint Question

For example, if these were the only apples available, which would you choose? *

Option 1	Option 2	Option 3
		
Type: Fuji	Type: Pink Lady	Type: Honeycrisp
Price: \$ 2 / lb	Price: \$ 1.5 / lb	Price: \$ 2 / lb
Freshness: Average	Freshness: Excellent	Freshness: Poor

1. You are provided with different **sets** of attributes.
2. You choose one **set** instead of one **attribute**.

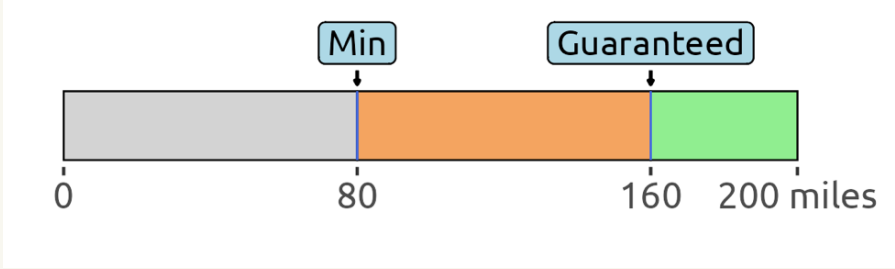
SMC Programs

Attributes

No.	Attributes	Range
1	Enrollment Cash	\$50 to \$300
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4	Min Battery	20% to 40%
5	Guaranteed Battery	60% to 80%

Sample Program

Attributes	Values
Enrollment Cash	\$300
Monthly Cash	\$20
Monthly Override	5



0 80 160 200 miles

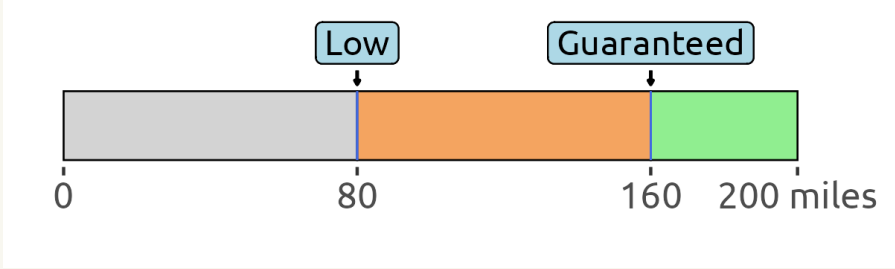
V2G Programs

Attributes

No.	Attributes	Range
1	Enrollment Cash	\$50 to \$300
2	Occurrence Cash	\$2 to \$20
3	Monthly Occurrence	1 to 4
4	Lower Bound	20% to 40%
5	Guaranteed Battery	60% to 80%

Sample Program

Attributes	Values
Enrollment Cash	\$300
Occurrence Cash	\$20
Monthly Occurrence	1

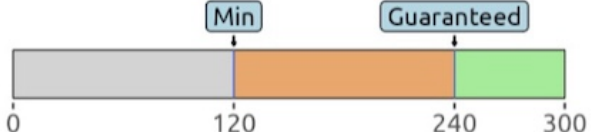


A horizontal bar chart illustrating a range from 0 to 200 miles. The bar is divided into three segments: gray (0 to 80 miles), orange (80 to 160 miles), and green (160 to 200 miles). A blue box labeled 'Low' with a downward arrow points to the 80-mile mark. Another blue box labeled 'Guaranteed' with a downward arrow points to the 160-mile mark.

Sample SMC Question

(1 of 6) If your utility offers you these 2 SMC programs, which one do you prefer?
(Your BEV has maximum range of **300** miles.)

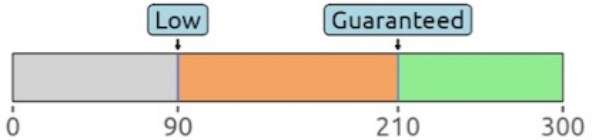
[Access the SMC Attributes](#)

Option 1	Option 2	Option 3
Enrollment Cash: \$100 Monthly Cash: \$20 Override Allowance: 1 per Month Battery Thresholds (in Miles):  A horizontal bar representing the 300-mile range of the BEV. It is divided into three segments: a grey segment from 0 to 60 miles, an orange segment from 60 to 240 miles, and a green segment from 240 to 300 miles. A blue box labeled 'Min' points to the 60-mile mark, and another blue box labeled 'Guaranteed' points to the 240-mile mark.	Enrollment Cash: \$200 Monthly Cash: \$10 Override Allowance: 1 per Month Battery Thresholds (in Miles):  A horizontal bar representing the 300-mile range of the BEV. It is divided into three segments: a grey segment from 0 to 120 miles, an orange segment from 120 to 240 miles, and a green segment from 240 to 300 miles. A blue box labeled 'Min' points to the 120-mile mark, and another blue box labeled 'Guaranteed' points to the 240-mile mark.	Not Interested

Sample V2G Question

(1 of 6) If your utility offers you these 2 V2G programs, which one do you prefer?
(Your BEV has maximum range of **300** miles.)

[Access the V2G Attributes](#)

Option 1	Option 2	Option 3
Enrollment Cash: \$100 Occurrence Cash: \$5 Monthly Occurrence: 2 Battery Thresholds (in Miles):  A horizontal bar representing a 300-mile range, divided into three segments: grey (0-90 miles), orange (90-210 miles), and green (210-300 miles). Arrows point to the 90-mile mark labeled 'Low' and the 210-mile mark labeled 'Guaranteed'.	Enrollment Cash: \$100 Occurrence Cash: \$20 Monthly Occurrence: 2 Battery Thresholds (in Miles):  A horizontal bar representing a 300-mile range, divided into three segments: grey (0-120 miles), orange (120-180 miles), and green (180-300 miles). Arrows point to the 120-mile mark labeled 'Low' and the 180-mile mark labeled 'Guaranteed'.	Not Interested

Survey Fielding - 1356 in Total

Meta: Facebook, Messenger, Instagram - **Voluntary**

- Fielding from March to July in 2024
- 803 results after filtering

Dynata: Survey Panel - **Payment to real BEV owners only**

- Fielding from September to November in 2024
- 553 results after filtering



Facebook



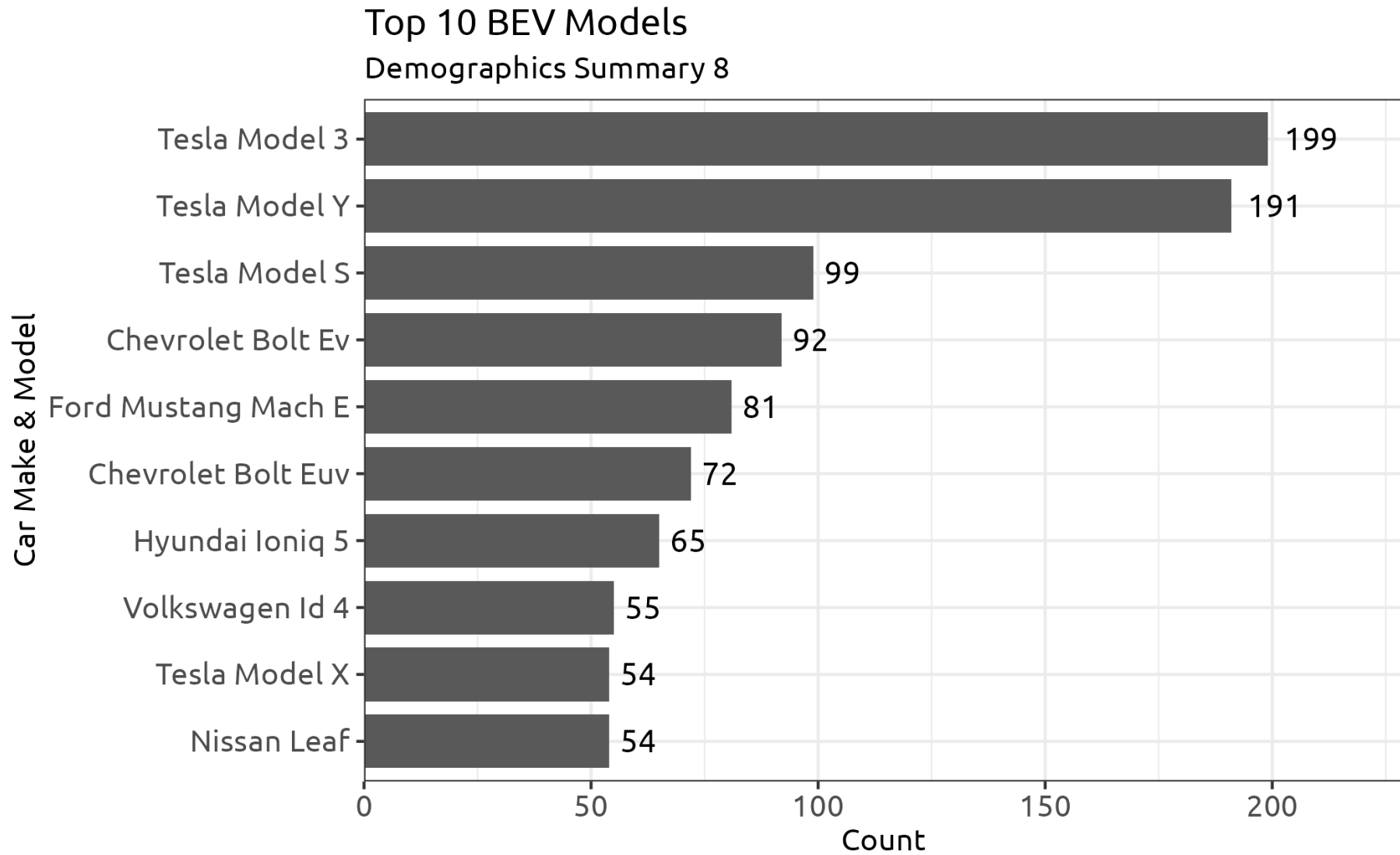
Messenger



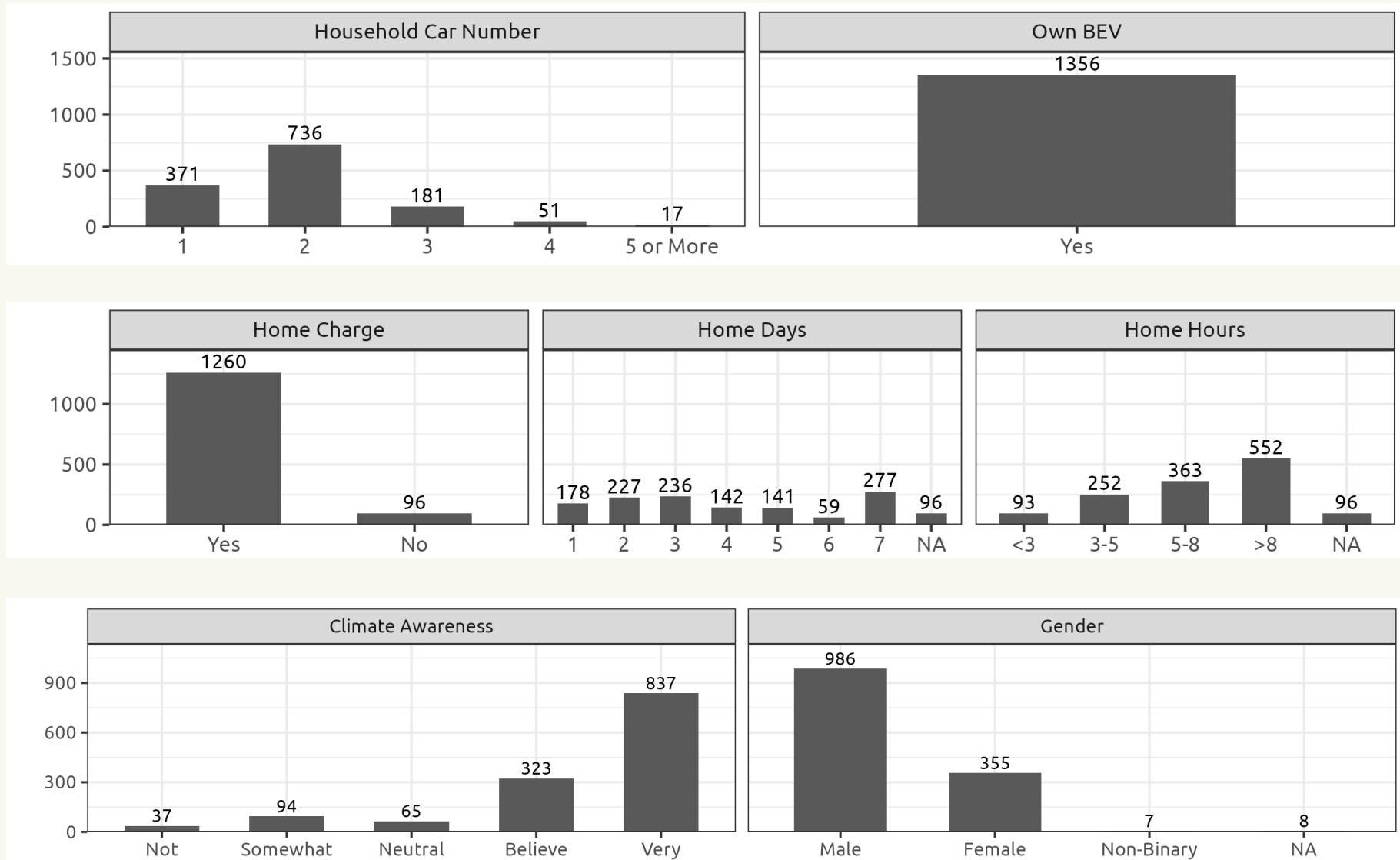
Instagram



Survey Results - Top 10 BEV



Survey Results - Demographics

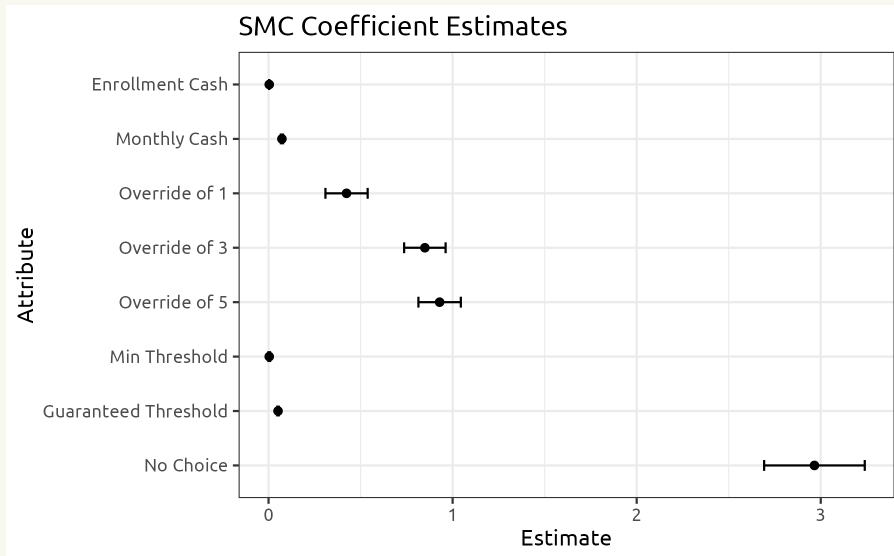


Survey Results - Willingness to Participate

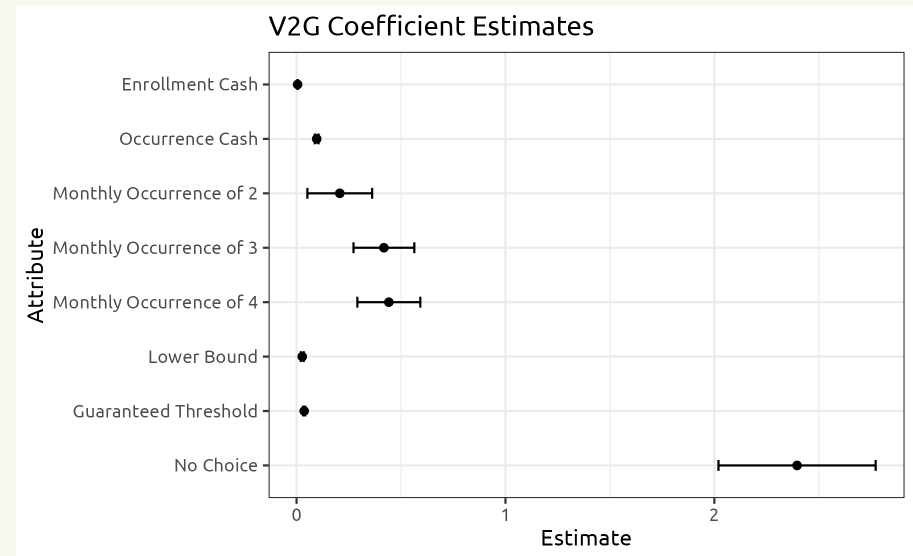
Multinomial Logit Models

$$u_j = v_j + \epsilon_j = \beta'x + \epsilon_j \quad P_j = \frac{e^{v_j}}{\sum_{k=1}^J e^{v_k}}$$

SMC Estimates

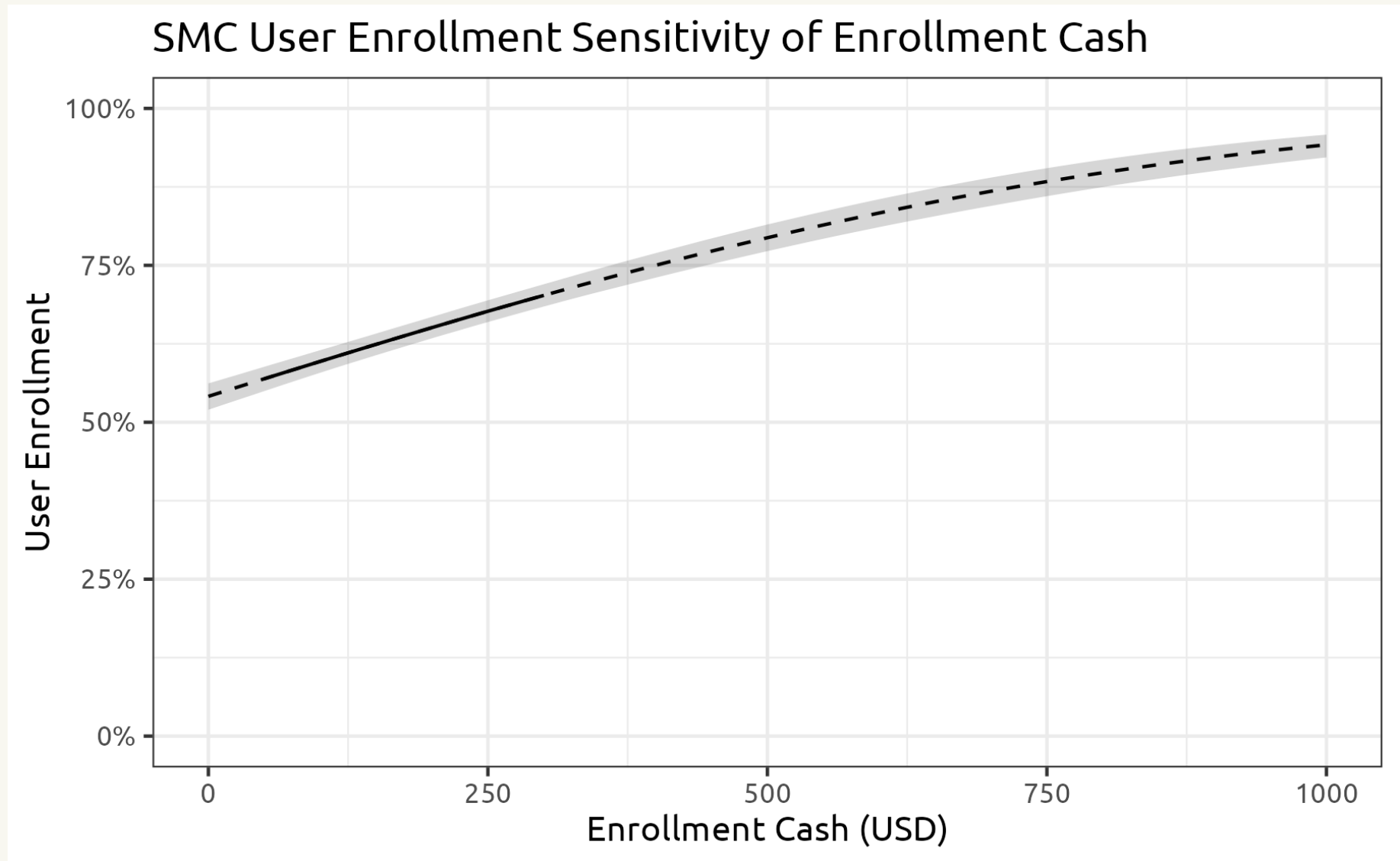


V2G Estimates



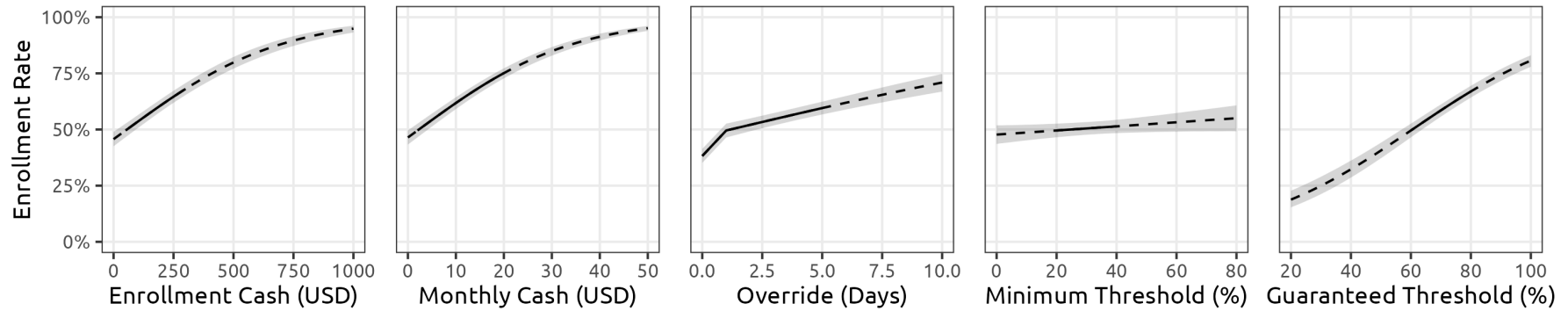
Without compensation, users will not participate.

Enrollment Sensitivity

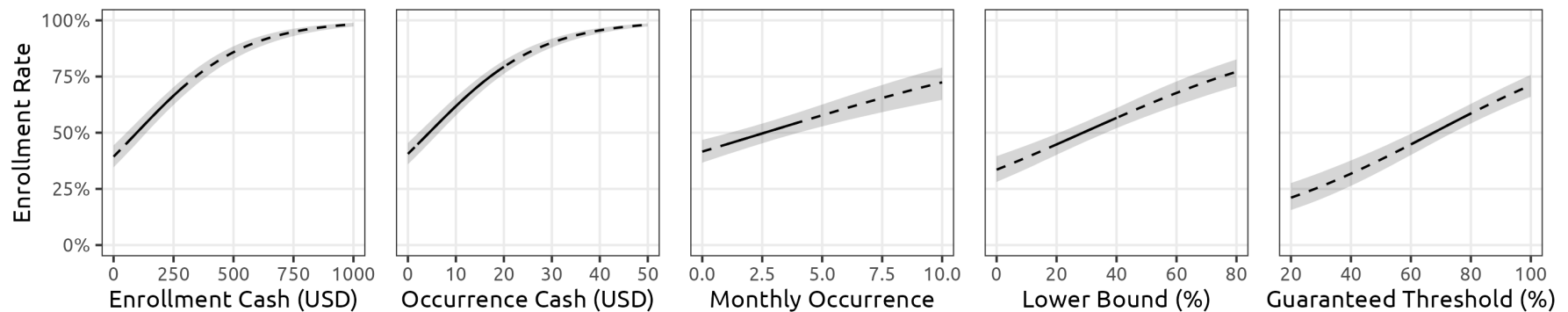


Enrollment Sensitivity

A) Supplier Managed Charging (SMC)



B) Vehicle-to-Grid (V2G)



1. Steeper slope indicates higher sensitivity.
2. Diminishing returns exist.

Equivalencies of 5% Enrollment Increase

SMC

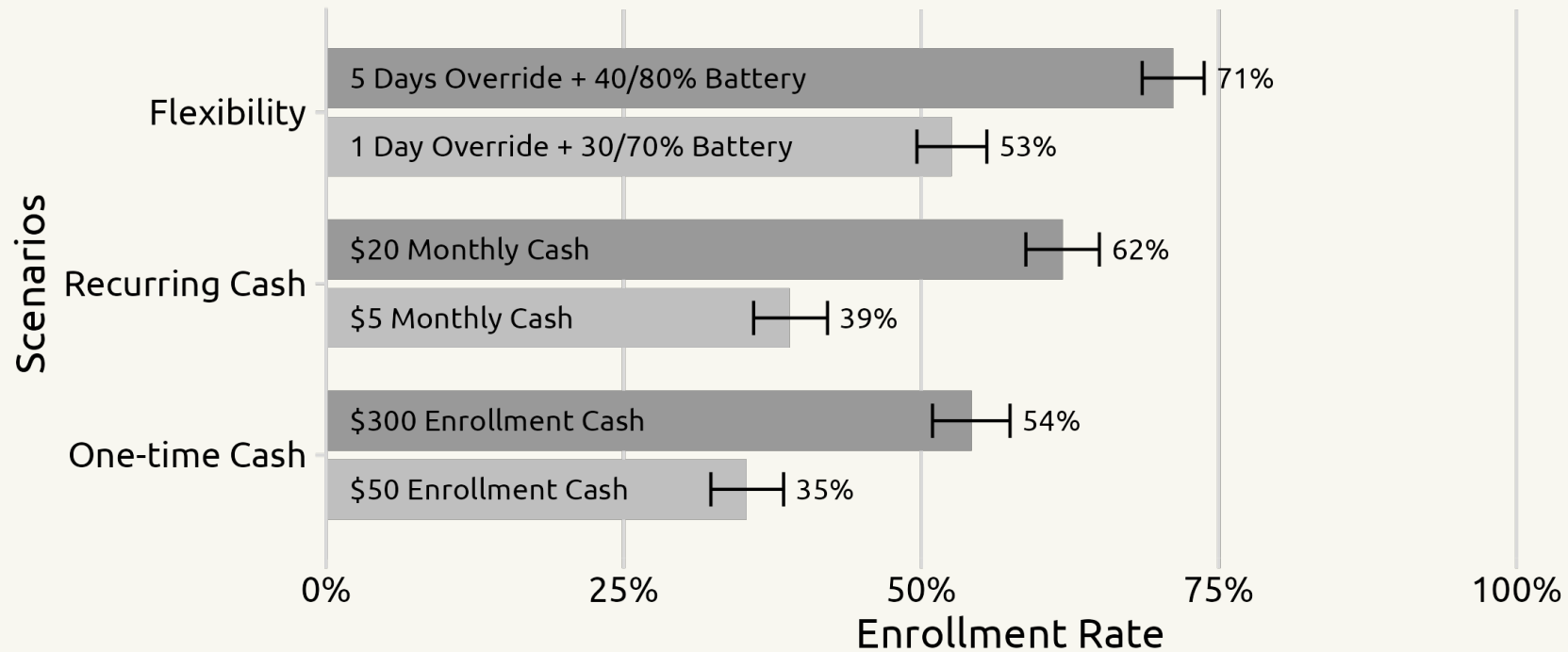
Attribute	Equivalence Value	Unit
Enrollment Cash	64.7	\$
Monthly Cash	3.2	\$
Override Days	2.0	Days
Minimum Threshold	54.8	%
Guaranteed Threshold	5.5	%

V2G

Attribute	Equivalence Value	Unit
Enrollment Cash	45.0	\$
Occurrence Cash	2.3	\$
Monthly Occurrence	1.5	Times
Lower Bound	8.5	%
Guaranteed Threshold	7.2	%

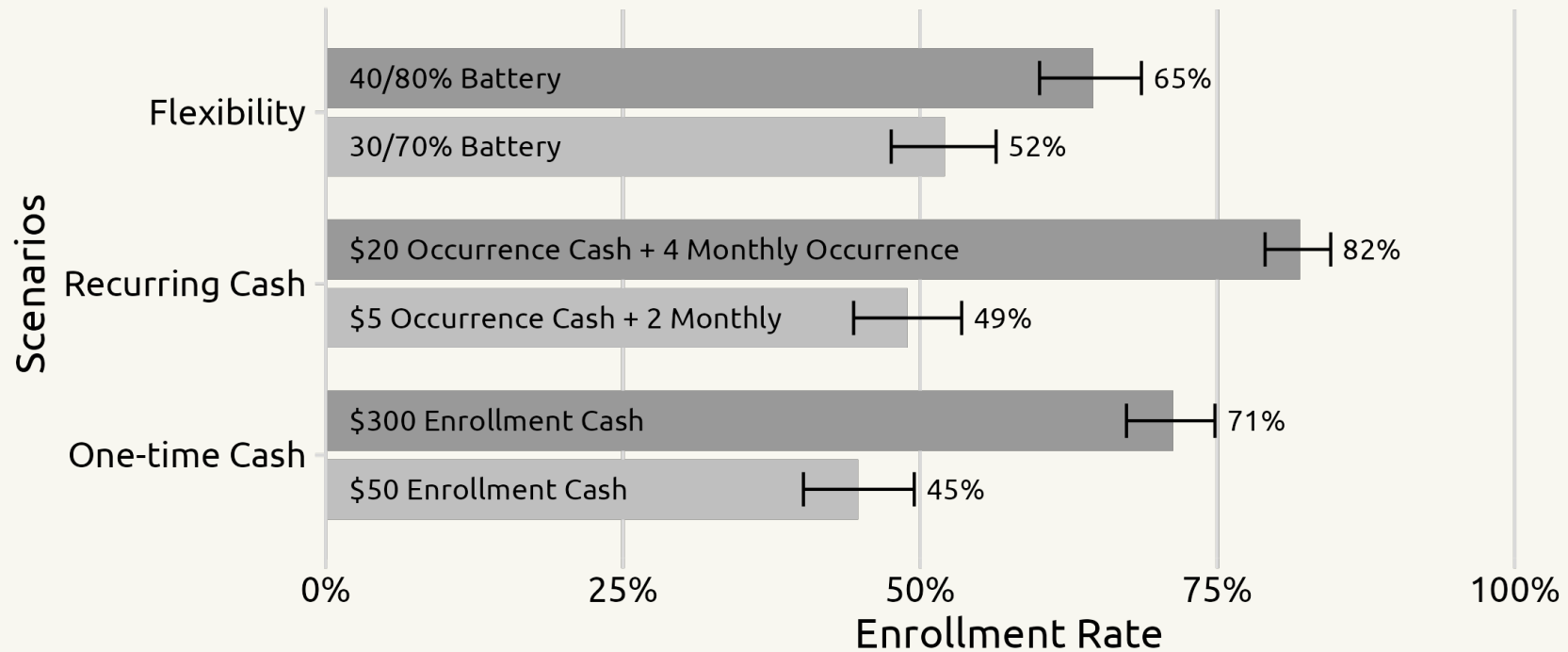
1. **Smaller** value indicates higher efficiency.
2. **Recurring** incentives are more important than one-time.
3. In **SMC**, **Guaranteed** threshold is more important than V2G, indicating range anxiety.
4. In **V2G**, **Monetary** incentives are valued more than SMC.

SMC Scenario Analysis



1. **Flexibility** is highly valued.
2. **Recurring** incentives are more important than one-time.
3. Payment alone is not enough.

V2G Scenario Analysis



1. Still, **recurring** incentives are more important than one-time.
2. But **flexibility** is not as important compared with SMC.
3. Owners are willing to leverage BEV as a source of income.

Smart Charging Enrollment Simulator

Smart Charging Enrollment Simulator

[About](#)

[⚡ SMC \(Supplier-Managed Charging\)](#)

[🔌 V2G \(Vehicle-to-Grid\)](#)



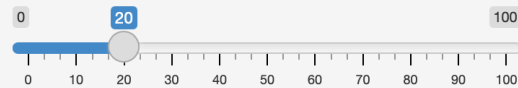
SMC Attributes:

Enrollment Cash (\$)

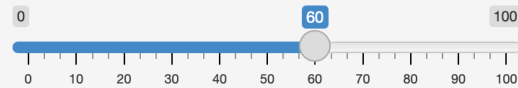
Monthly Cash (\$)

Override Allowance per Month

Minimum Threshold (%)



Guaranteed Threshold (%)



Reset

Predicted SMC Enrollment Probability:

31.9%

About SMC:

- SMC (Supplier-Managed Charging) allows the utility to monitor, manage, and restrict BEV charging to optimize energy flow during night charging at home.
- By participating in SMC, your BEV will be mostly charged during off-peak periods.

SMC Attributes Explained:

Attribute	Description
Enrollment Cash	The one-time payment you'll receive if you stay for at least 3 months.
Monthly Cash	The recurring monthly payment you'll receive if you don't exceed override allowance.
Override Allowance	The monthly frequency of override to normal charging, effective for 24hrs. If you exceed the limit, no monthly cash for this month.
Minimum Threshold	SMC won't be triggered below this threshold. In the survey it's converted to miles.
Guaranteed Threshold	SMC will give you this much of range by the morning (8 hrs' charging). In the survey it's converted to miles.

Reference List

- Huang, Bing, Aart Gerard Meijssen, Jan Anne Annema, and Zofia Lukszo. 2021. "Are Electric Vehicle Drivers Willing to Participate in Vehicle-to-Grid Contracts? A Context-Dependent Stated Choice Experiment." *Energy Policy* 156 (September): 112410. <https://doi.org/10.1016/j.enpol.2021.112410>.
- Philip, Thara, and Jake Whitehead. 2024. "Consumer Preferences Towards Electric Vehicle Smart Charging Program Attributes: A Stated Preference Study." Rochester, NY. <https://doi.org/10.2139/ssrn.4812923>.
- Wong, Stephen D., Susan A. Shaheen, Elliot Martin, and Robert Uyeki. 2023. "Do Incentives Make a Difference? Understanding Smart Charging Program Adoption for Electric Vehicles." *Transportation Research Part C: Emerging Technologies* 151 (June): 104123. <https://doi.org/10.1016/j.trc.2023.104123>.