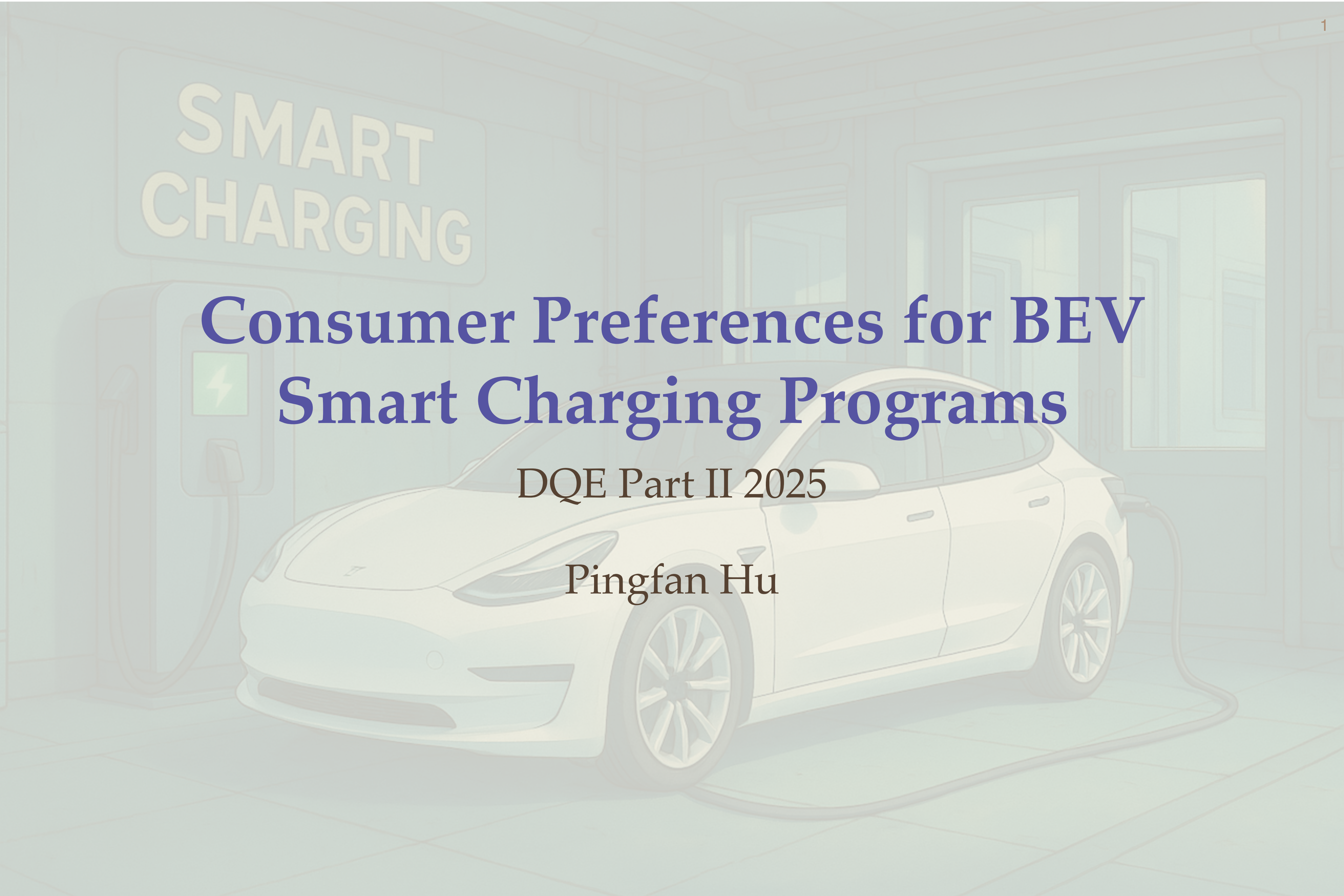


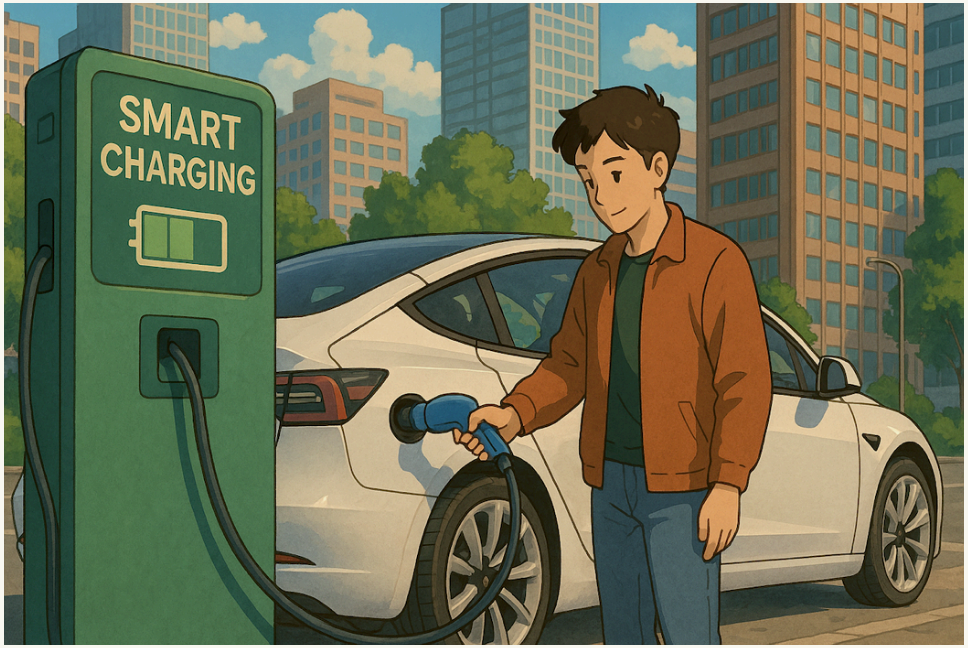
Consumer Preferences for BEV Smart Charging Programs

DQE Part II 2025

Pingfan Hu

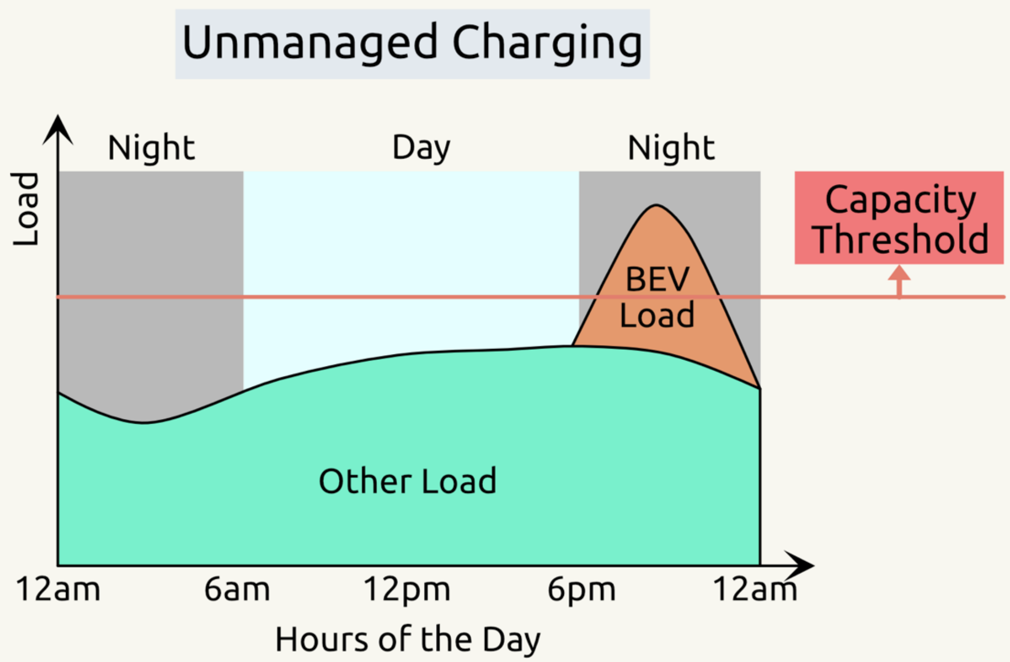
Introduction

- **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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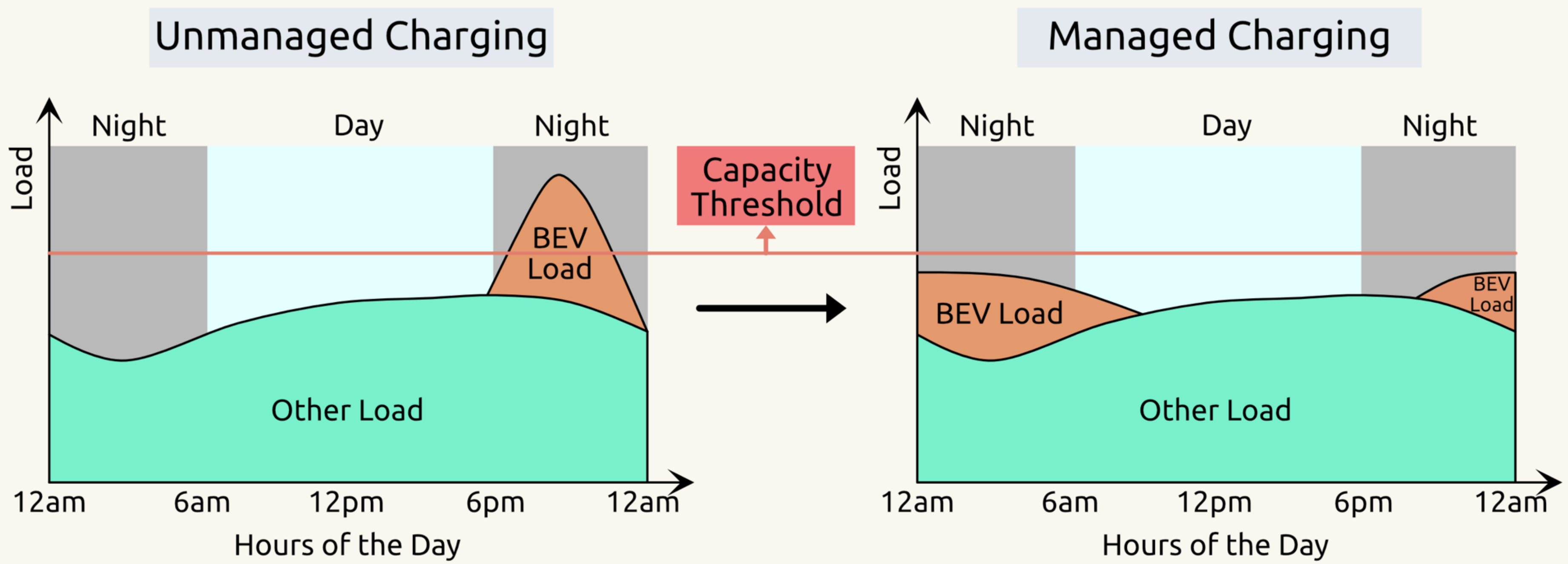
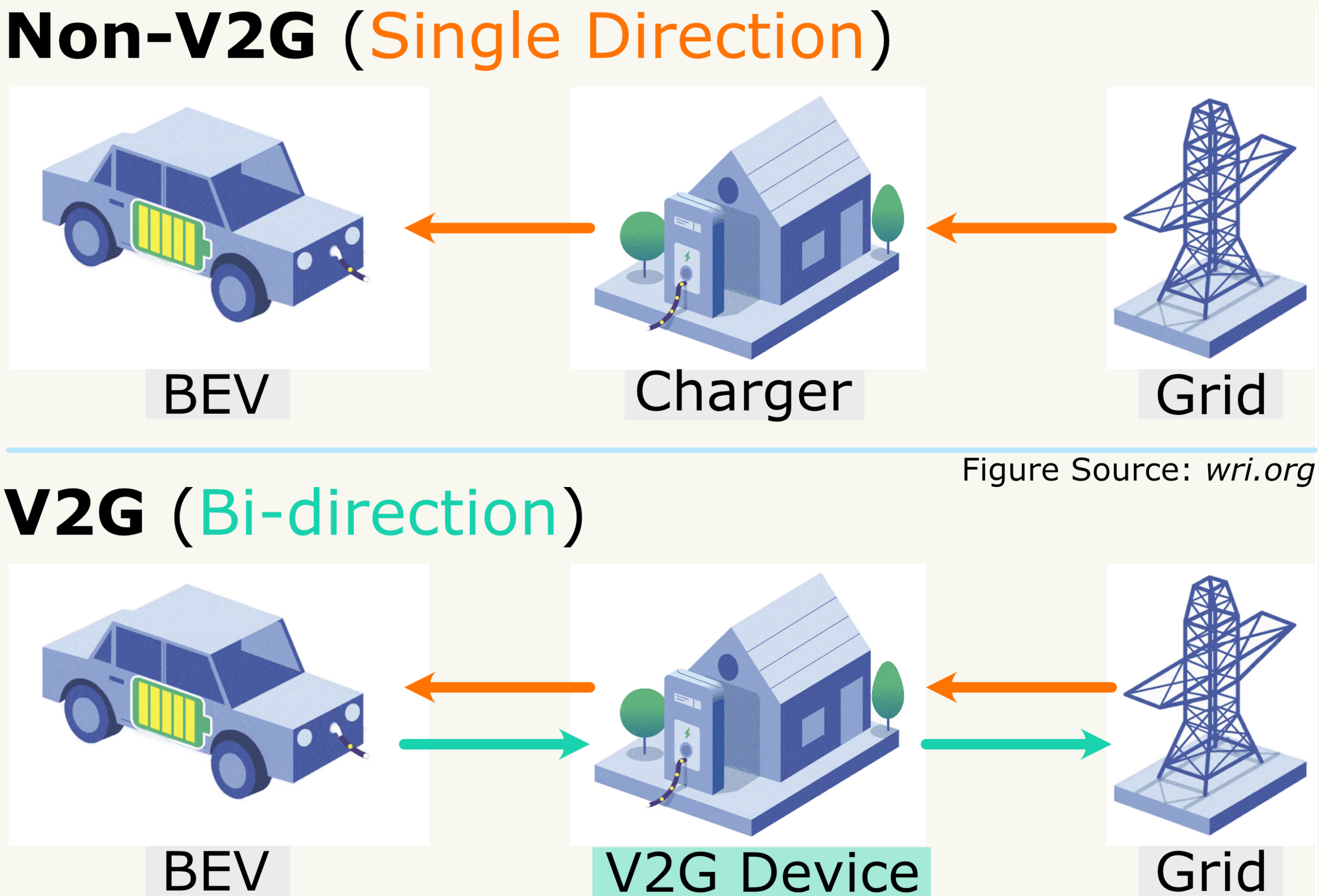


Managed charging avoids overload caused by BEV charging.

V2G - Vehicle-to-Grid



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**.

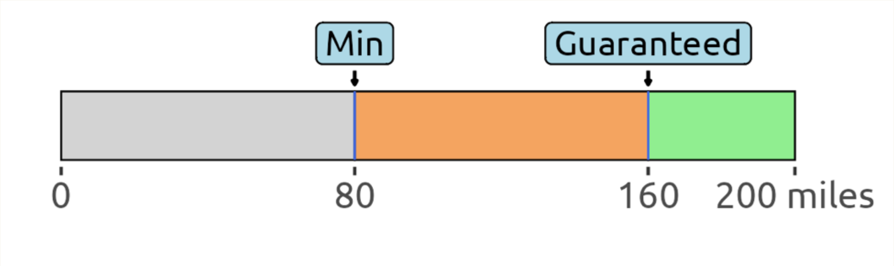
SMC Programs

Attributes

No.	Attributes	Range
1	Enrollment Cash	\$50 to \$300
2	Monthly Cash	\$2 to \$20
3	Monthly Override	0 to 5
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



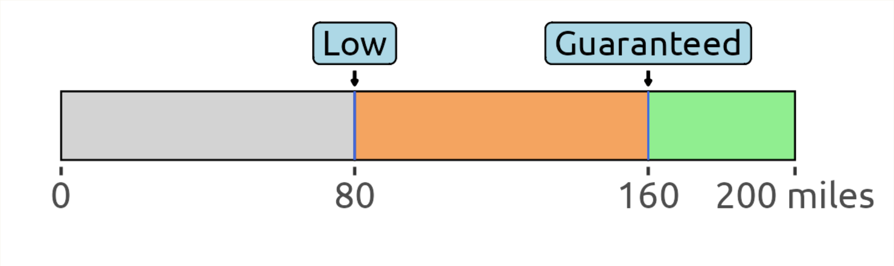
V2G Programs

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

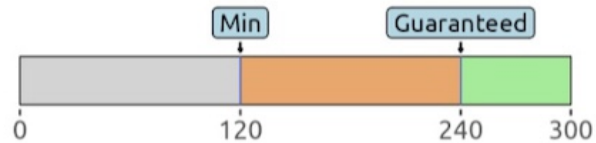
Attributes	Values
Enrollment Cash	\$300
Occurrence Cash	\$20
Monthly Occurrence	1



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): 	Enrollment Cash: $200 Monthly Cash: $10 Override Allowance: 1 per Month Battery Thresholds (in Miles): 	Not Interested

Sample V2G Question

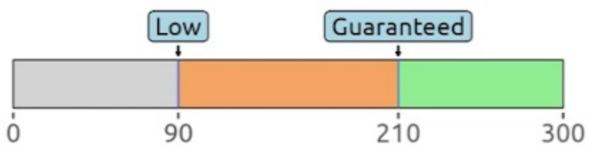
(1 of 6) If your utility offers you these 2 V2G programs, which one do you prefer?
(Your BEV has maximum range of **300** miles.)

Access the V2G Attributes

Option 1

Enrollment Cash: $100
Occurrence Cash: $5
Monthly Occurrence: 2

Battery Thresholds (in Miles):



Option 2

Enrollment Cash: $100
Occurrence Cash: $20
Monthly Occurrence: 2

Battery Thresholds (in Miles):

Option 3

Not Interested

Survey Fielding - 1356 in Total

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

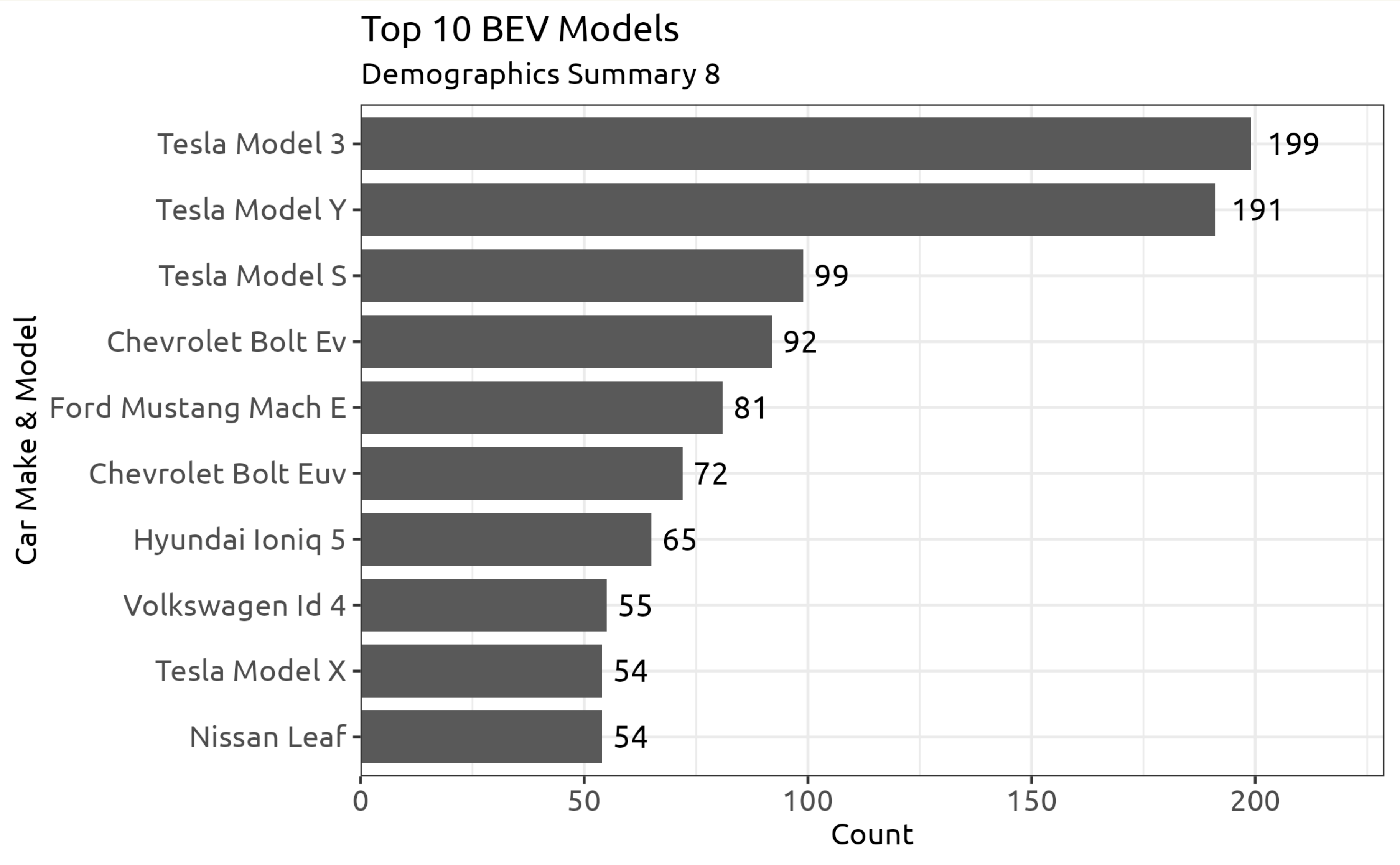
- Fielding from March to July in 2024
- **803** results after filtering

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

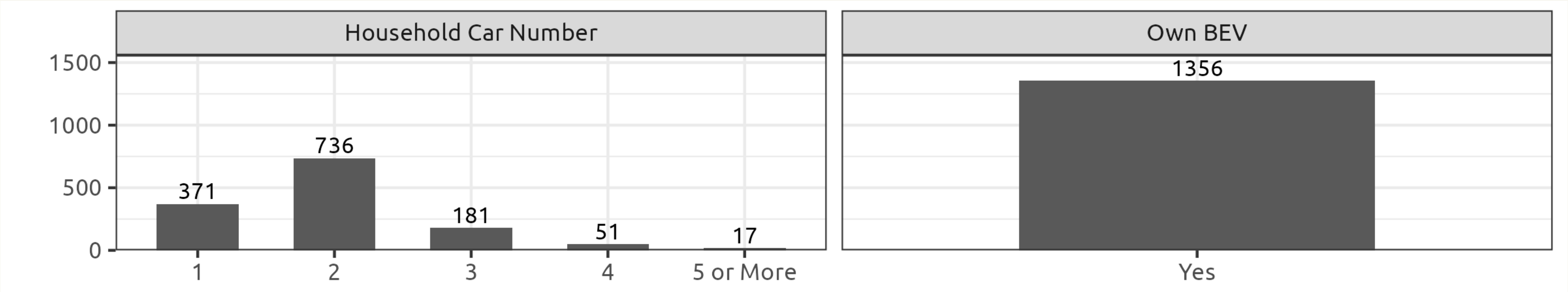
- Fielding from September to November in 2024
- **553** results after filtering

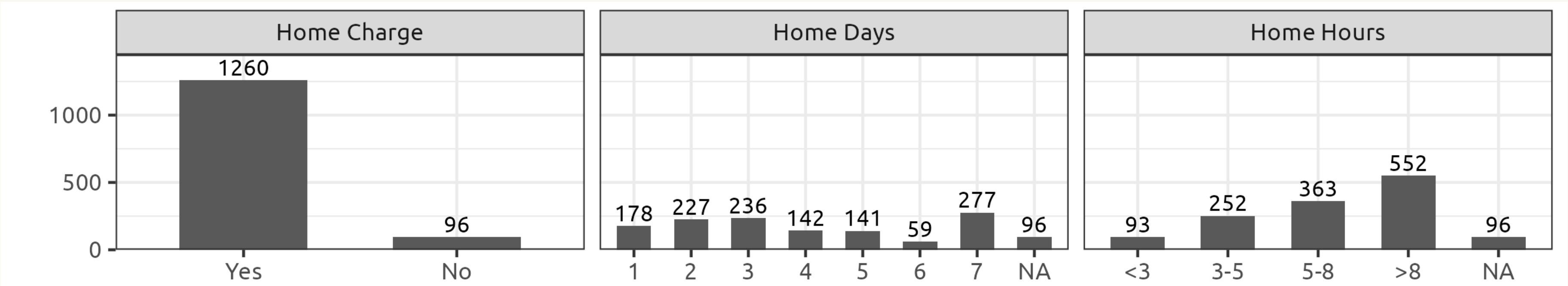
Facebook Messenger Instagram | dynata

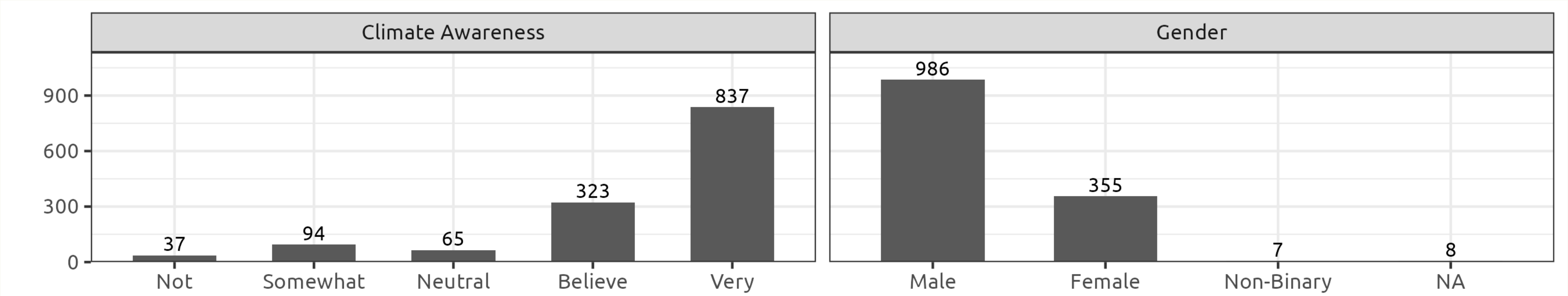
Survey Results - Top 10 BEV



Survey Results - Demographics





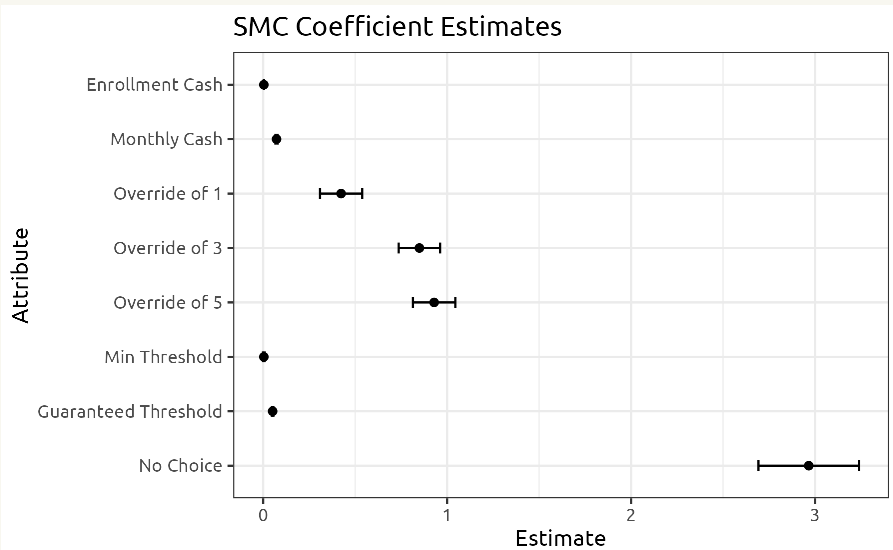


Survey Results - Willingness to Participate

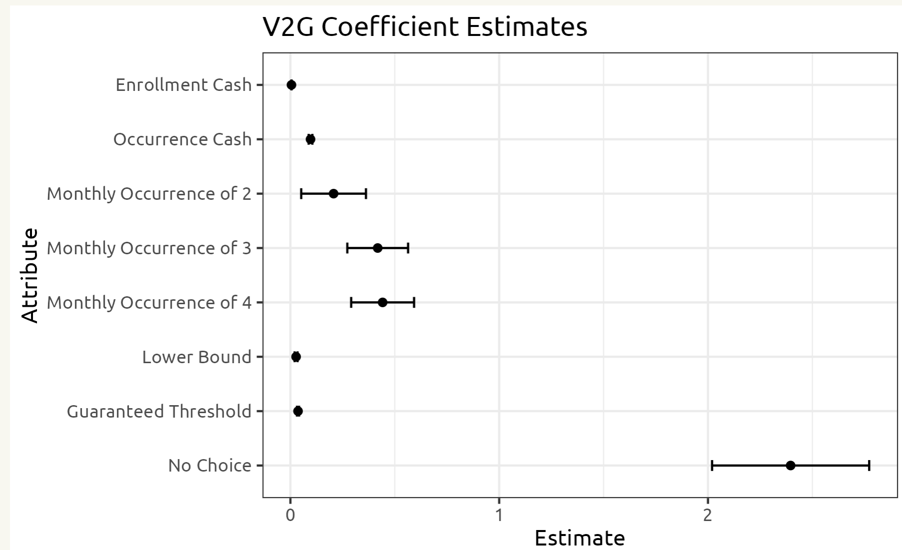
Multinomial Logit Models

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

SMC Estimates

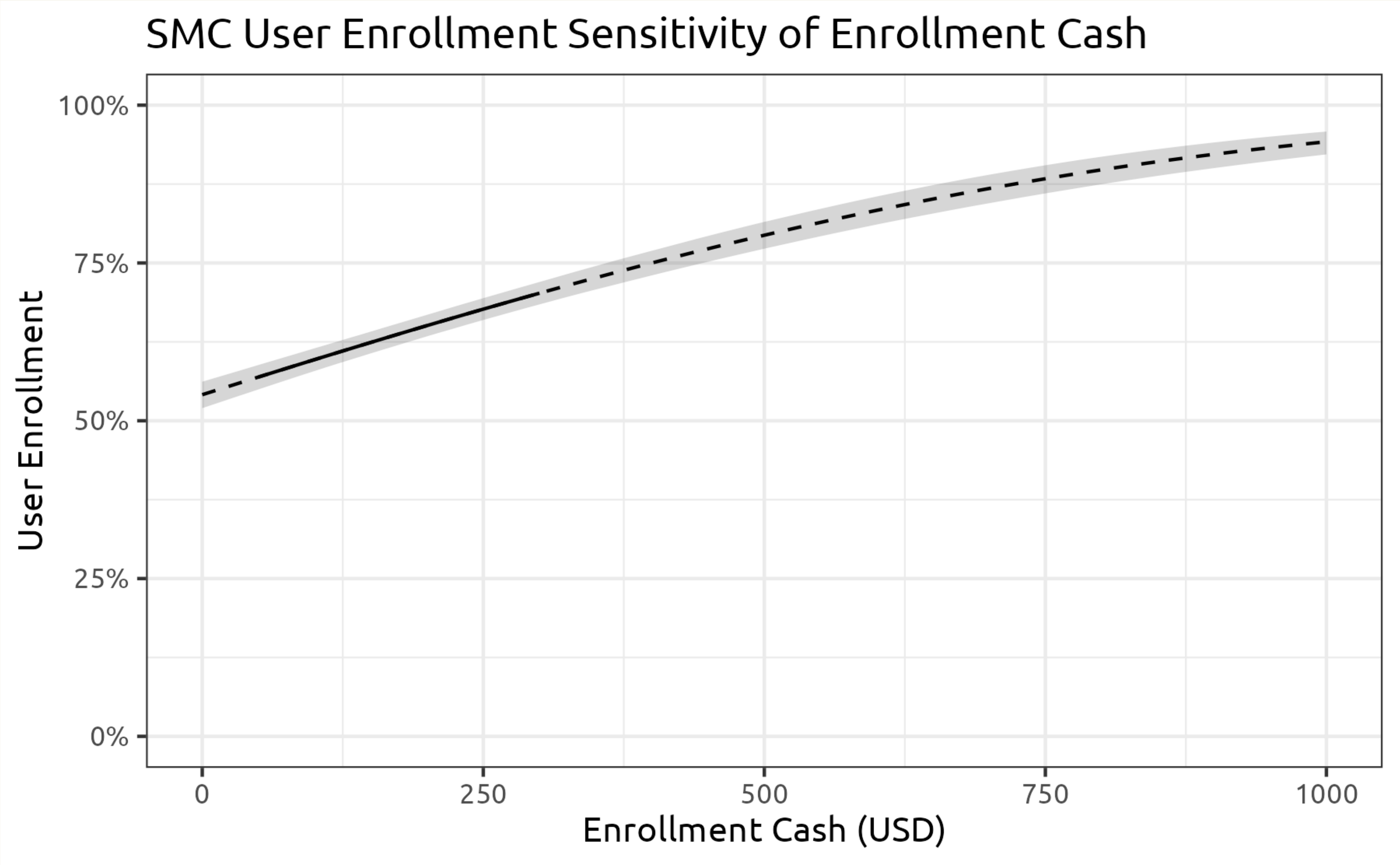


V2G Estimates

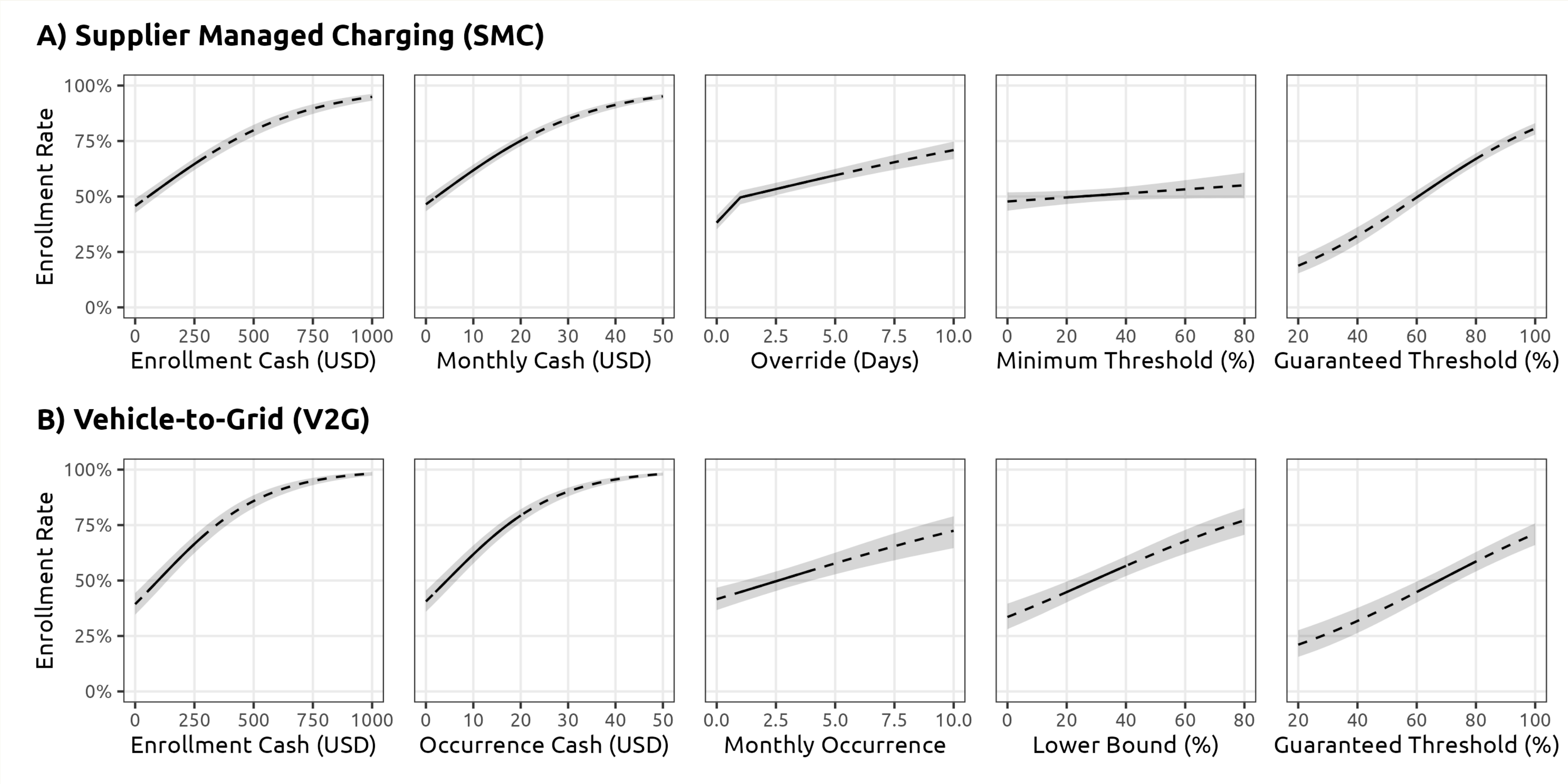


Without compensation, users will not participate.

Enrollment Sensitivity



Enrollment Sensitivity



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

Equivalencies of 5% Enrollment Increase

SMC

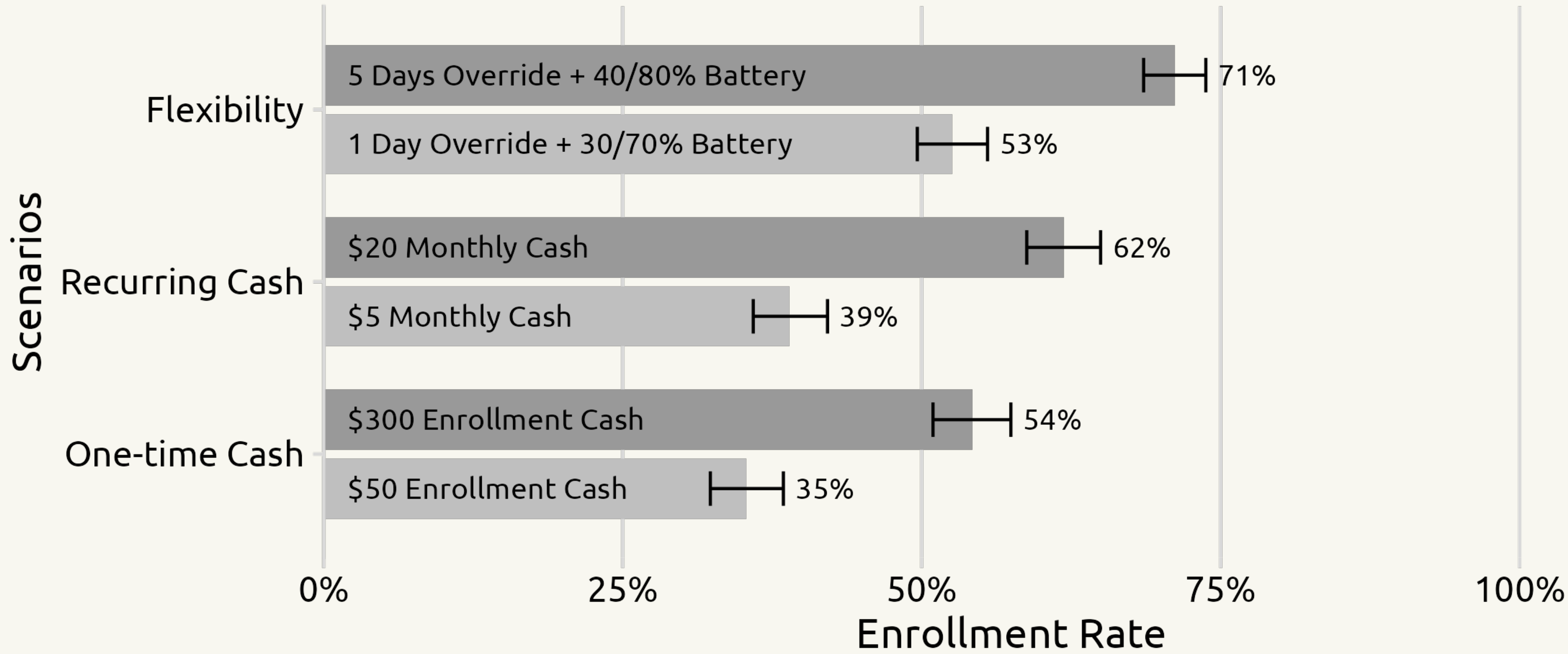
Attribute	Equivalence Value	Unit
Enrollment Cash	64.7	$
Monthly Cash	3.2	$
Override Days	2.0	Days
Minimum Threshold	54.8	%
Guaranteed Threshold	**5.5**	**%**

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	%

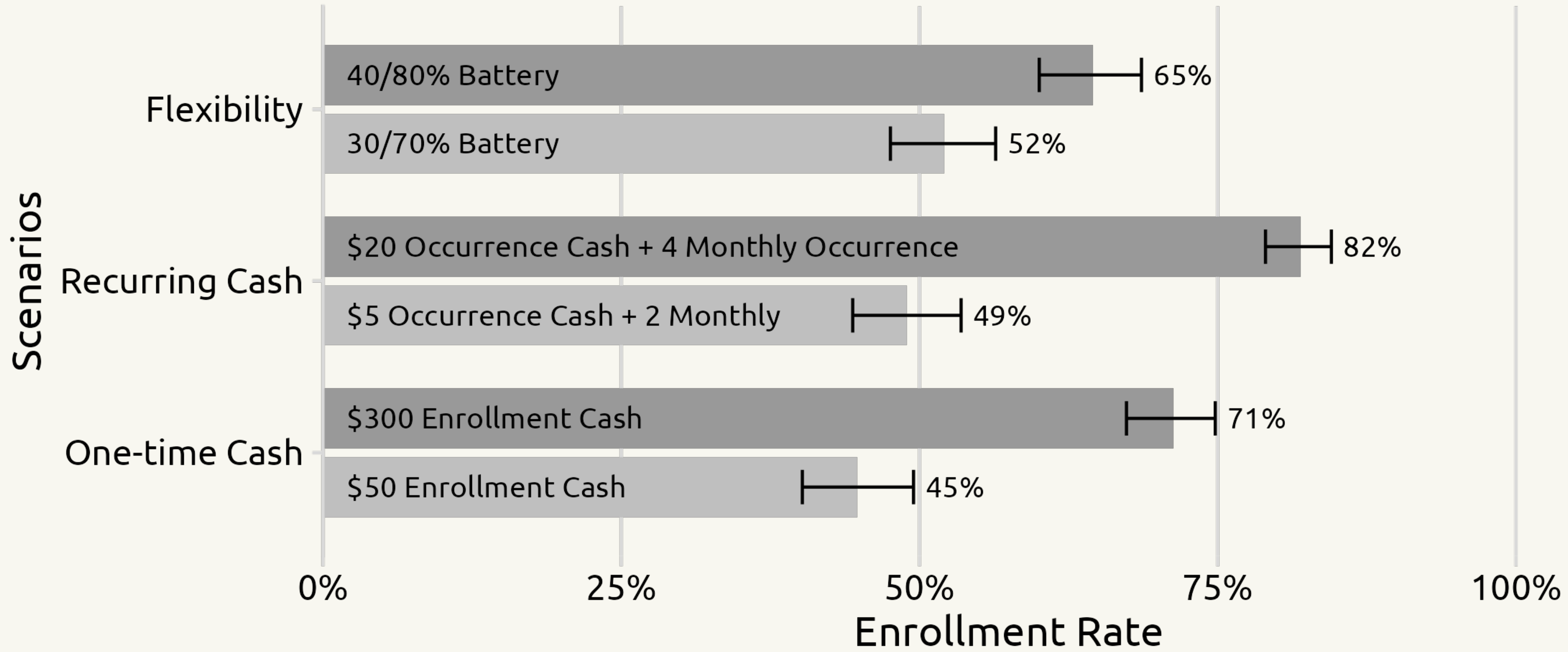
1. **Smaller** value indicates higher efficiency.
2. **Recurring** incentives are more important than one-time.
3. In **SMC**, **Guaranteed** threshold is more important than V2G, indicating range anxiety.
4. In **V2G**, **Monetary** incentives are valued more than SMC.

SMC Scenario Analysis



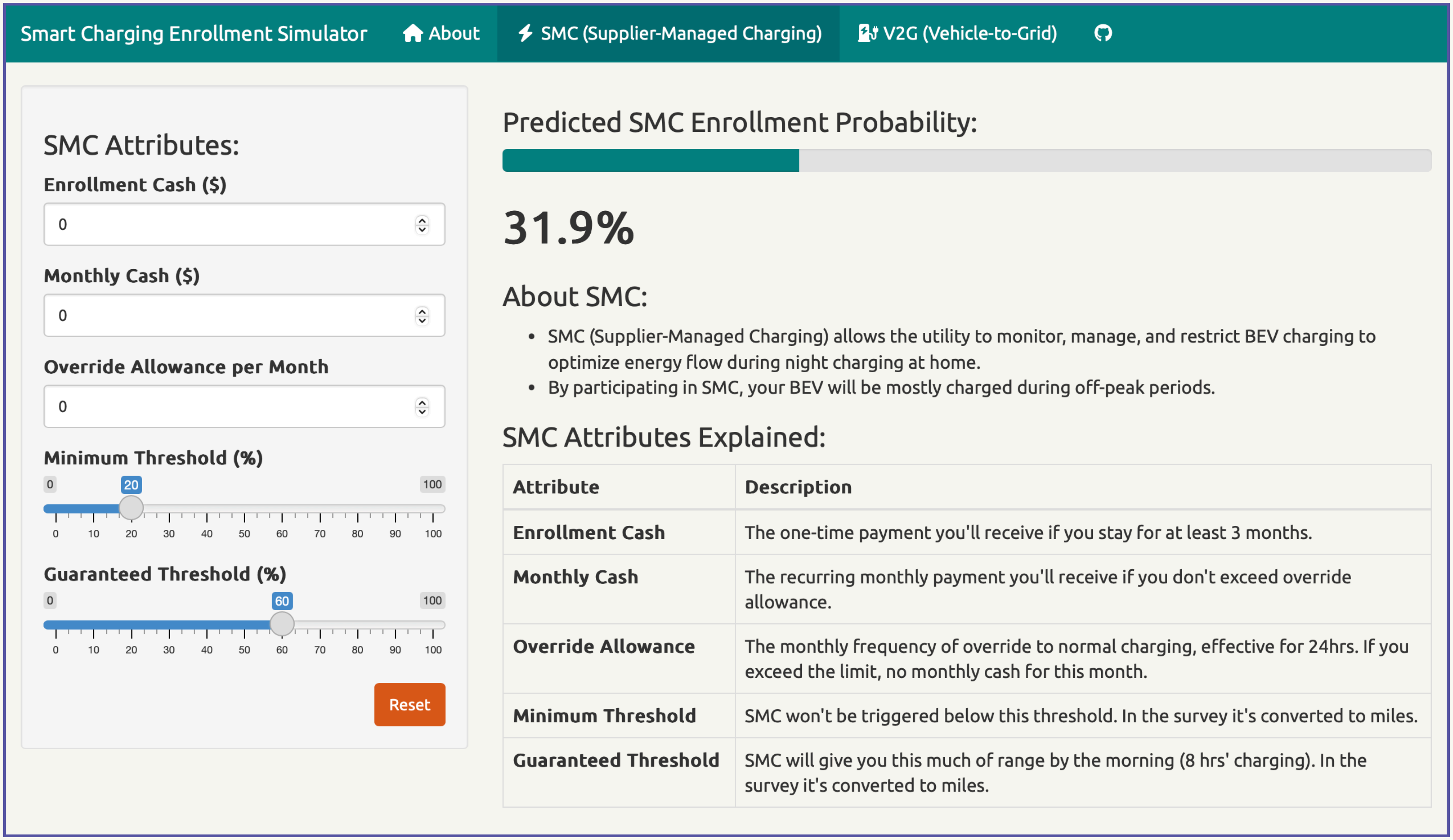
1. **Flexibility** is highly valued.
2. **Recurring** incentives are more important than one-time.
3. Payment alone is not enough.

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



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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.

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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.