Measuring Consumer Willingness to Participate in BEV Smart Charging Programs

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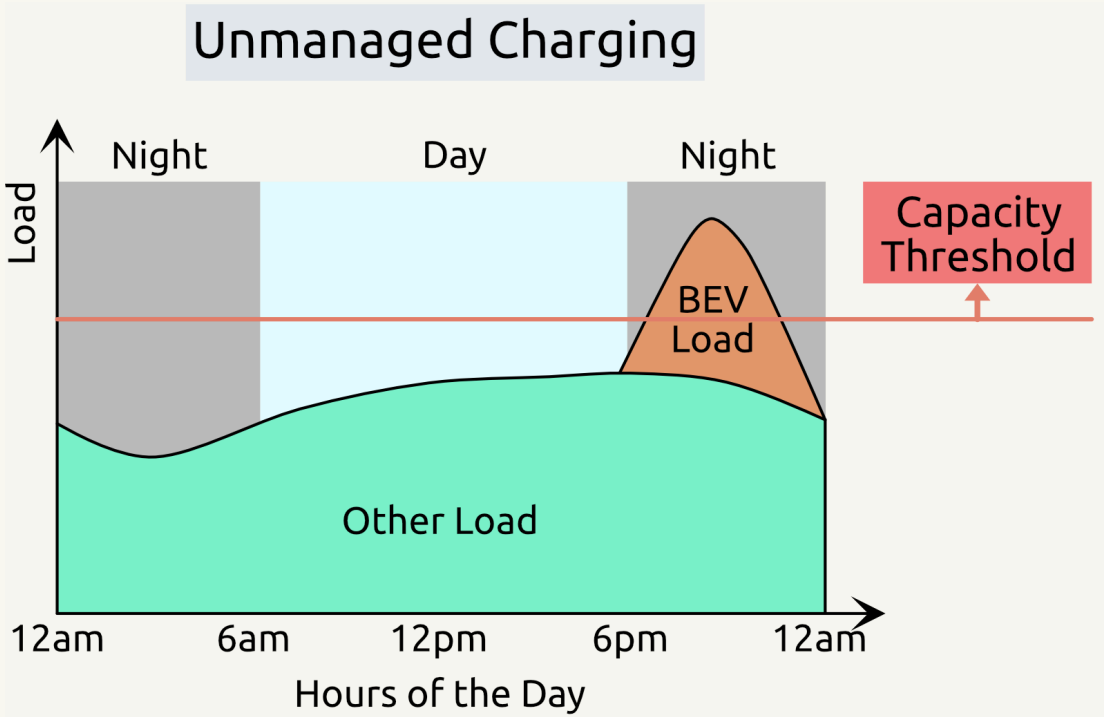
Introduction

- BEVs (Battery Electric Vehicles) can reduce CO_2 and prevent air pollution.
- But managing BEV charging can become a problem for the grid.
- Smart charging can help, but depends on user acceptance.

SMC - Supplier Managed Charging

- SMC smooths out overnight EV charging demand.
- Electricity demand is controlled below capacity threshold.



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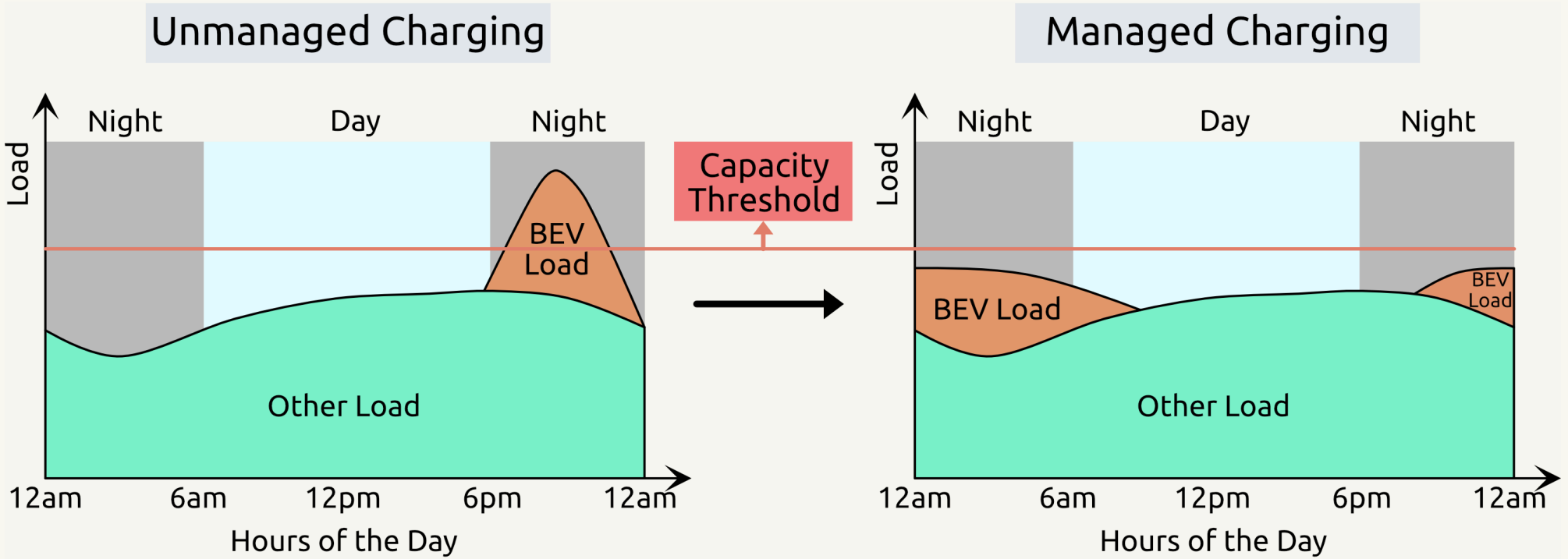


Managed charging avoids overload caused by BEV charging.

V2G - Vehicle-to-Grid

Non-V2G (Single Direction)

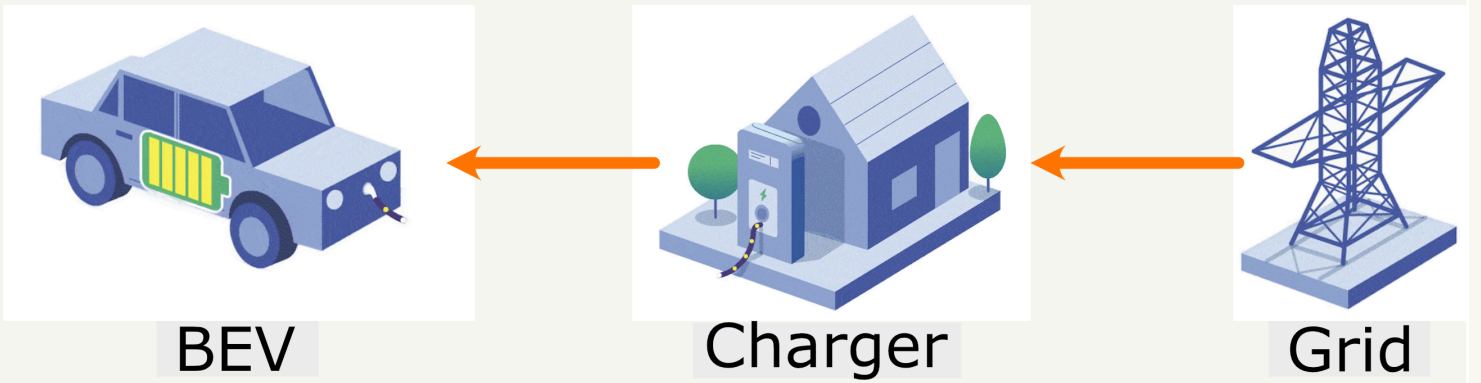
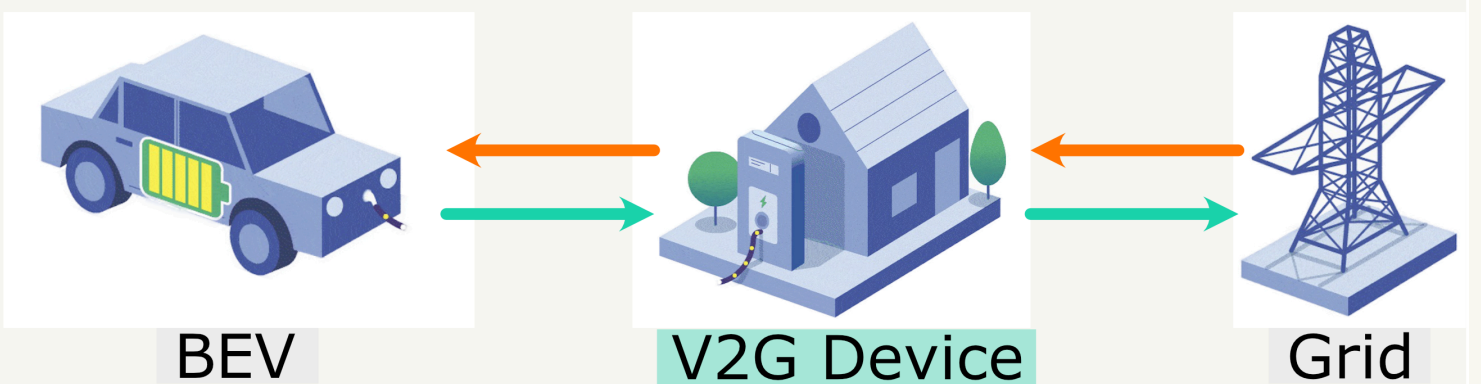


Figure Source: *wri.org*

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.

Mixed logit model to evaluate utilities for 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

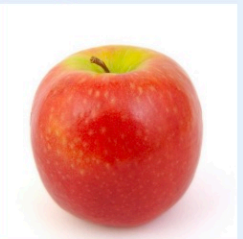
Conjoint Attributes Sample

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.**

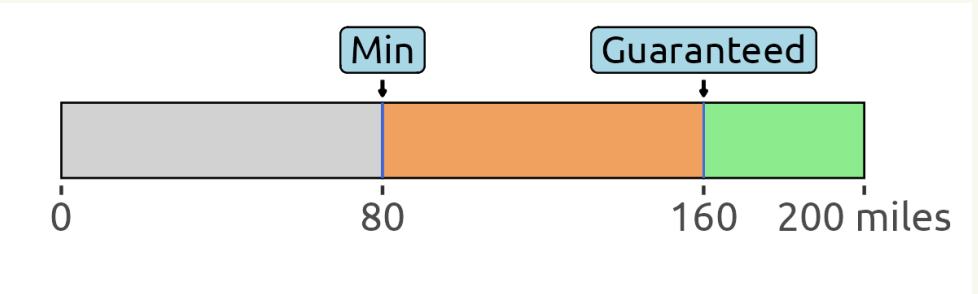
SMC Programs

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



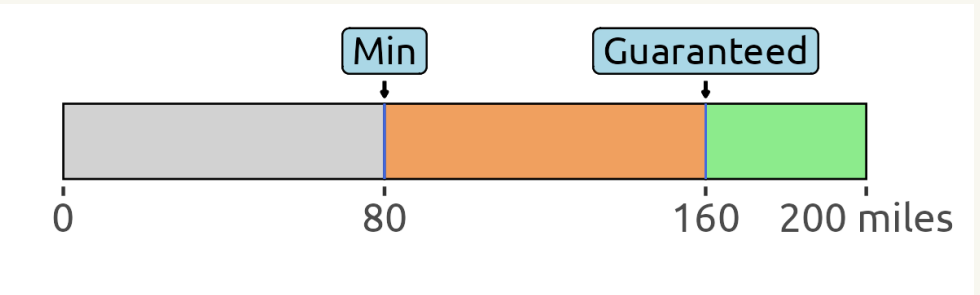
V2G Programs

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

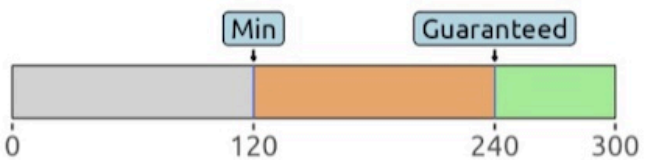
Attributes	Values
Enrollment Cash	$300
Occurrence Cash	$20
Monthly Occurrence	1



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.)

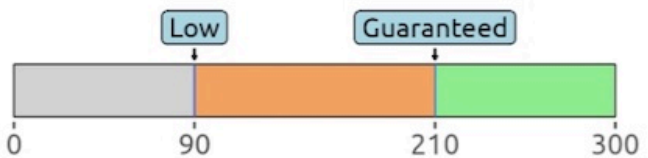
Access the SMC Attributes

Option 1	Option 2	Option 3
Enrollment Cash: $100 Monthly Cash: $20 Override Allowance: 1 per Month	Enrollment Cash: $200 Monthly Cash: $10 Override Allowance: 1 per Month	Not Interested
Battery Thresholds (in Miles): 	Battery Thresholds (in Miles): 	

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):  	Enrollment Cash: $100 Occurrence Cash: $20 Monthly Occurrence: 2 Battery Thresholds (in Miles):  	Not Interested

Survey Fielding

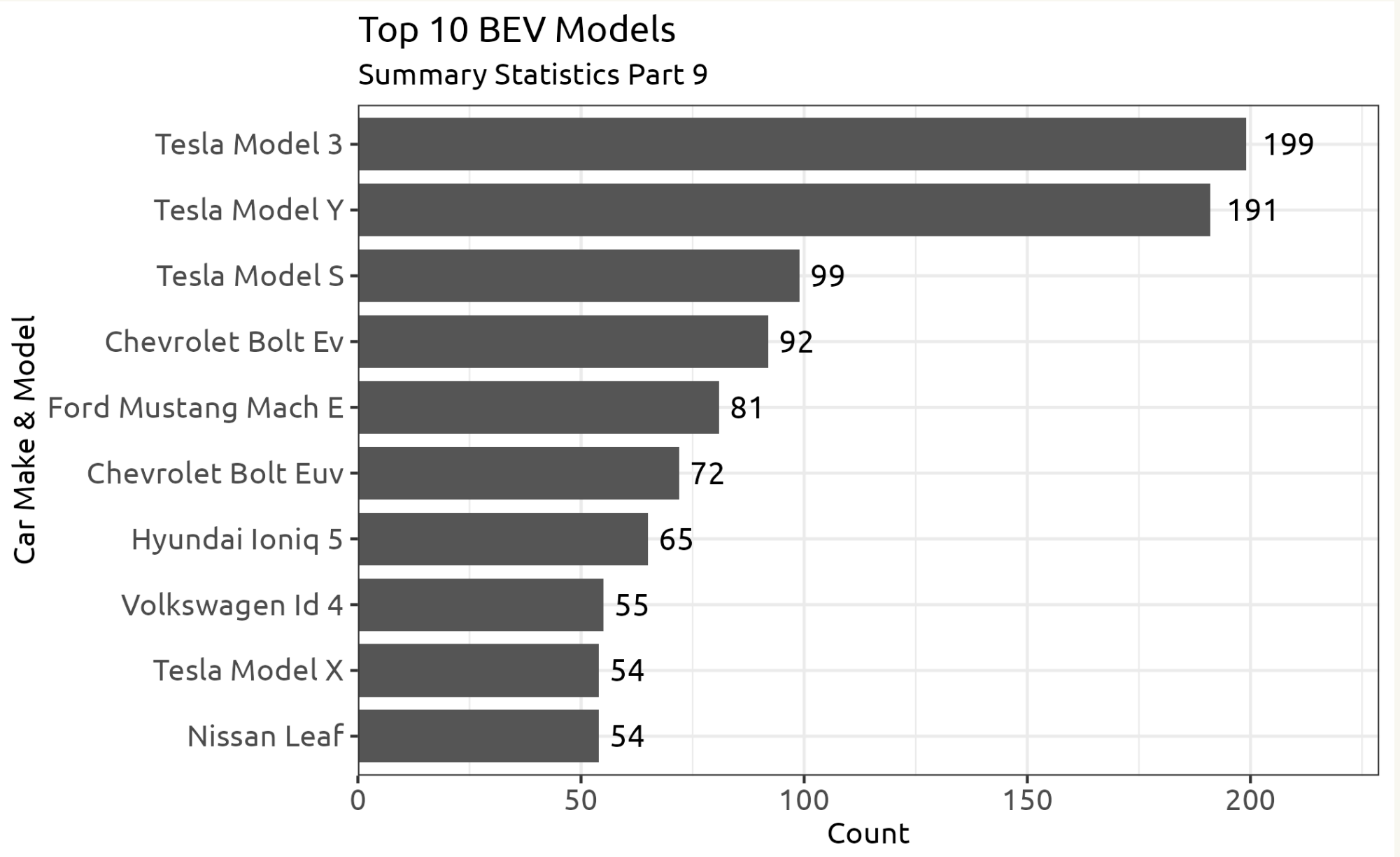
Meta: Facebook, Messenger, Instagram - **Voluntary**

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

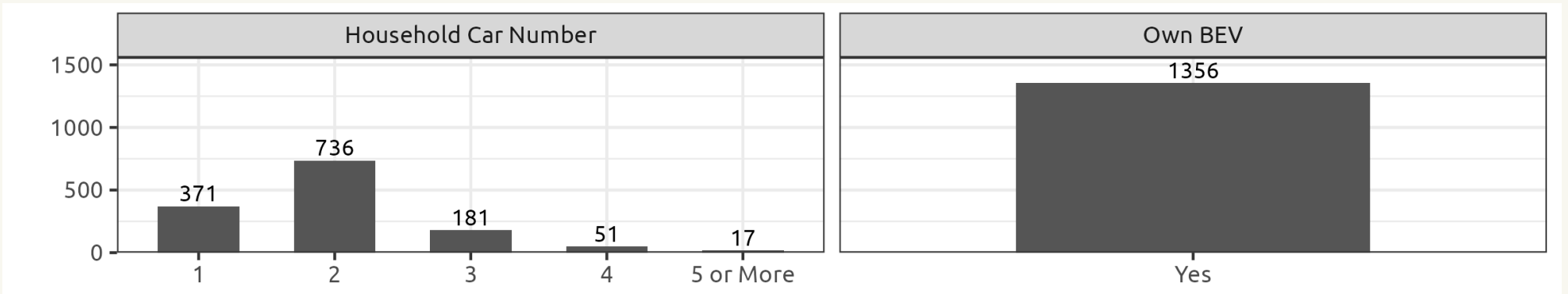
Dynata: Survey Panel - **Payment to real BEV owners only**

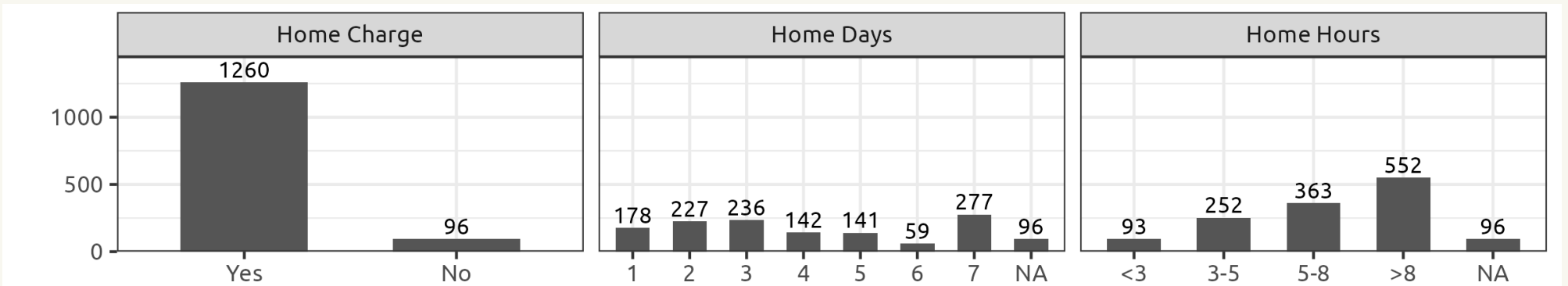
- Fielding from September to November in 2024
- **553** results after filtering

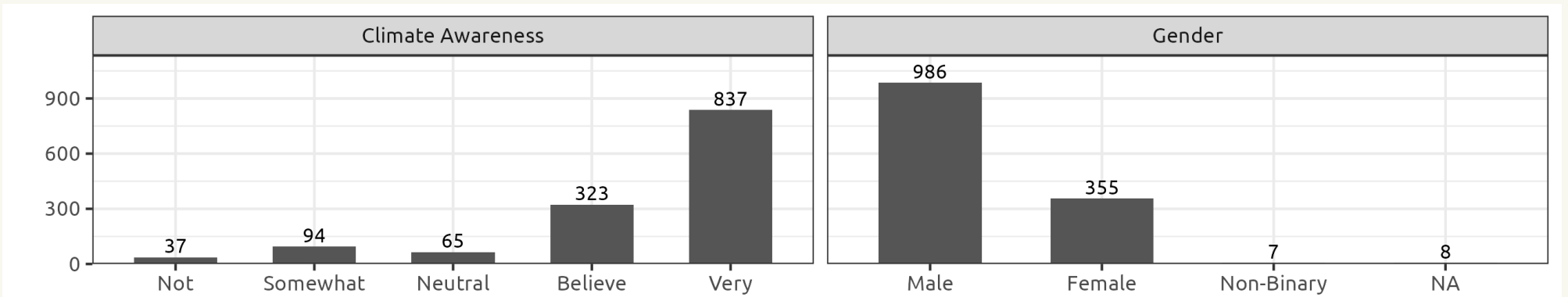
Survey Results - Top 10 BEV



Survey Results - Demographics





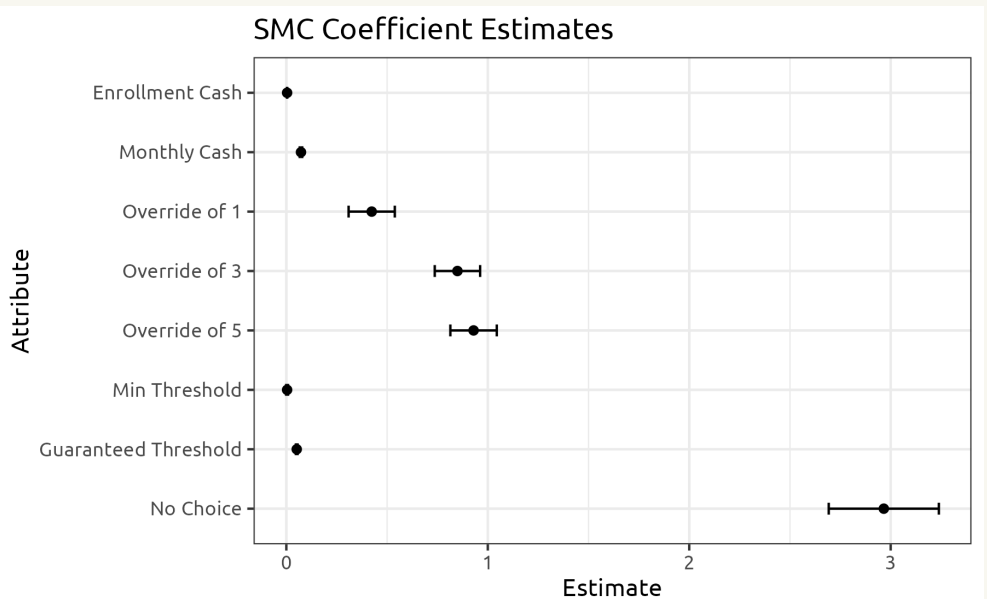


Survey Results - Willingness to Participate

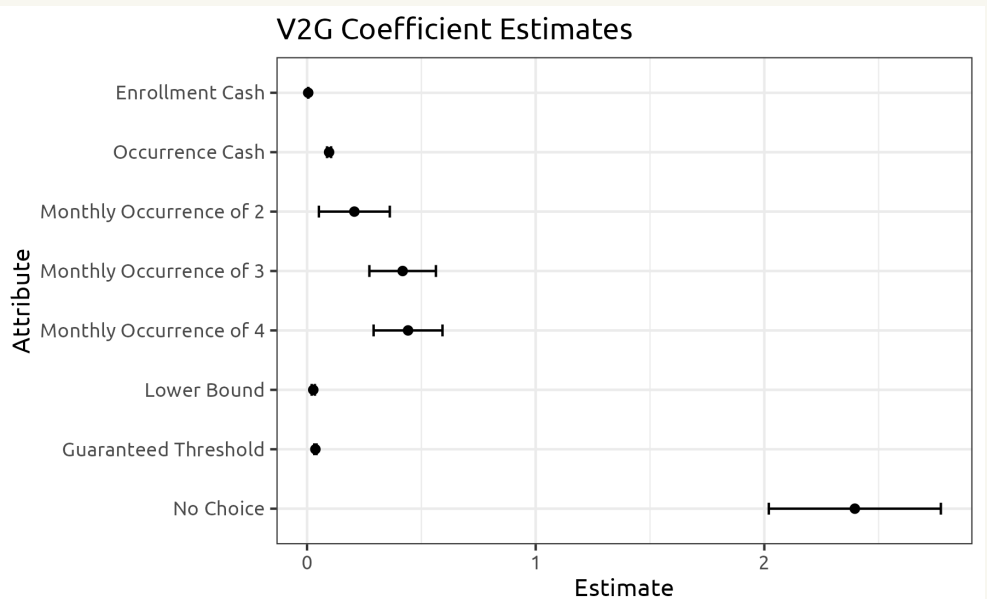
Mixed Logit Models

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

SMC Estimates

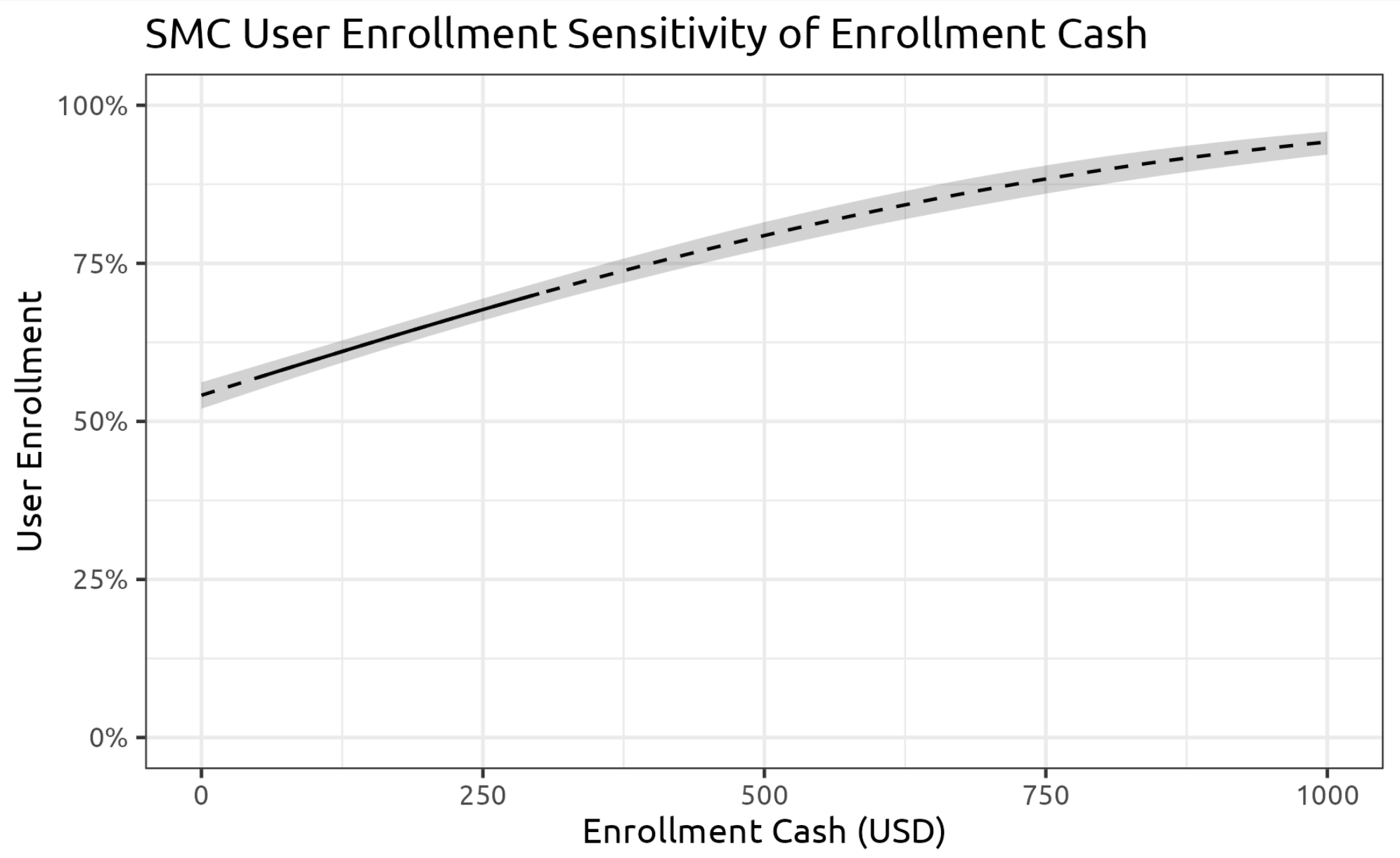


V2G Estimates

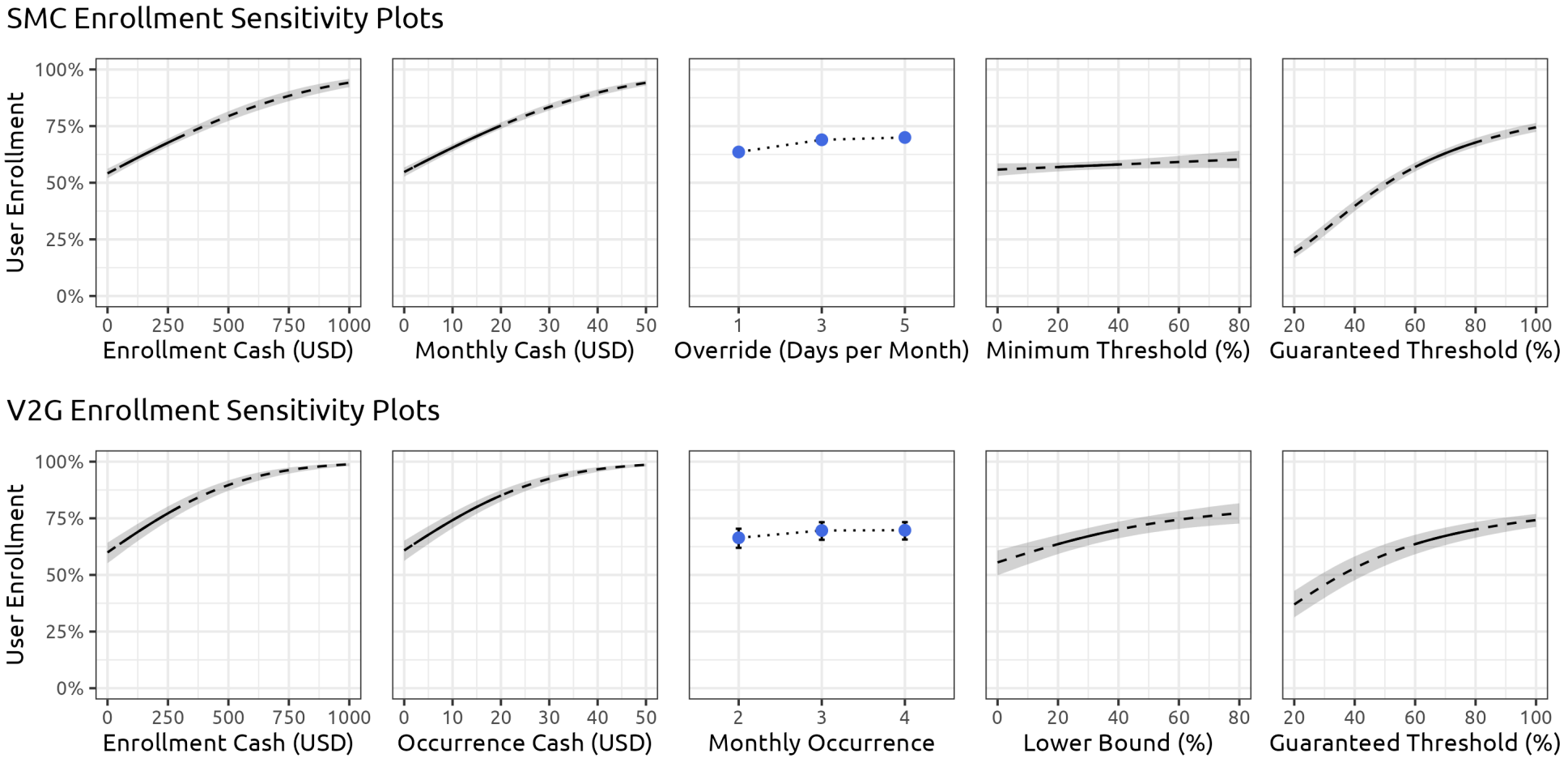


Without compensation, users will not participate.

Enrollment Sensitivity

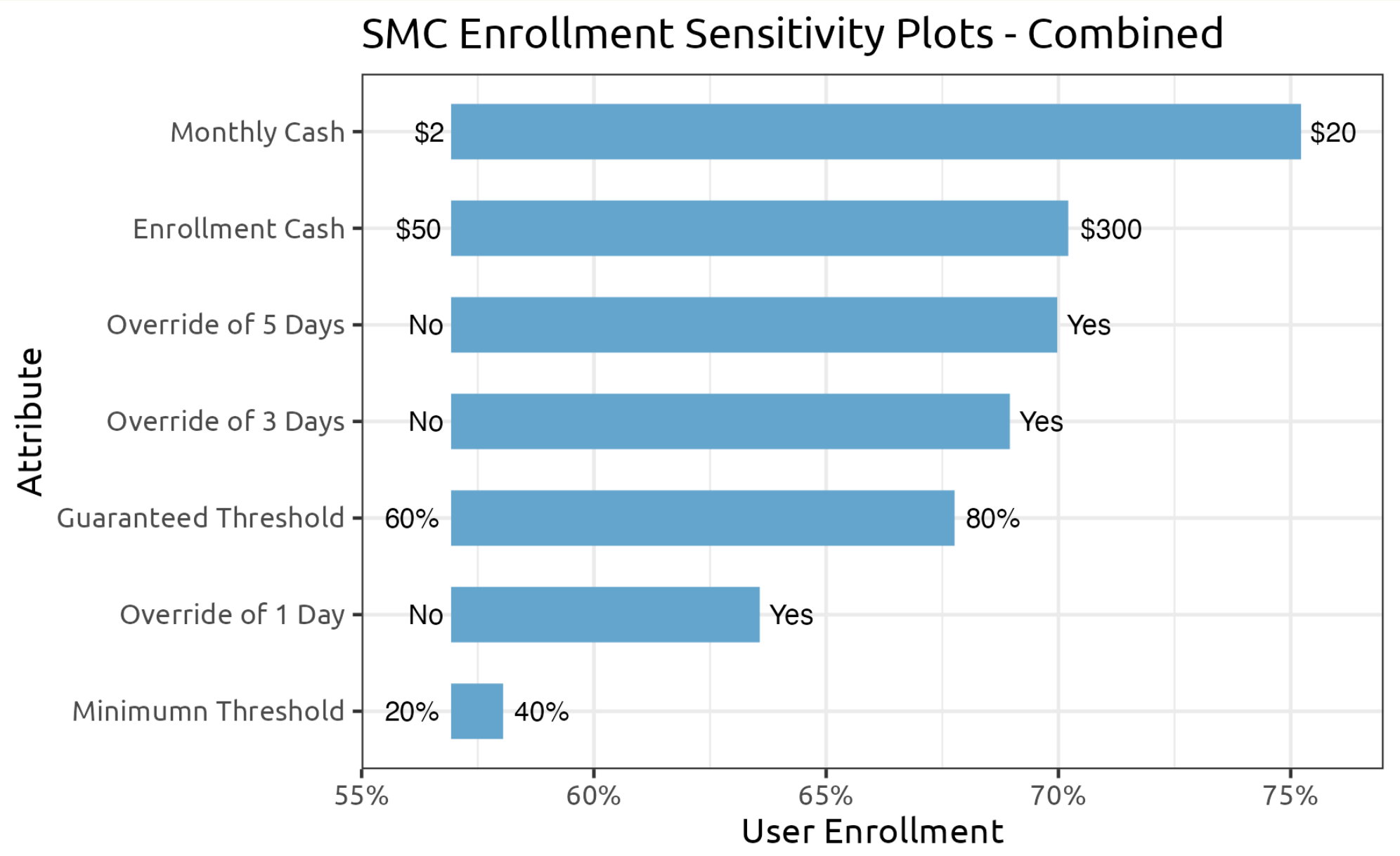


Enrollment Sensitivity

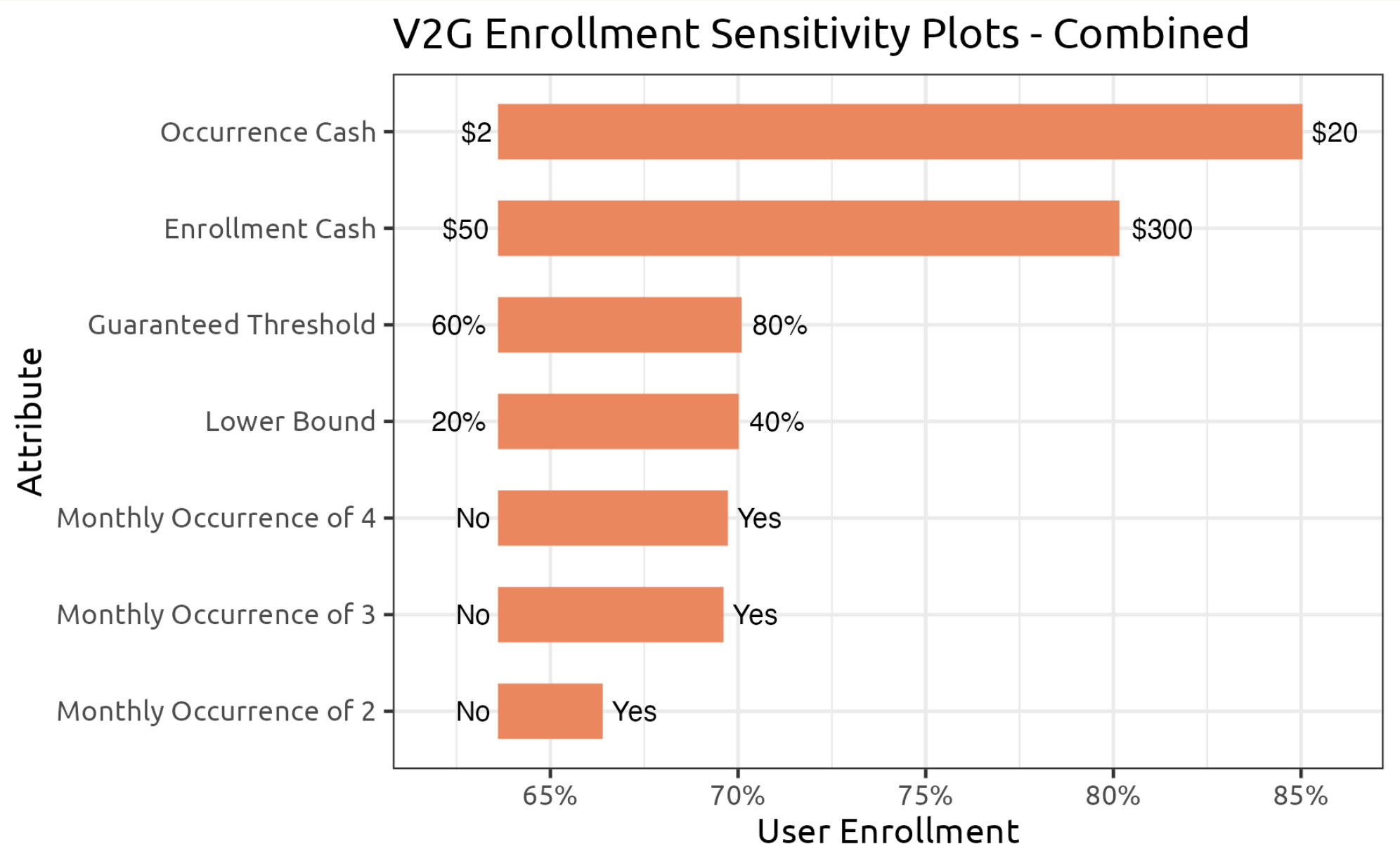


Steeper slope indicates higher sensitivity.

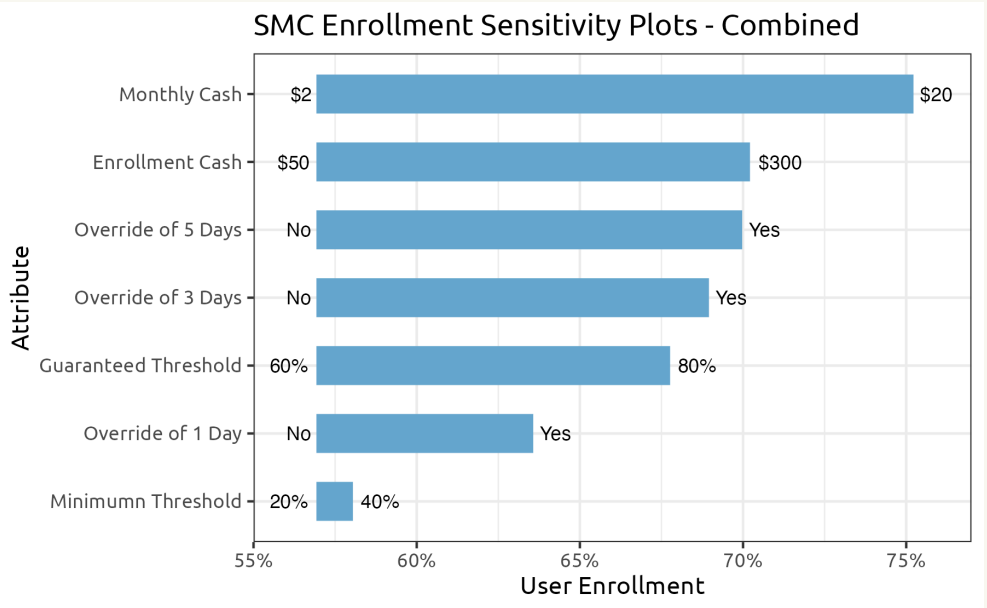
Enrollment Sensitivity Combined - SMC

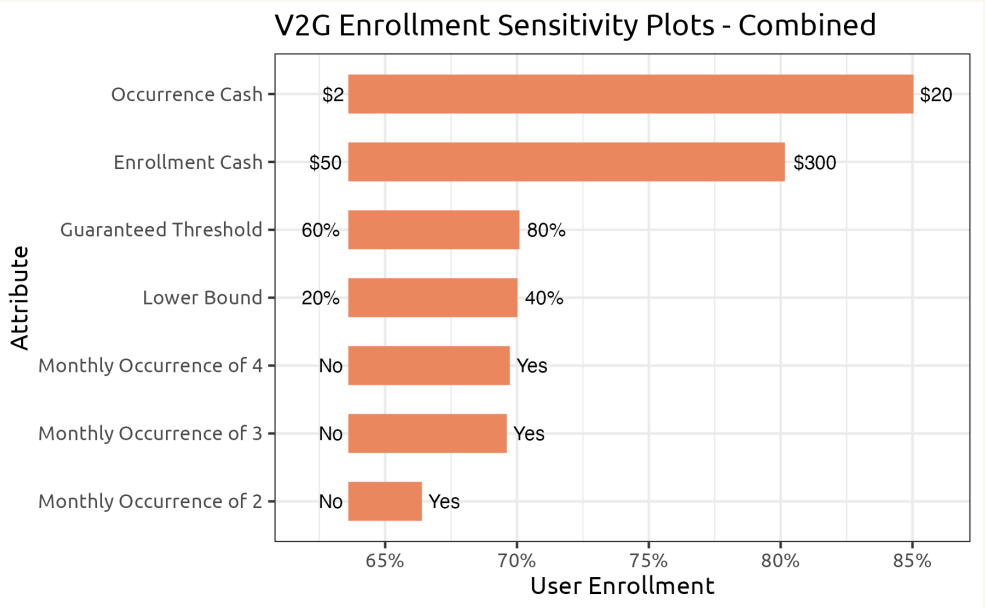


Enrollment Sensitivity Combined - V2G



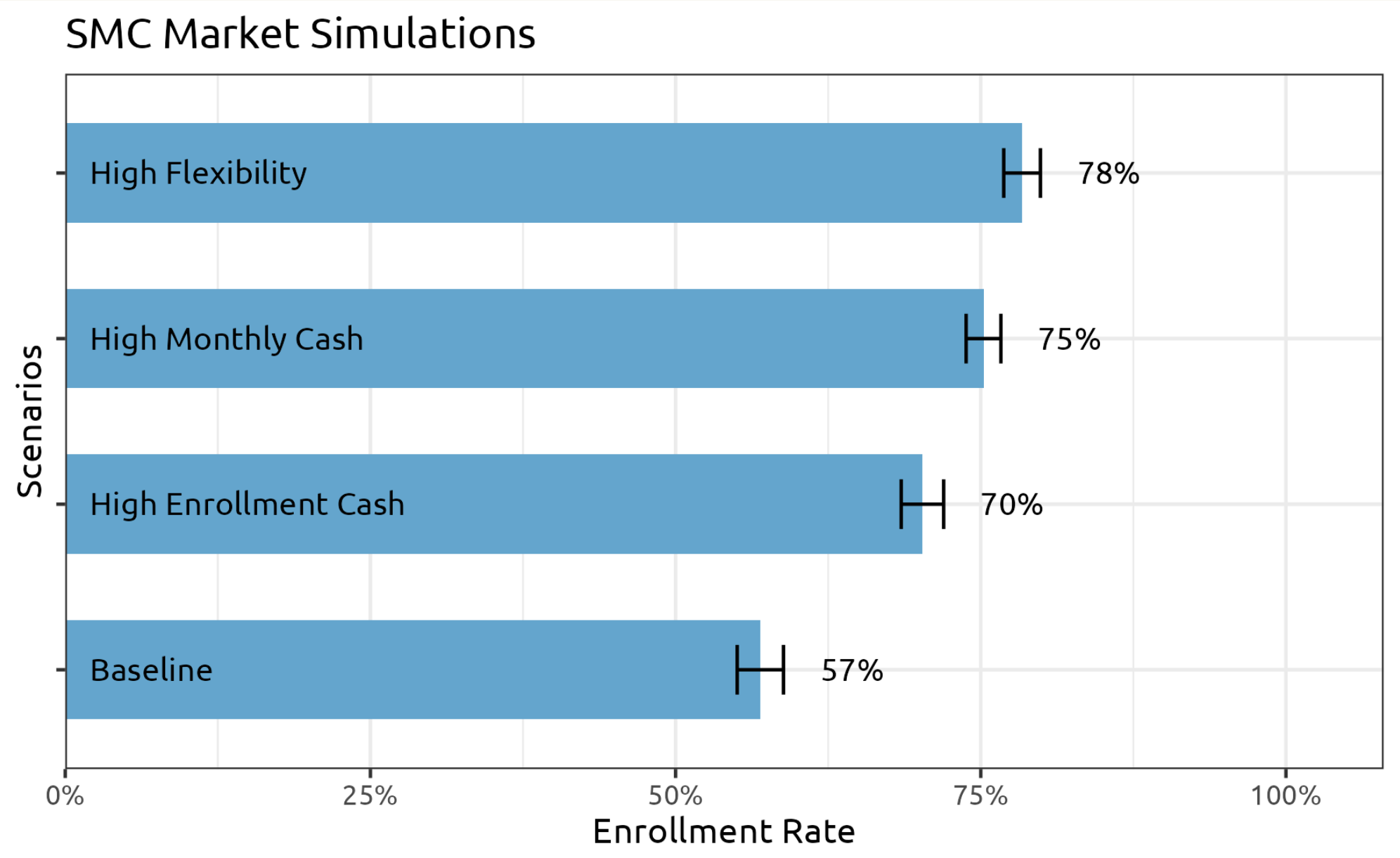
Enrollment Sensitivity Combined - Summary



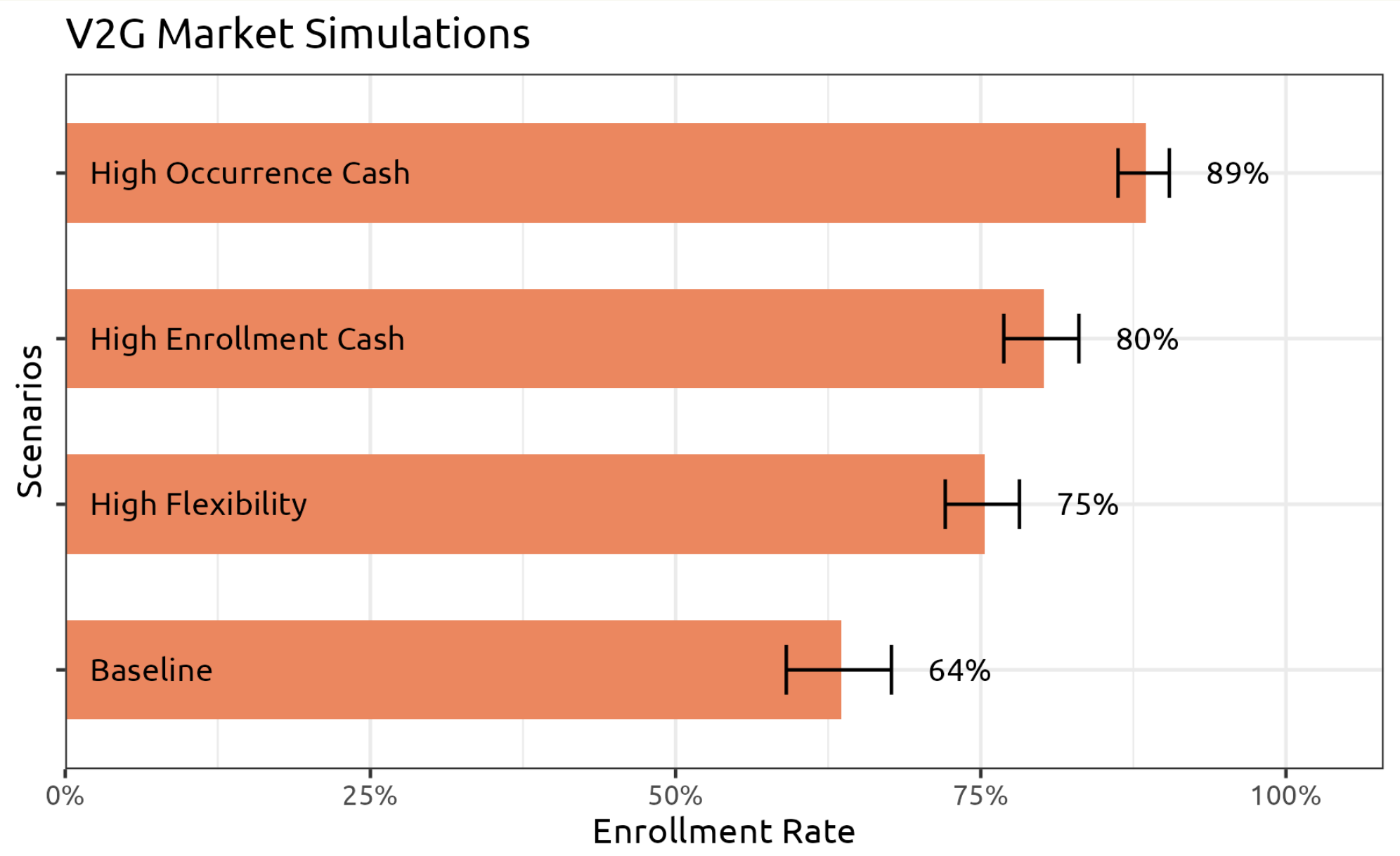


1. **Monetary** incentives are important.
2. **Recurring** incentives are more important than one-time.
3. For SMC, **range anxiety** is vital, since it happens regularly.
4. For V2G, usability is compromised.
5. Diminishing returns exist.

Market Simulation - SMC



Market Simulation - V2G



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.