

Introduction

- Unmanaged Battery Electric Vehicle (BEV) charging can increase costs and emissions.
- Managed charging can reduce costs and pollution. It can reduce peak loads to avoid overloading the power grid.
- Smart charging is a type of managed charging, which includes Supplier-Managed Charging (SMC), and Vehicle-to-Grid (V2G).



Research Questions

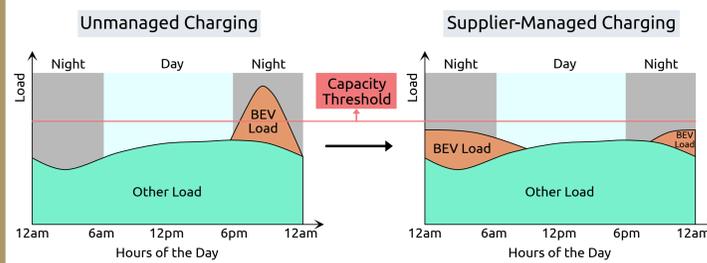
- 1.Sensitivity:** How do changes in smart charging program features influence BEV owners' willingness to opt in?
- 2.Market Share:** Under what conditions will BEV owners be more willing to opt in to smart charging programs?

Method

- 1.Conjoint survey** to collect BEV owners' willingness. Obtained **1,356** results from Meta and Dynata.
- 2.Multinomial logit model (MNL)** for utility simulations in enrollment sensitivity, equivalency study, and scenario analysis.

Smart Charging Programs

Supplier-Managed Charging (SMC)



Supplier-managed charging avoids peak loads by shifting BEV charging to times with less peak demand.

Vehicle-to-Grid (V2G)

Non-V2G (Single Direction)



V2G (Bi-direction)



Figure Source: wri.org

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

Conjoint Survey & Logit Model

Survey Question

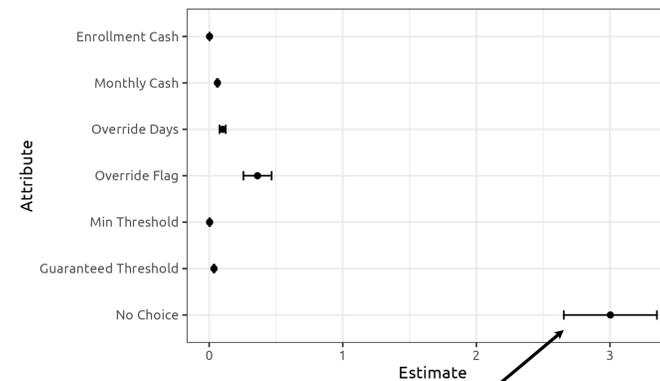
Option 1	Option 2	Option 3
Enrollment Cash: \$50 Monthly Cash: \$2 Override Allowance: 0 per month	Enrollment Cash: \$300 Monthly Cash: \$20 Override Allowance: 5 per month	Not Interested
Battery Thresholds (in Miles): Min: 60, Guaranteed: 180, 300	Battery Thresholds (in Miles): Min: 120, Guaranteed: 240, 300	

- Conjoint questions provide different **sets** of options.
- If you choose one option, you choose the whole set.
- In short, conjoint is about forcing people to make trade-offs.

Logit Model

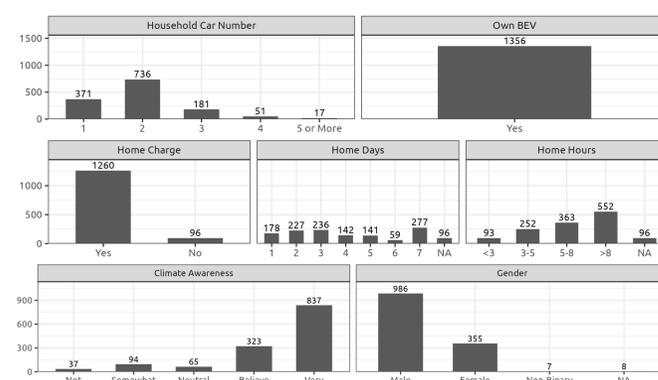
$$P_j = \frac{e^{v_j}}{e^{v_j} + e^{v_k}}$$

$$\tilde{u}_j = v_j + \tilde{\epsilon}_j = \beta_1 x_{j1} + \beta_2 x_{j2} + \dots + \tilde{\epsilon}_j$$



Without compensation, users will not participate.

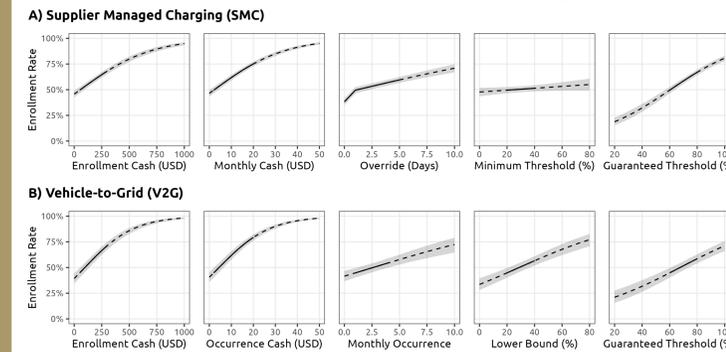
Demographic Results



- We have **100%** BEV ownership.
- Most families have at least **2** cars.
- Most owners charge **at home** for more than **8** hours.
- Most owners care of climate very much.
- Most owners are **male**.

Analysis

Enrollment Sensitivity



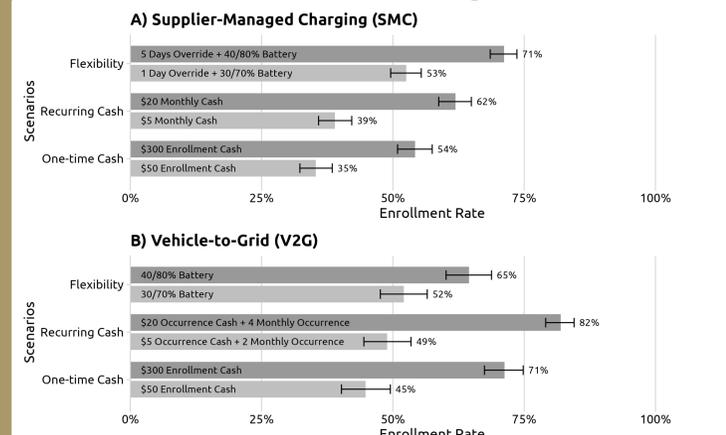
- Steeper slope indicates higher sensitivity.
- Diminishing returns exist, but solid parts (directly from results) are basically linear.

Equivalency of 5% Increase

SMC			V2G		
Attribute	Equivalence Value	Unit	Attribute	Equivalence Value	Unit
Enrollment Cash	64.7	\$	Enrollment Cash	45.0	\$
Monthly Cash	3.2	\$	Occurrence Cash	2.3	\$
Override Days	2.0	Days	Monthly Occurrence	1.5	Times
Minimum Threshold	54.8	%	Lower Bound	8.5	%
Guaranteed Threshold	5.5	%	Guaranteed Threshold	7.2	%

- For SMC, guaranteed threshold is highly important, as is recurring incentives.
- For V2G, both thresholds matter, as is recurring incentives.

Scenario Analysis



In general, flexibility is more significant in SMC, while receiving payments is more significant for V2G.

