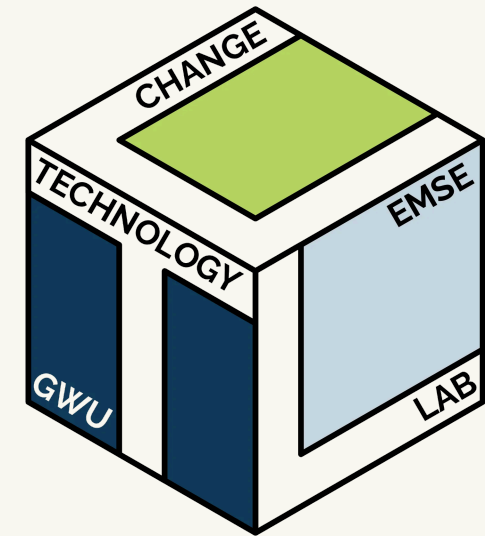


Sustainable Transportation, Sustainable Research:

Consumer Adoption and Grid Peak-Shaving
of Battery Electric Vehicle Smart Charging,
Inspiring the surveydown Survey Platform

Pingfan Hu

George Washington University



Pingfan Hu



EDUCATION

-  **PhD** Candidate in Systems Engineering, advised by Dr. John Helveston, George Washington University, USA
-  **M.P.E** in Mechanical Engineering, University of Sydney, Australia
-  **B.S.** in Industrial Engineering, Pennsylvania State University, USA

WORK EXPERIENCE

-  **Assistant Process Engineer**, Kurtz Erska, Germany
-  **Project Engineer**, Daimler Beijing, China
-  **Project Engineer**, Hasco Rail, USA



Research Interests



Data Science in transportation systems and human behavior



Open-Source Software in R tools for survey research

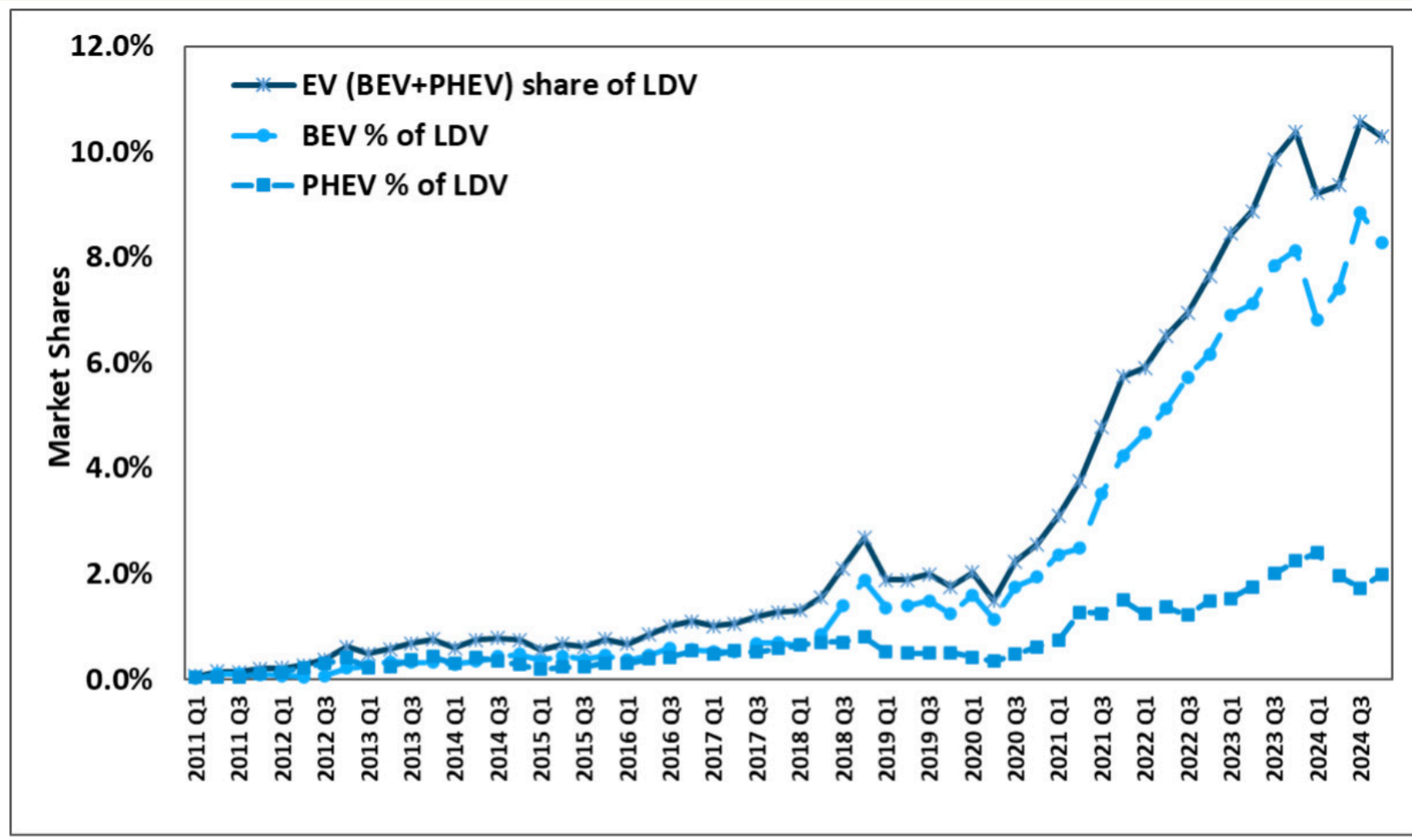


Agentic AI Engineering around Claude Code

pingfan.org ↗



EV sales in US reaching ~10% of sales

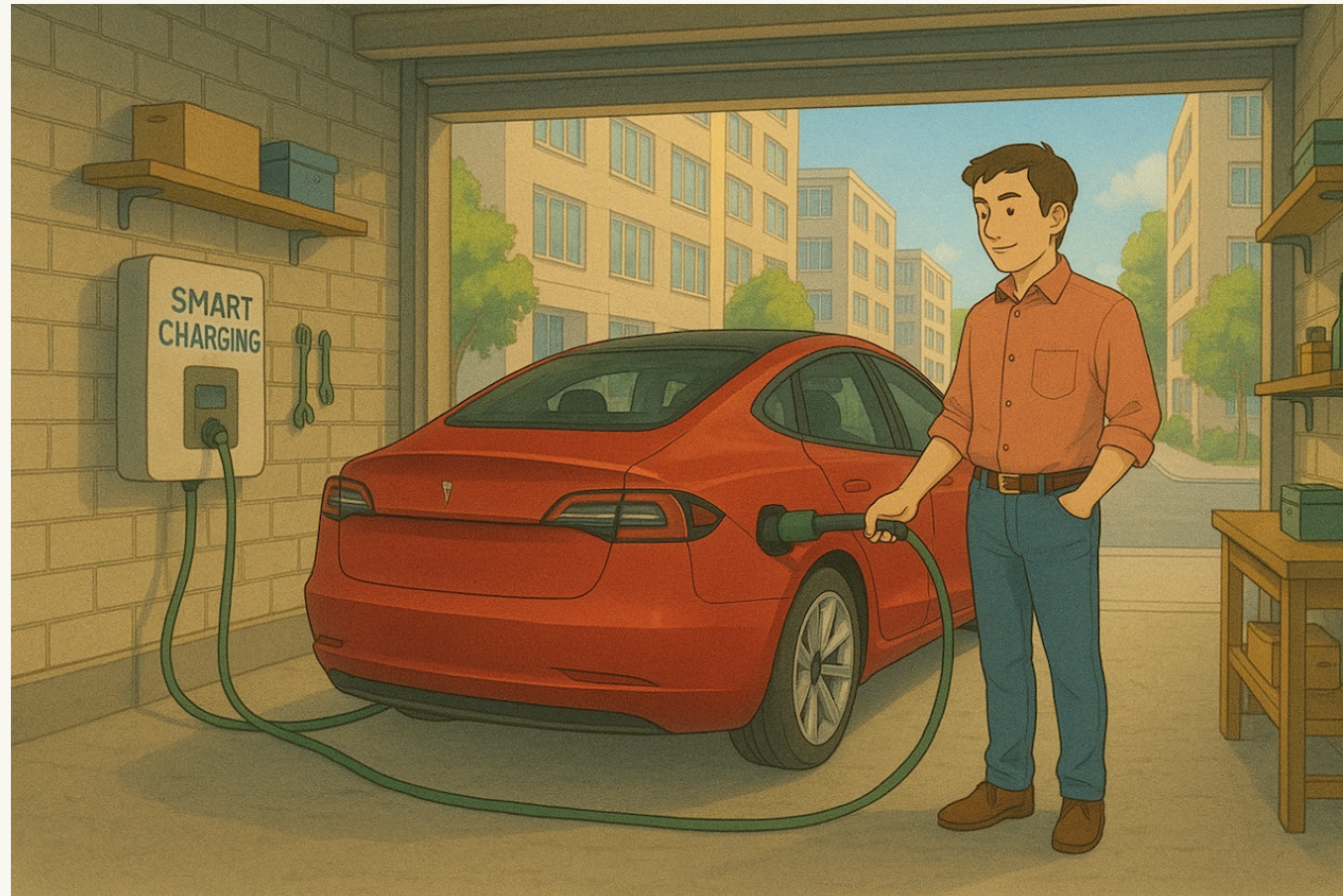


Source: Argonne National Lab, www.anl.gov/ev-facts/model-sales



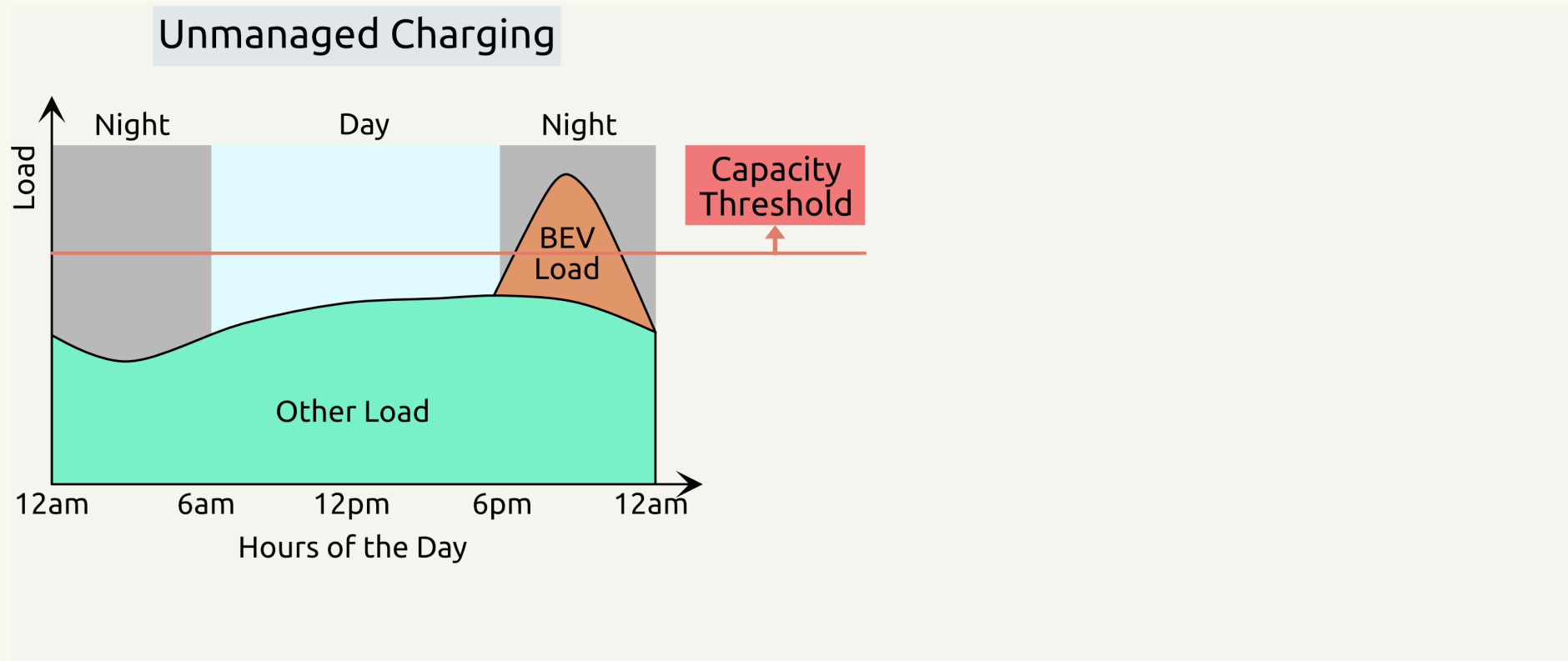
Introduction

- **Unmanaged** BEV charging is becoming a problem to the grid.
- **Managed** charging is cheaper and smooths out the grid load.
- **Smart** charging: Supplier-Managed Charging (SMC) and Vehicle-to-Grid (V2G).



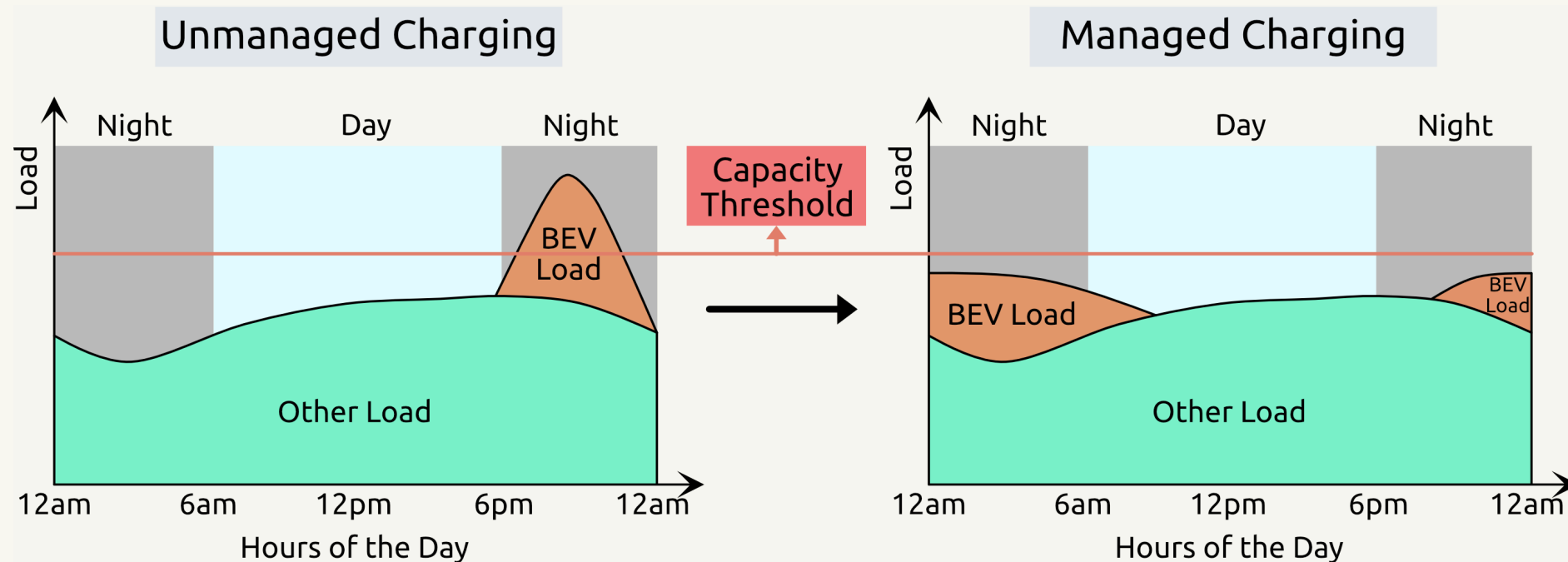
SMC - Supplier Managed Charging

- SMC smooths out the BEV charging spike (called “Peak-shaving”).
- Electricity demand is controlled below the capacity threshold.
- It saves money and reduces pollution.



SMC - Supplier Managed Charging

- SMC smooths out the BEV charging spike (called “Peak-shaving”).
- Electricity demand is controlled below the capacity threshold.
- It saves money and reduces pollution.



Managed charging avoids overload caused by BEV charging.



V2G - Vehicle-to-Grid

Non-V2G (Single Direction)

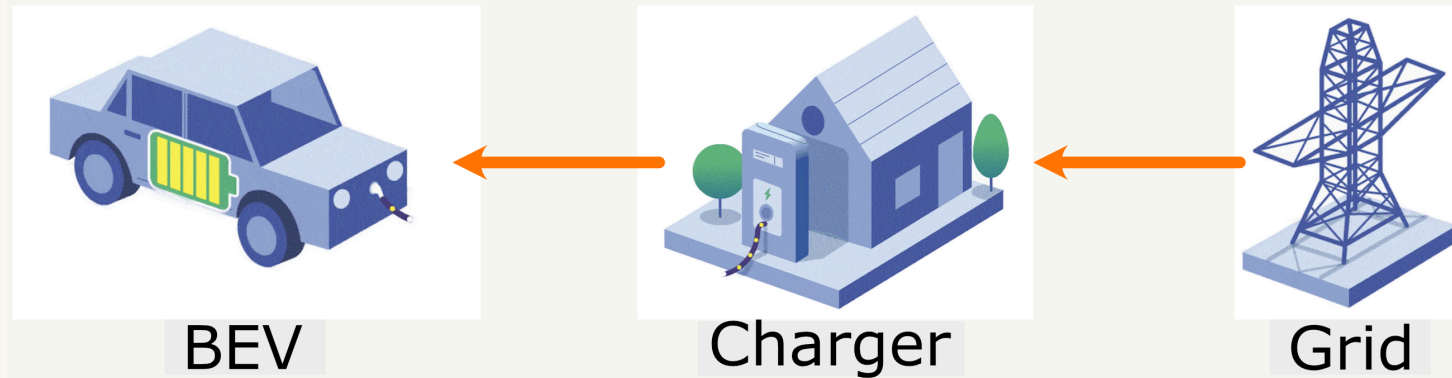
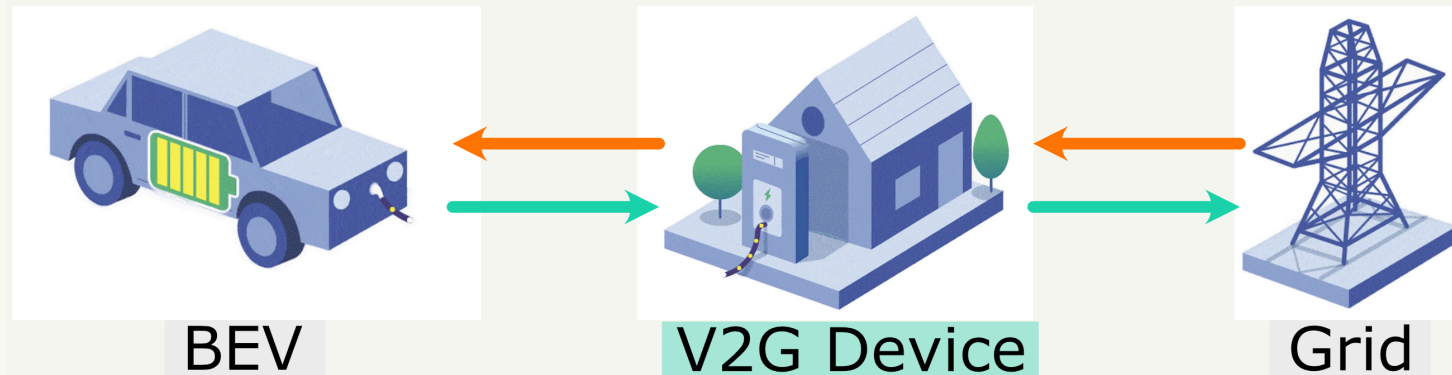


Figure Source: wri.org

V2G (Bi-direction)



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

Smart charging effectiveness depends on
enrollment and **peak-shaving**.



Three Inter-connected Studies

Survey Research & Modeling

Battery Electric Vehicle Smart Charging Adoption

Simulation Research

Grid Peak-Shaving
Quantification

Software Development

The surveydown Survey
Platform



Study 1

Battery Electric Vehicle Smart Charging Adoption

Published in *Environmental Research Letters*:

Hu, Pingfan, Tarroja, B., Dean, M., Forrest, K., Hittinger, E., Jenn, A. & Helveston, J.P. (2025) "Measuring electric vehicle owners' willingness to participate in smart charging programs" *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/ae2597>



Prior studies have few EV owners in sample

1. A survey-based study by Wong et al. (2023) examined **incentives'** effect on EV owners' acceptance, **but EV ownership in sample was only 19%.**
2. A survey-based study by Philip & Whitehead (2024) found **range anxiety** matters, **but EV ownership in sample was only 1.28%.**
3. A survey-based study by Huang et al. (2021) indicates the importance of **fast charging**, **but the sample size was only 157.**

We need high BEV ownership & a large sample size.



Research Questions

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

Approach

1. **Conjoint survey** to collect BEV owners' willingness.
2. **Mixed logit model** for utility simulations.



Survey Design

Conjoint Questions

1. Monetary Incentives
2. Charging Limitations
3. Flexibility

Demographic Questions

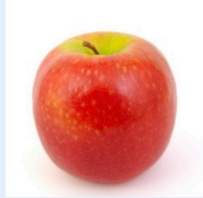
1. BEV Ownership
2. Personal Info
3. Household Info



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

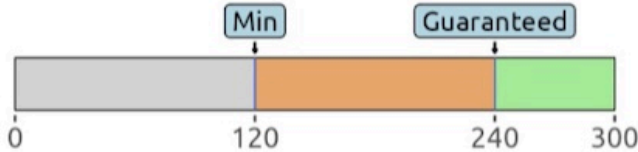
1. Provide respondents with different **sets** of attributes.
2. Observe choices across random sets.
3. Estimate **utility** of each attribute.



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	
Battery Thresholds (in Miles): 	Battery Thresholds (in Miles): 	Not Interested



Survey Fielding - 1,356 in Total



Meta Ads: Voluntary participants

- 803 responses
- March to July in 2024

Dynata Recruitment: Paid survey

- 553 responses
- September to November in 2024



Facebook



Messenger



Instagram



Survey Results - Willingness to Participate

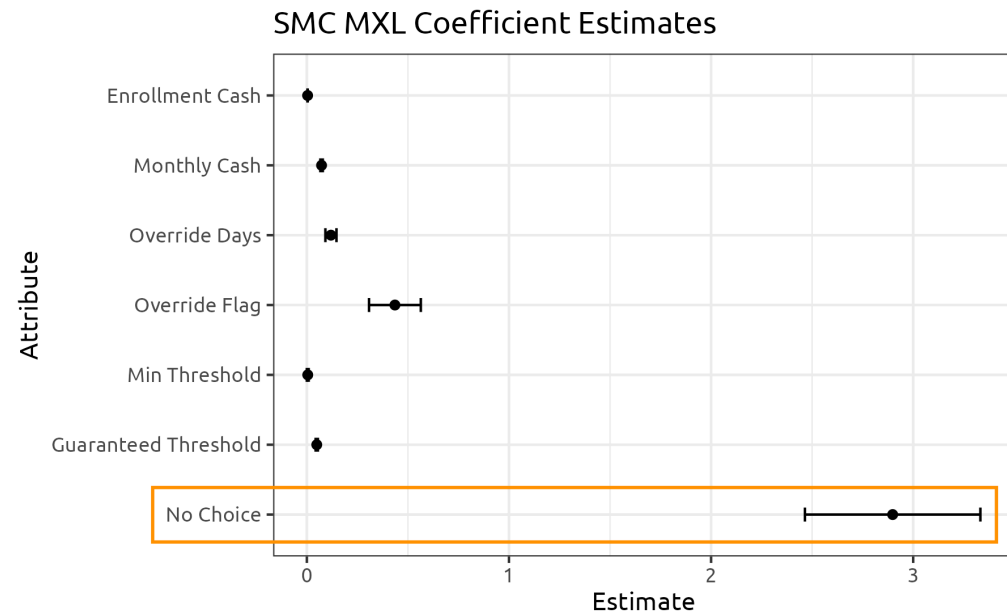
Mixed Logit Models

$$u_j = v_j + \epsilon_j = \beta'x + \epsilon_j$$

$$P_j = \frac{e^{v_j}}{\sum_{k=1}^J e^{v_k}}$$

Utility estimated using maximum likelihood estimation (MLE).

SMC Coefficient Estimates



Without compensation, users will not participate.



Enrollment Sensitivity

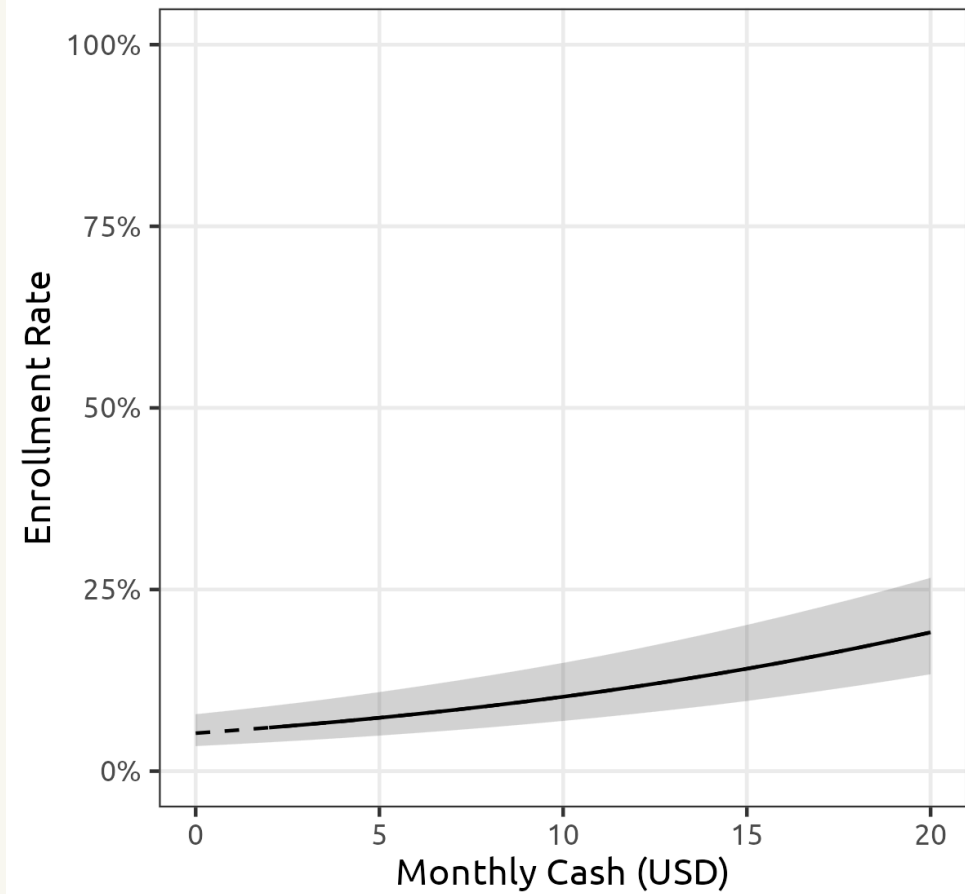
Baseline Simulation

Choice between “None” and this program:

Attributes	Values
Enrollment Cash	\$0
Monthly Cash	\$0 - \$20
Monthly Override	0

Sensitivity Plot

SMC Sensitivity of Monthly Cash



Smart Charging Enrollment Simulator

Smart Charging Enrollment Simulator

About

⚡ SMC (Supplier-Managed Charging)

🚗 V2G (Vehicle-to-Grid)

SMC Attributes:

Enrollment Cash (\$)

50

Monthly Cash (\$)

5

Override Allowance per Month

1

Minimum Threshold (%)

010100

0102030405060708090100

Guaranteed Threshold (%)

030100

0102030405060708090100

Reset

Predicted SMC Enrollment Probability:

45.1%

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.



Study 2

Quantifying the Peak-Shaving Potential and Cost Efficiency of BEV Supplier-Managed Charging

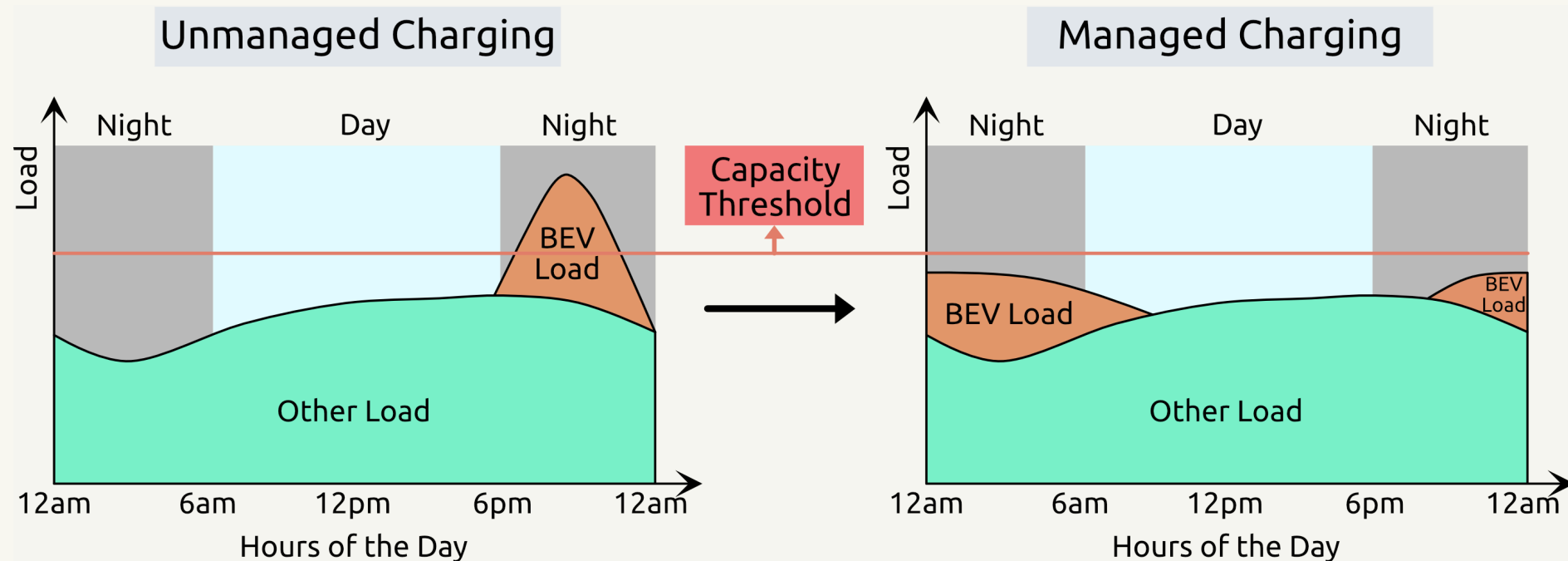
Submitted to *Environmental Research: Infrastructure and Sustainability*

Manuscript ERIS-100972, awaiting review



Recall the SMC Peak-shaving

- SMC smooths out the BEV charging spike (called “Peak-shaving”).
- Electricity demand is controlled below the capacity threshold.
- It saves money and reduces pollution.



Managed charging avoids overload caused by BEV charging.



Prior studies assume enrollment is high and free

1. Most grid studies **assume** optimal or near-100% participation (Tarroja et al., 2015), but real pilots enroll far fewer.
2. Enrollment is **not free**: utilities must pay incentives (Bailey et al., 2023), yet costs are rarely counted.
3. Few studies compare peak-shaving **across grid regions** with different load shapes.

We connect **consumer enrollment** with **grid simulation**.



Research Questions

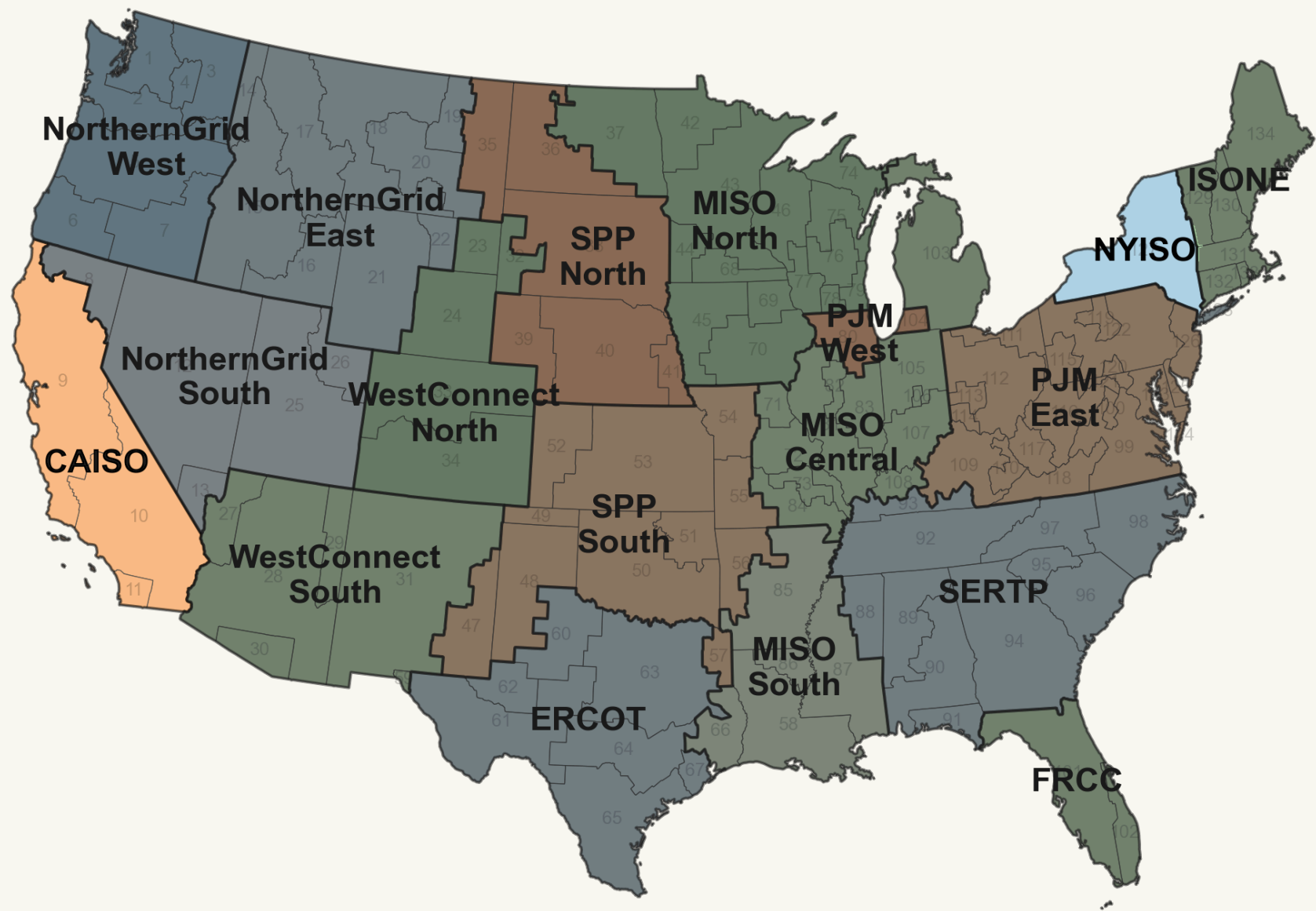
1. **Peak-shaving:** How much can SMC reduce peak demand in contrasting grid regions?
2. **Cost efficiency:** How much does peak shaving cost per unit, and is more enrollment always better?

Approach

1. **Scenario-based simulation** for CAISO and NYISO.
2. **Enrollment model:** incentives vs participation.



18 GEA regions in the USA



	CAISO	NYISO
Single Families	7.69 million	3.16 million
Different Energy Sources	Solar	Hydro
Net load shape	“Duck curve”	Flat profile
Seasonal effect	Minimal	Strong in winter (heating)

Both lead in BEV adoption, with contrasting grid structures.



Data Sources

Source	Provides	Role in Simulation
2022 NHTS	Real trip records nationwide	Charge time & energy needs
2025 GridStatus.io	Net load time series	Regional grid baselines
2025 U.S. Census	Single-family counts	Scale to total fleet energy
Study 1	Enrollment curve	Cost efficiency analysis



Simulation Overview

Scenario Inputs

Regions

CAISO
NYISO

Time Periods

Annual average
Extreme days
Seasonal

EV:House

1:1
1:2
1:4

SMC Enrollment

0%
10%
...
100%

Load Shifting Window

10AM-8PM -> 8PM-7AM
10AM-9PM -> 9PM-7AM
10AM-10PM -> 10PM-7AM
10AM-11PM -> 11PM-7AM
10AM-12AM -> 12AM-7AM

Peak-Shaving Model

Data Source

Grid Net Load

2025 CAISO & NYISO
time-series data

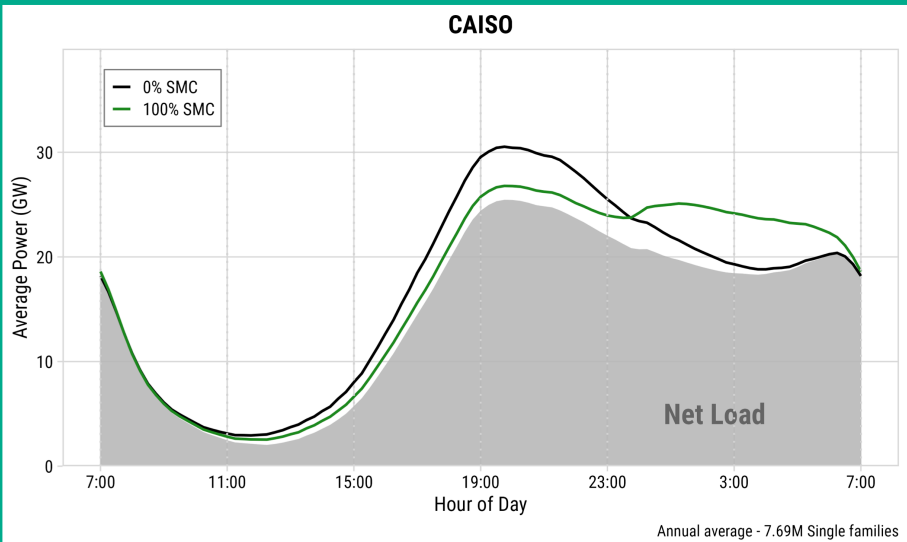
Household Count

2025 U.S. Census
CAISO: 7.69M
NYISO: 3.16M

Travel Patterns

2022 NHTS Results

One Example Run



Run the peak-shaving model multiple times with varying scenario inputs.

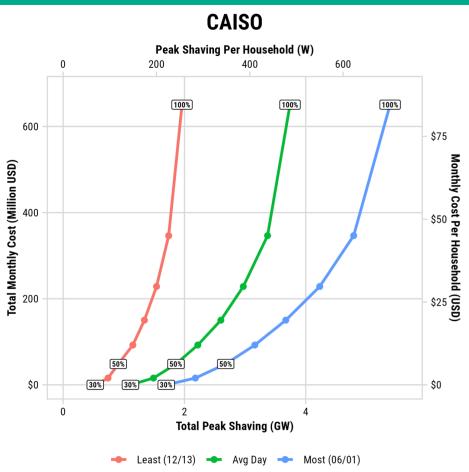
Cost Efficiency Simulation

Data Source

Enroll vs Cost Model

2024 Discrete Choice
Experiment
(1,356 BEV owners)

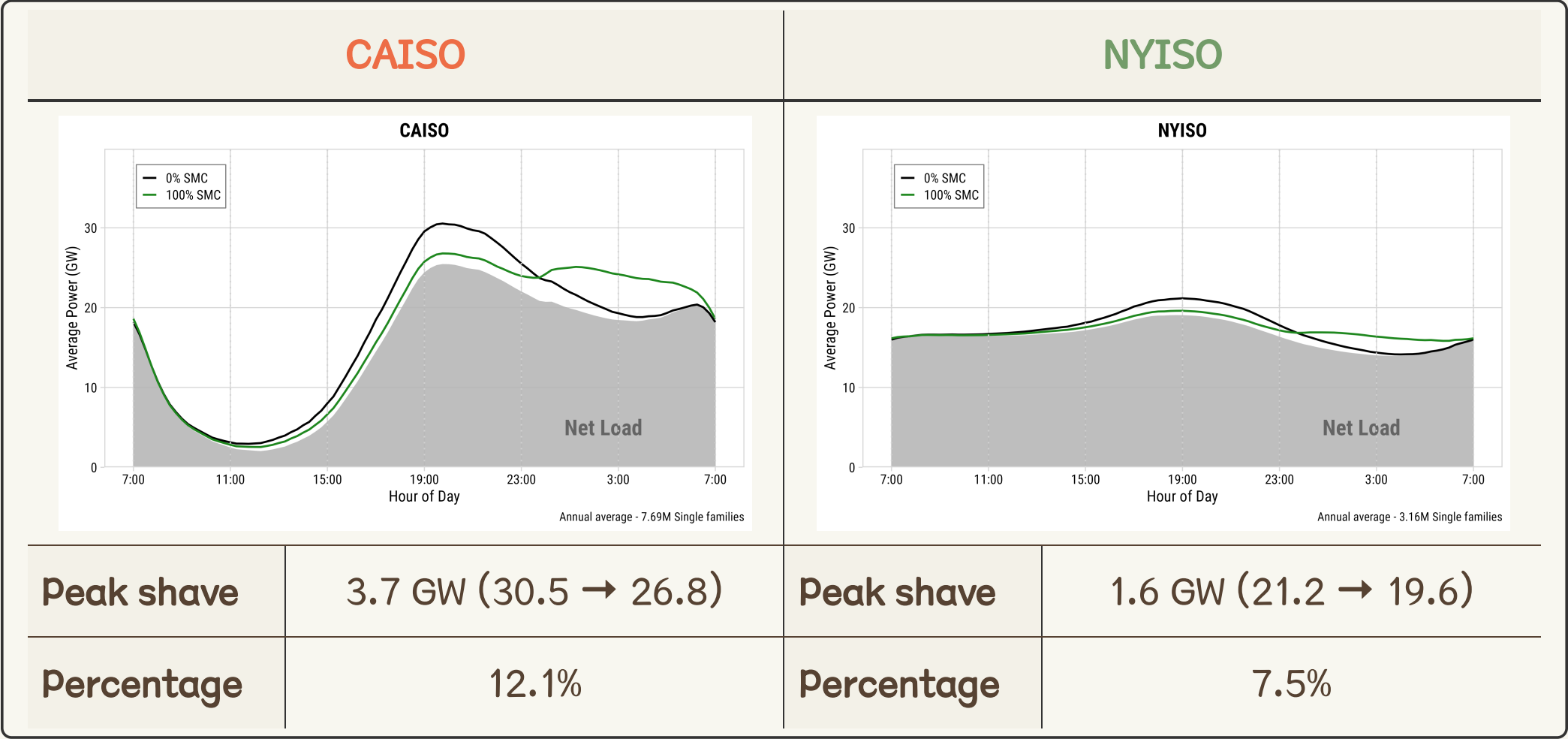
Extreme Days Example



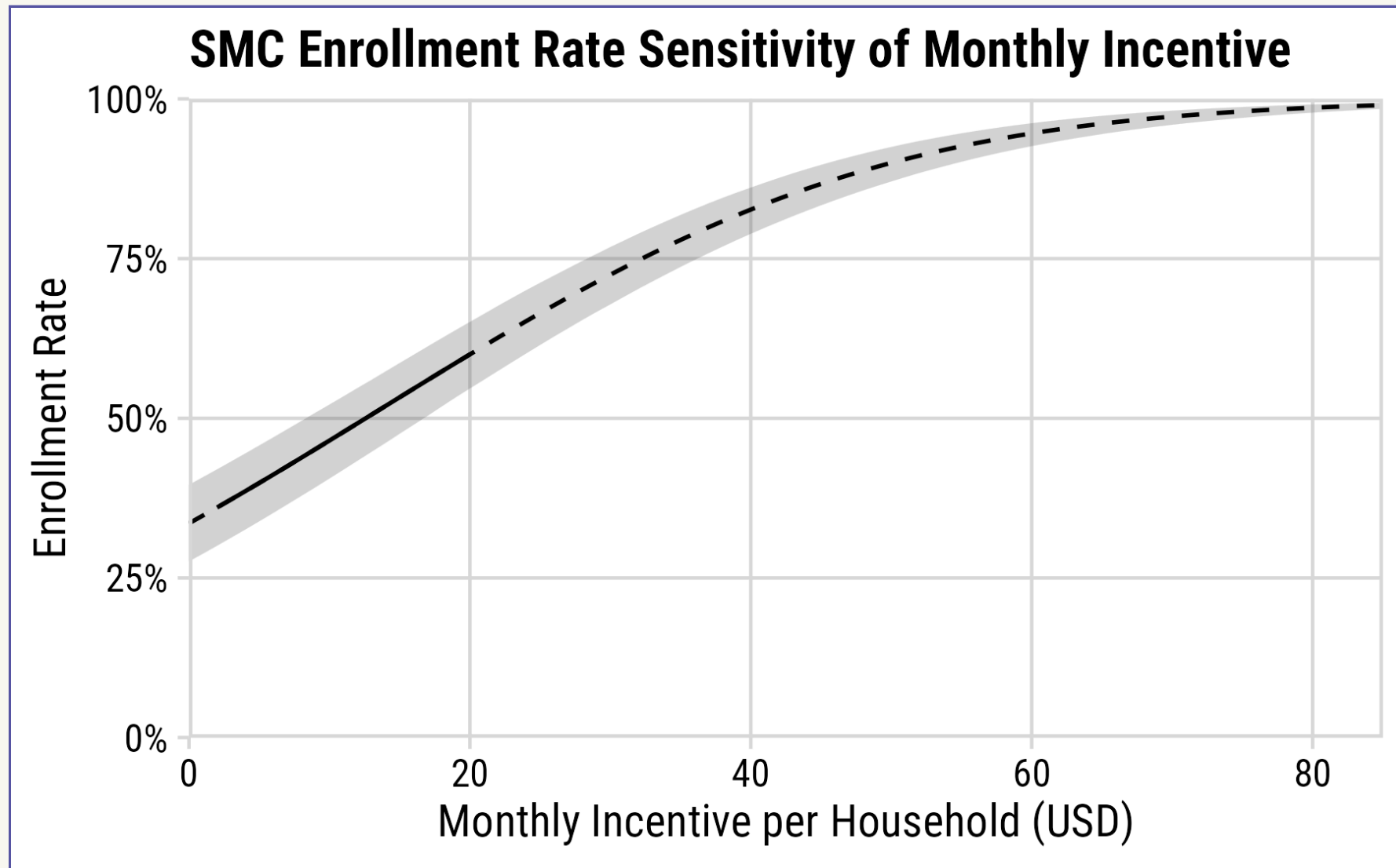
Contains annual average, extreme days, seasonal averages, and different EV-to-house ratios



Peak Shaving: Annual Average



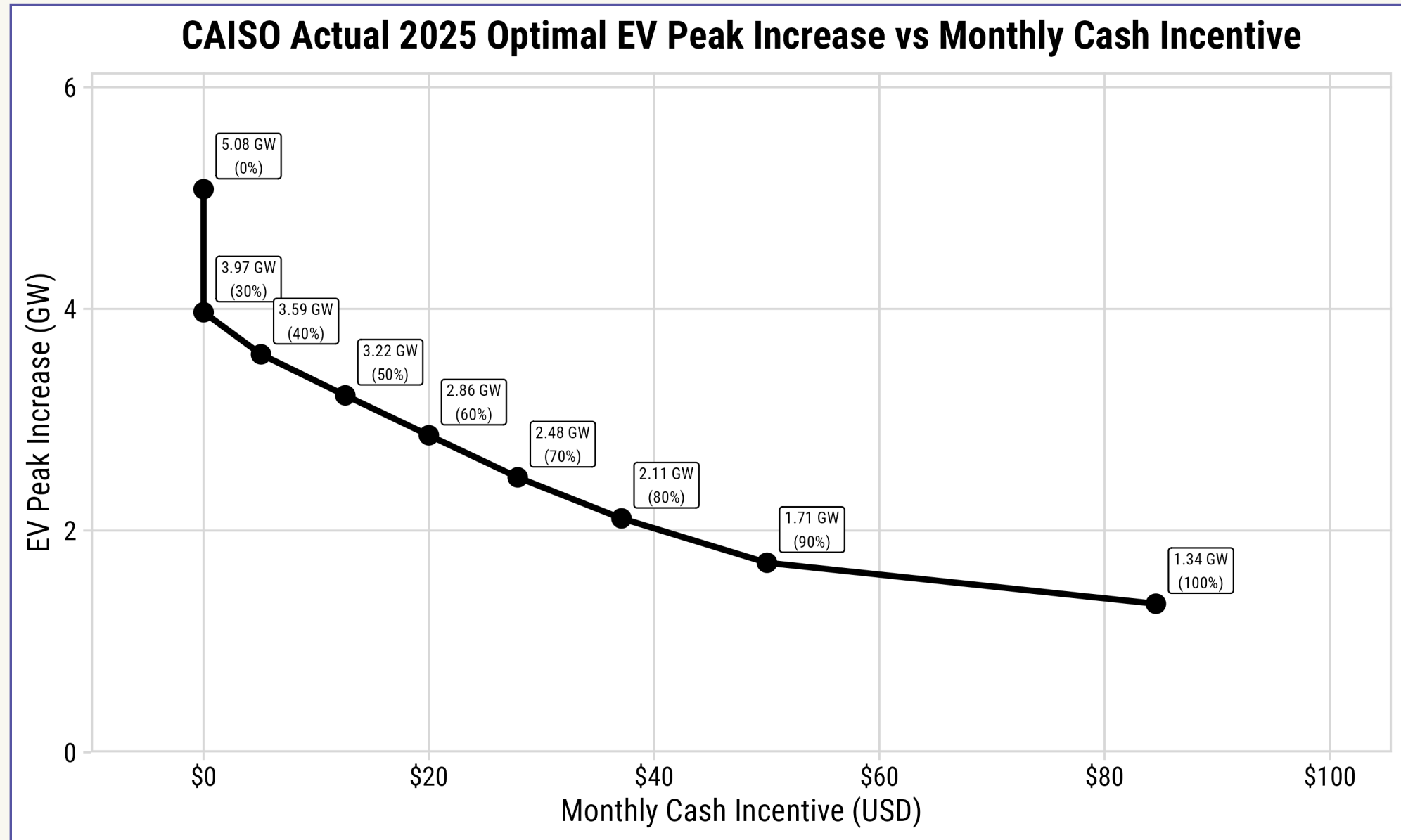
Enrollment Curve from Study 1



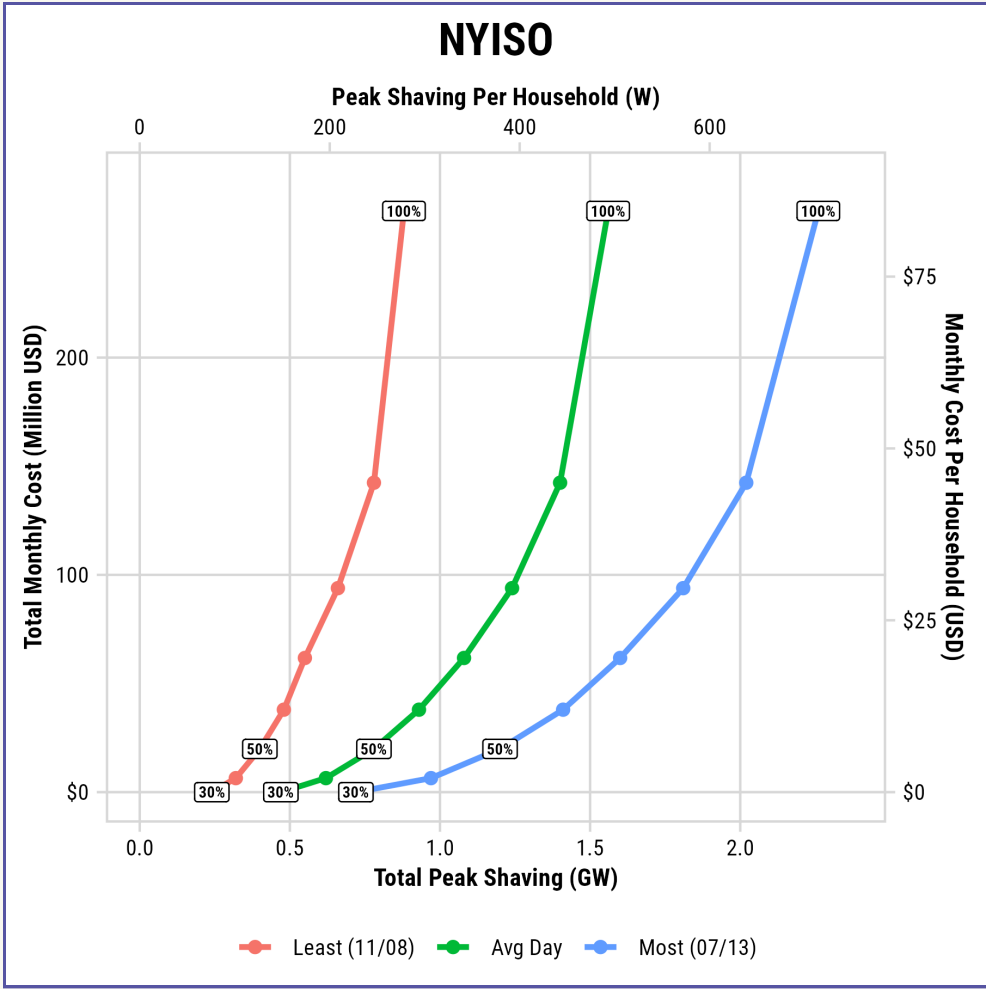
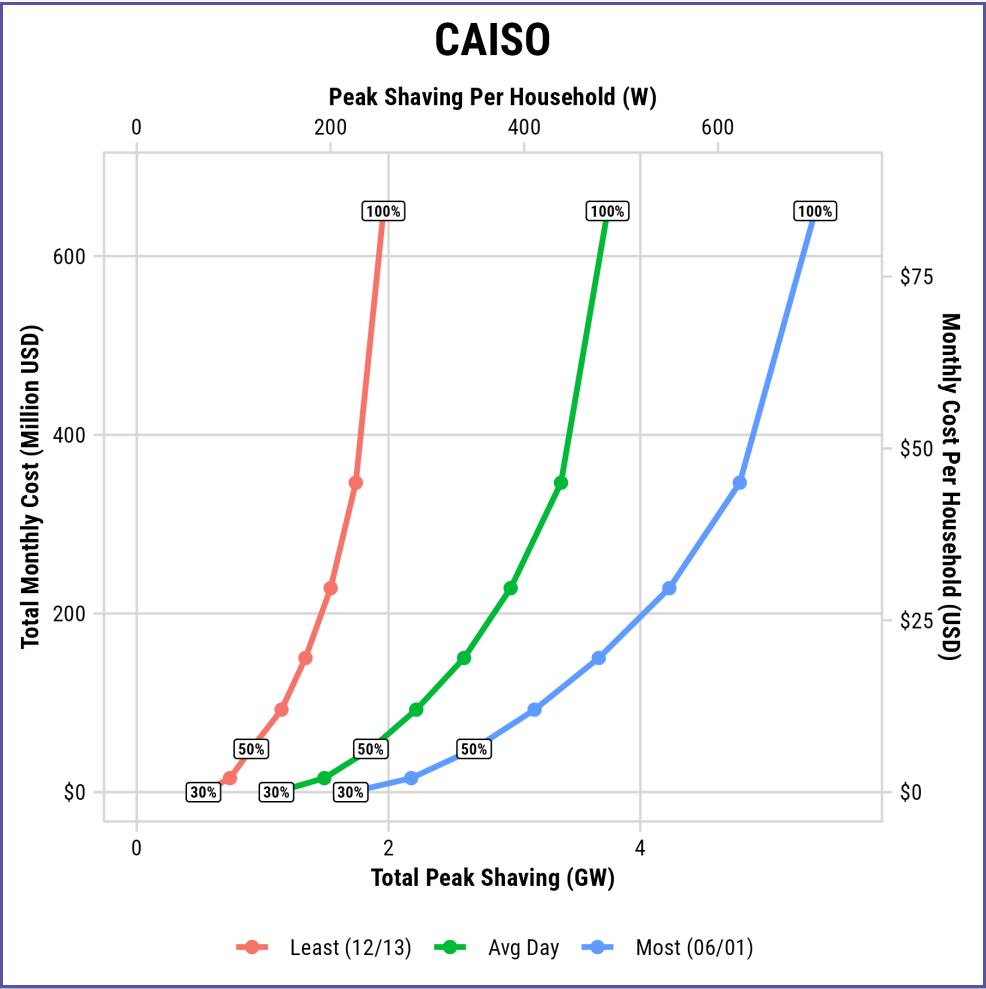
Mixed logit prediction based on ~1300 real BEV owners.



Peak from BEV charging decreases with higher enrollment



Cost Efficiency Frontier



Cost efficiency is highest at moderate enrollment (30–50%).



Conclusions

1. The **cost-effectiveness** of peak shaving requires:
moderate enrollment (30-50%), and seasonal effect consideration.
2. **Peak-shaving** potential is:
14.4% for CAISO, and 7.9% for NYISO.
3. SMC has **co-benefits** beyond monetary value:
fewer emissions, longer battery life, and lower storage capacity requirements.

Limitations

- a. Stated preference being optimistic.
- b. Only considered single-family homes.
- c. Grid conditions based on today's data.



Study 3

The **surveydown** Survey Platform

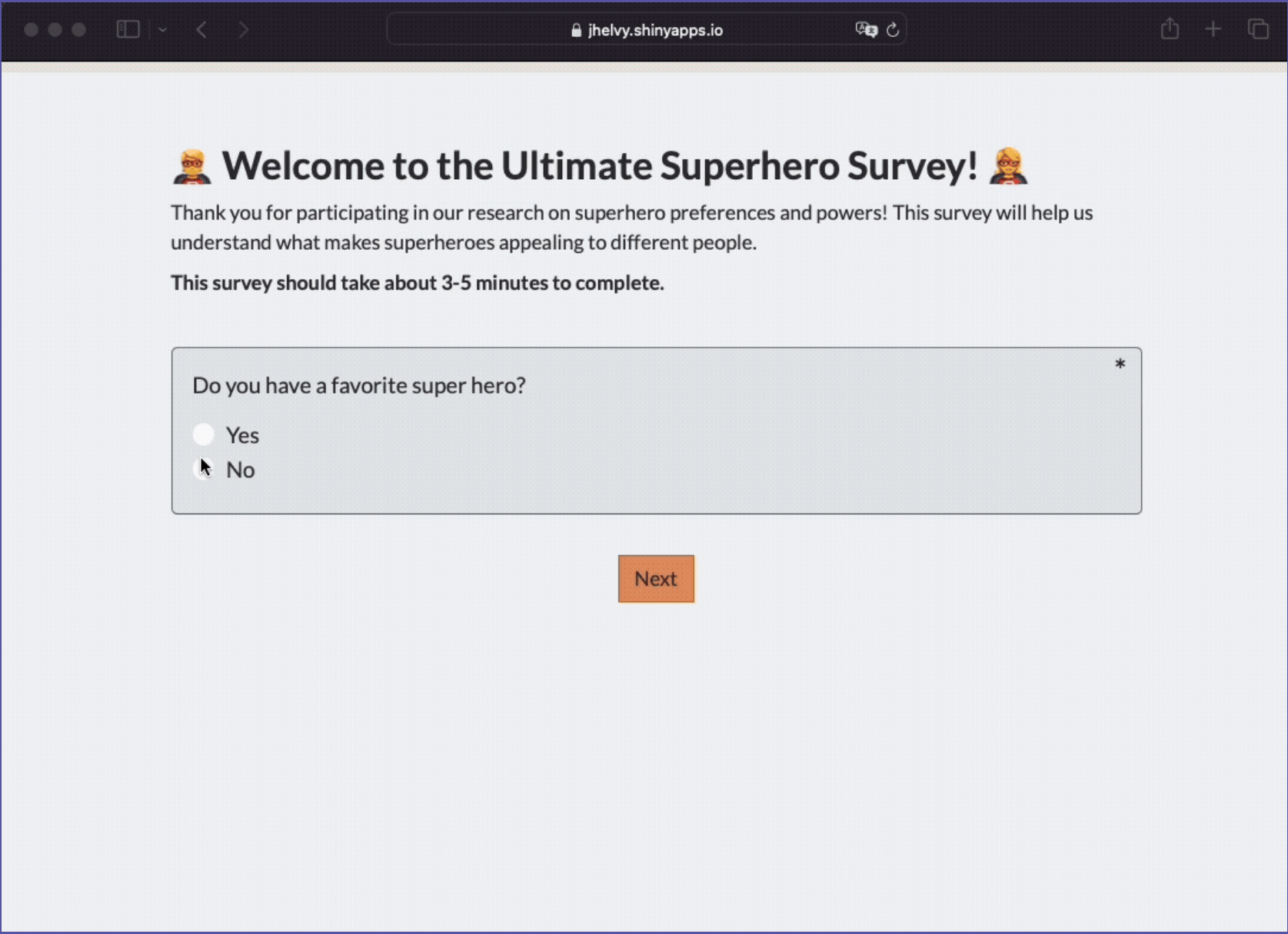
Published in *PLoS ONE*:

Hu, Pingfan, Bunea, Bogdan, & Helveston, J. P. (2025). “surveydown: An open-source, markdown-based platform for programmable and reproducible surveys” *PLOS ONE*, 20(8), e0331002. <https://doi.org/10.1371/journal.pone.0331002>

 surveydown.org ↗



Typical Web Survey



The screenshot shows a web browser window with the address bar displaying 'jhelvy.shinyapps.io'. The survey content is as follows:

Welcome to the Ultimate Superhero Survey!

Thank you for participating in our research on superhero preferences and powers! This survey will help us understand what makes superheroes appealing to different people.

This survey should take about 3-5 minutes to complete.

Do you have a favorite super hero? *

☐ Yes

☒ No

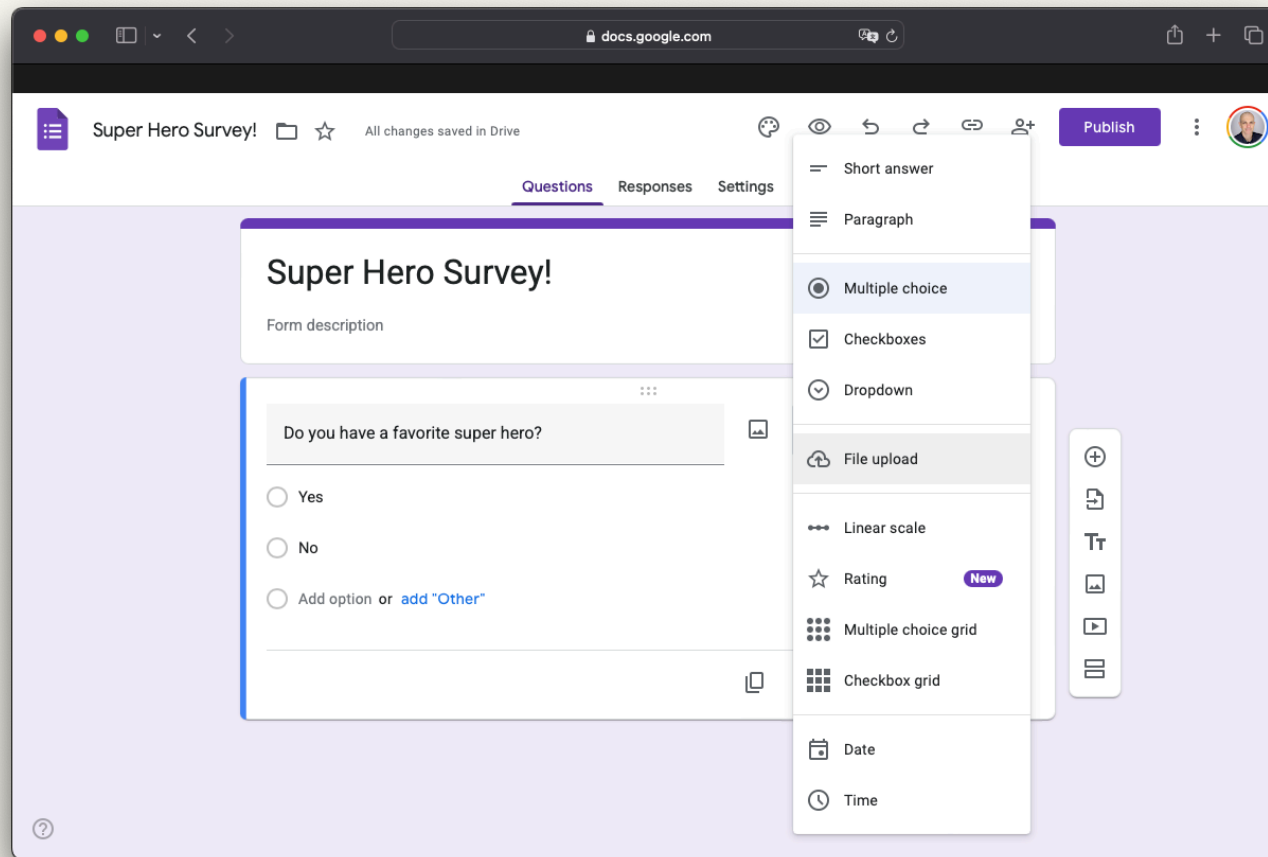
Next



Google Form - GUI Interface

The screenshot displays the Google Forms web interface. At the top, the browser address bar shows 'docs.google.com'. The form title is 'Super Hero Survey!' and it indicates 'All changes saved in Drive'. The 'Questions' tab is active, showing a question: 'Do you have a favorite super hero?' with radio button options for 'Yes', 'No', and 'Add option or add "Other"'. A dropdown menu is open, listing various question types: Short answer, Paragraph, Multiple choice (selected), Checkboxes, Dropdown, File upload, Linear scale, Rating (marked 'New'), Multiple choice grid, Checkbox grid, Date, and Time. The right sidebar contains icons for adding new questions, sections, and other elements.





Limitations

- ✗ Reproducibility
- ✗ Version control
- ✗ Limited features
- ✗ Open source



Qualtrics - Commercial Platform

**Qualtrics**

Qualtrics makes sophisticated research simple and empowers users to capture customer, product, brand & employee experience insight. It is used to meas... [Read more](#)

Employee Engagement



Market Share of Qualtrics

Current Customer(s) ⓘ

81,701

Market Share (Est.) ⓘ

57.68%

Ranking ⓘ

#1

Data captured from 6sense.com

Expensive!



Why not make surveys
from **code**?

~~Limitations~~

Features

- ✓ Reproducibility
- ✓ Version control
- ✓ Lots of features
- ✓ Open source
- ✓ Free!



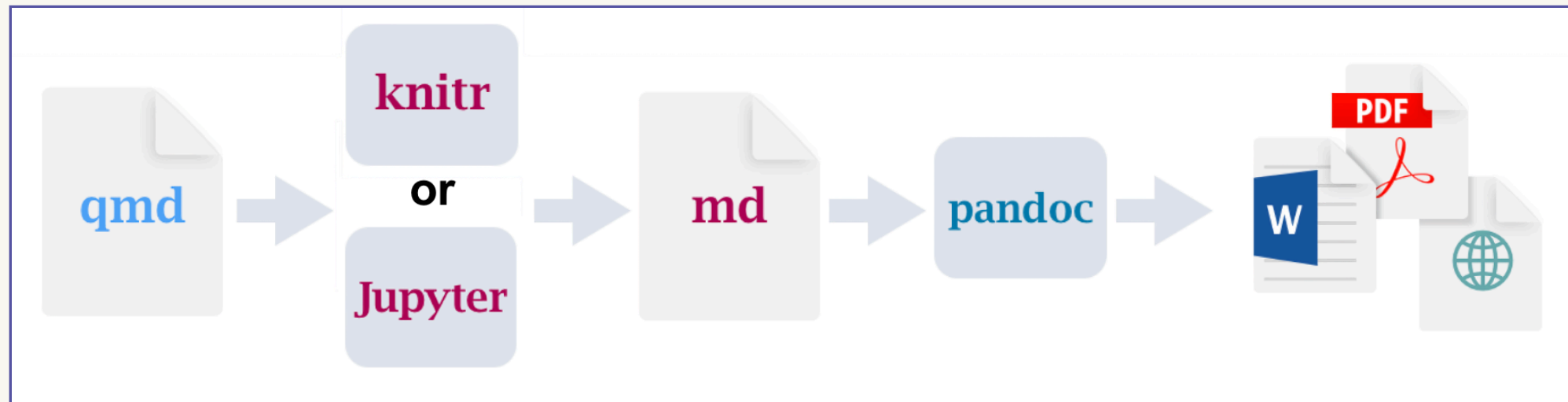
Introducing **surveydown**!



R package that renders Quarto files into surveys



Quarto is a publishing system



Original qmd file

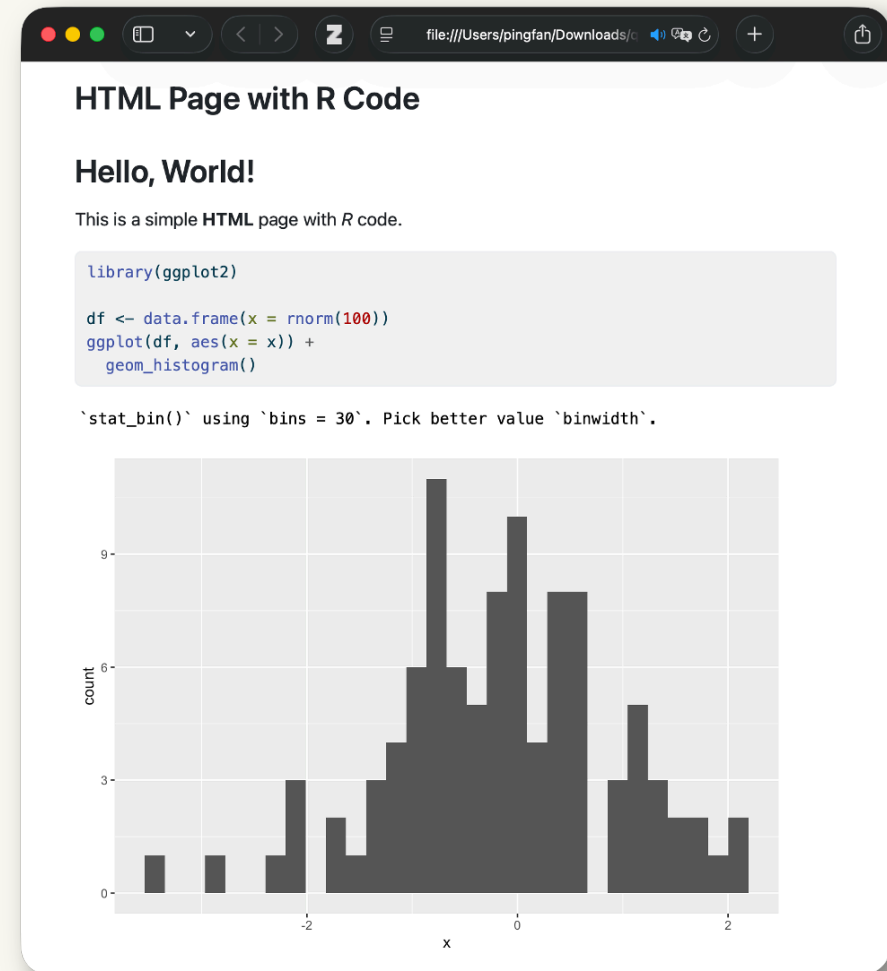
Markdown + R code chunks

```

1 ---
2 format: html
3 title: "HTML Page with R Code"
4 ---
5
6 # Hello, World!
7
8 This is a simple **HTML** page with *R* code.
9
10 ```{r}
11 library(ggplot2)
12
13 df <- data.frame(x = rnorm(100))
14 ggplot(df, aes(x = x)) +
15   geom_histogram()
16 ```

```

Rendered HTML



survey.qmd

```

1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id    = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...

```

Rendered Survey

localhost

Welcome to **surveydown**!

Do you have a favorite super hero?

☐ Yes

☐ No

Next



survey.qmd

```
1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id    = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...
```

YAML header for a “clean” output



survey.qmd

```
1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id   = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...
```

Load the **surveydown** Package



survey.qmd

```

1  ---
2  format: html
3  echo: false
4  warning: false
5  ---
6
7  ```{r}
8  library(surveydown)
9  ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id   = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...

```

Use triple-dash marker (---) to define survey pages

Quarto fences (:::) also OK:

```
::: {#welcome .sd-page}
```

Page content

```
:::
```



survey.qmd

```

1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id    = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...

```

Page content

- Markdown for text, images, etc.
- `sd_question()` for survey questions
- `sd_next()` for page navigation



survey.qmd

```

1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id    = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...

```

Rendered Survey

localhost

Welcome to **surveydown**!

Do you have a favorite super hero?

☐ Yes

☐ No

Next



survey.qmd

```

1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 --- welcome
12
13 # Welcome to `surveydown`!
14
15 ```{r}
16 sd_question(
17   type = "mc",
18   id   = "has_fav_hero",
19   label = "Do you have a favorite super hero?",
20   option = c(
21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 --- some_other_page
30
31 Other content...

```

Rendered Survey

Welcome to surveydown!

Do you have a favorite super hero?

☐ Yes

☐ No

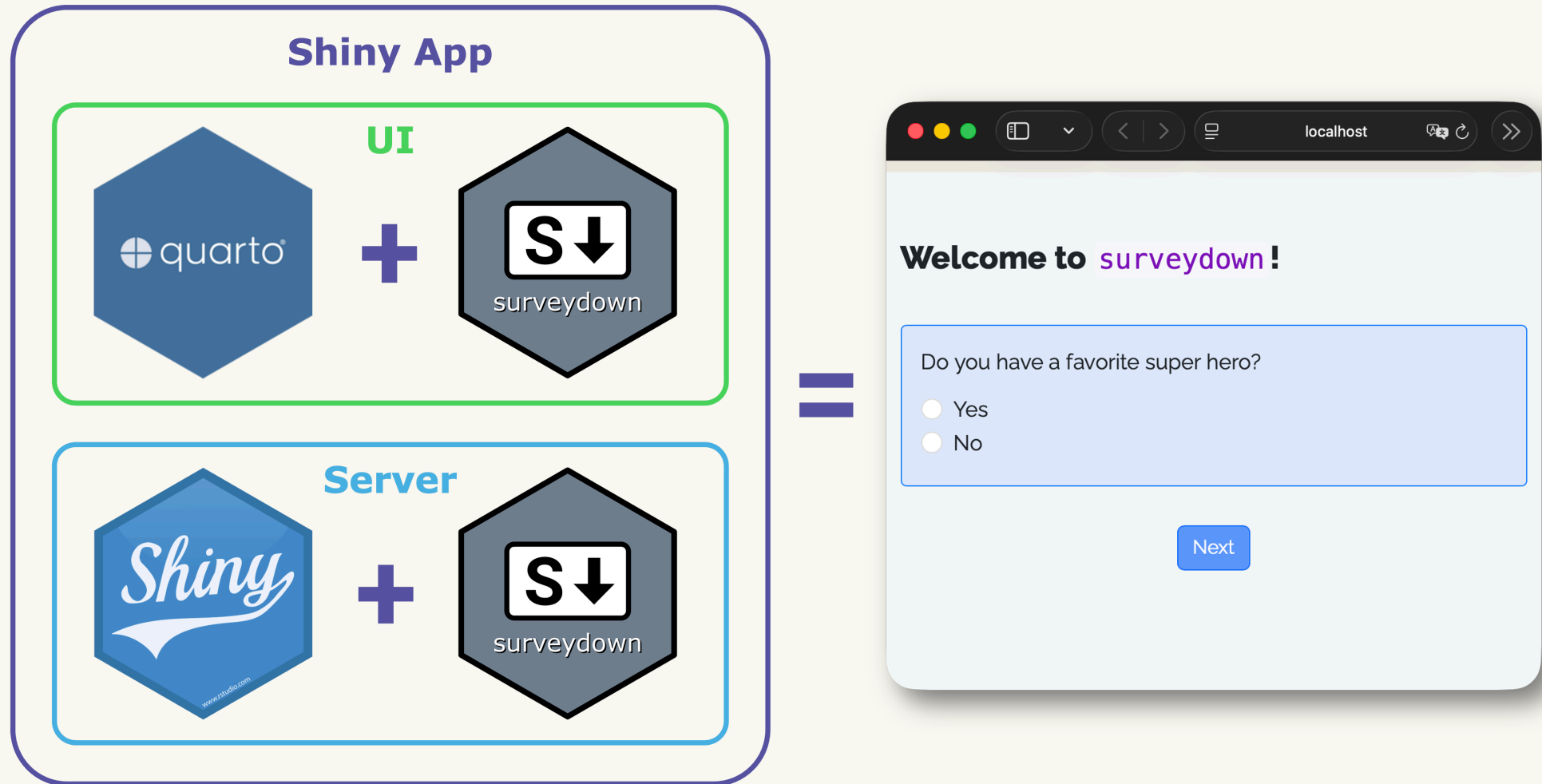
Next

has_fav_hero
yes
no
no
yes



Quarto renders to **static** html pages.
Shiny turns them **interactive**.





A complete surveydown survey

`survey.qmd`

A **Quarto doc** defining the survey content (pages, text, images, questions, etc.).

`app.R`

An **R script** defining the survey Shiny app.



PostgreSQL for response **data** storage.



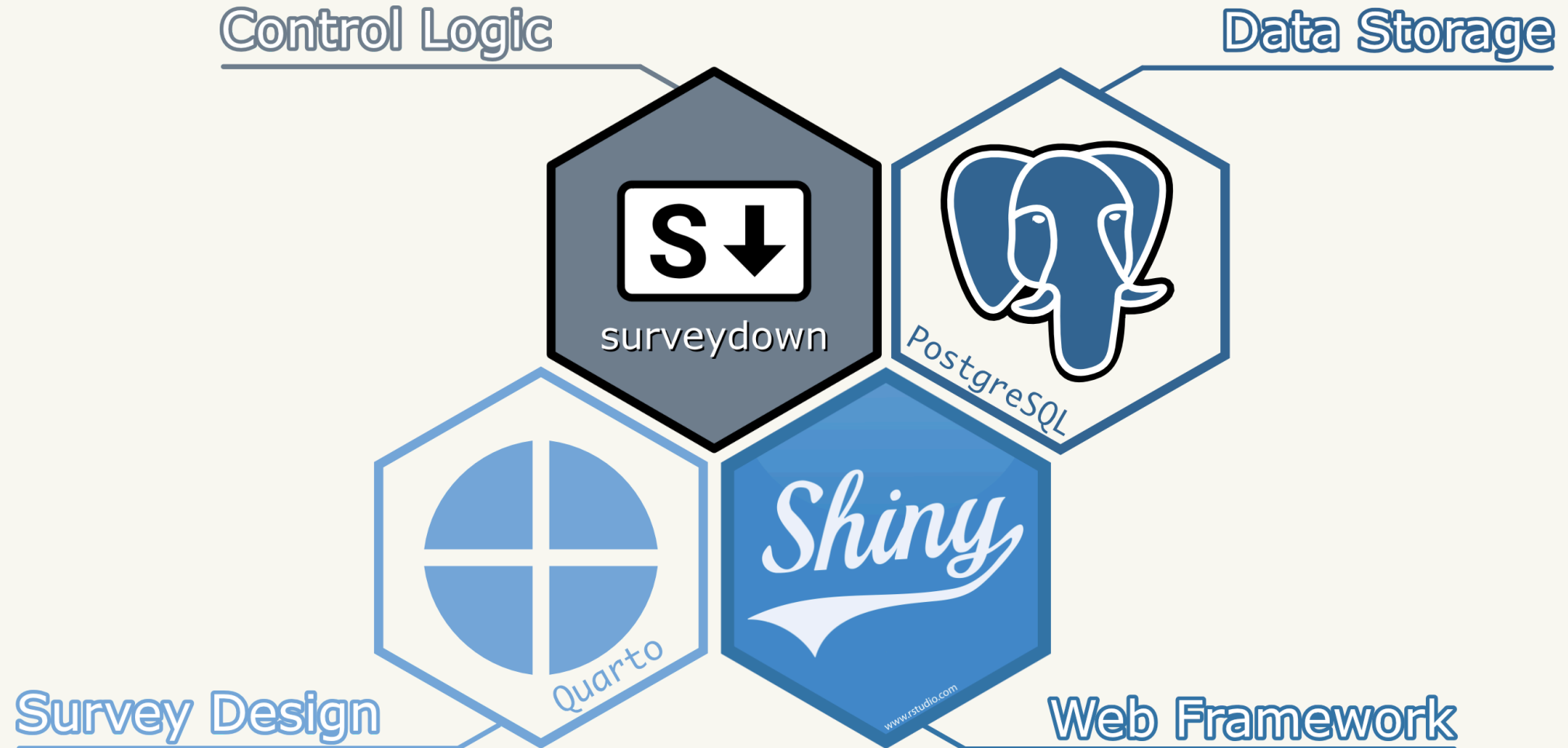
supabase.com

The screenshot shows the Supabase Table Editor interface. On the left is a sidebar with a 'Table Editor' section containing a list of tables: coders, data, demo, demo2, evRangeSurvey, leaf_miles, my_test_table, mydata, mytable1, newtable, responses, slider_test, slider_test2, slider_test3, speedtest, and superheros. The 'superheros' table is selected. The main area displays the table structure and data. The table has four columns: session_id (text), has_fav_hero (text), fav_hero_name (text), and hero_universe (text). There are 20 rows of data. The interface includes a top navigation bar with 'Demo', 'Free', 'surveydown', 'main', and 'Production' tabs, a 'Connect' button, and a user profile icon. The bottom of the interface shows pagination controls: 'Page 1 of 1', '100 rows', and '20 records'. There are also 'Refresh', 'Data', and 'Definition' buttons.

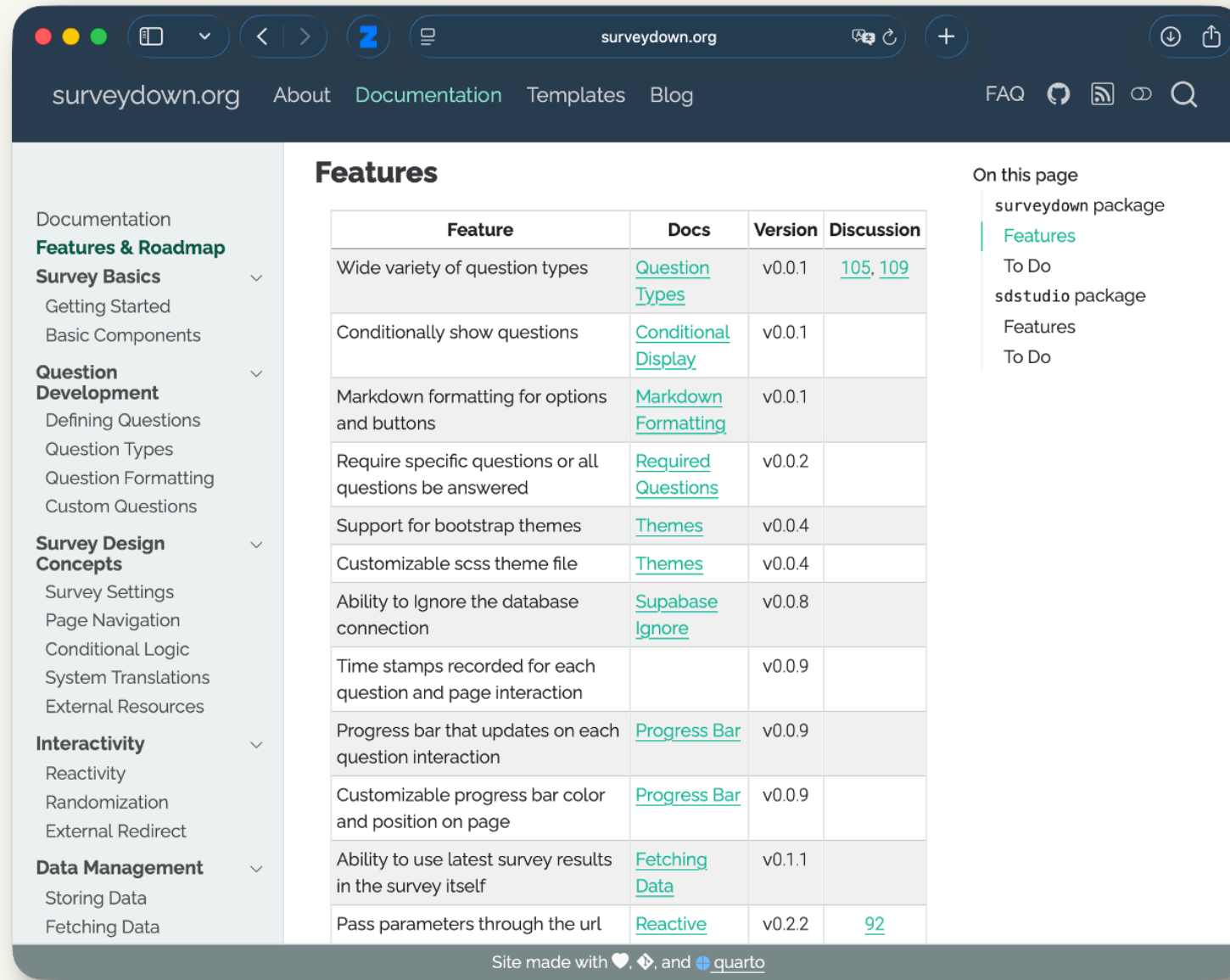
session_id	has_fav_hero	fav_hero_name	hero_universe
064585d4b3ce857a4a24e9dea4a657da	no	NULL	NULL
14d82544a547922107f492e6ee9a67dc	no	NULL	NULL
1eb83f38450cc4fa5b3bc8540d16f38	yes	Superman	dc
4ef1e74ae94737c502edb08db8e27f77	yes	NULL	marvel
5cf0f43d847425de2d015e1145ac3199	yes	Spiderman	all
676ae2ebd611f7ffe70586c23af5b53c	NULL	NULL	NULL
68fe326c20852efae79bca9b0b089815	no	NULL	NULL
6f436b4a64f154324ad6c4c883e99002	yes	Monkey King	marvel
8352cbbaad349838729c489c43f08c4f	yes	Spiderman	dc
86e11fbaa660bc1d94b686fd0206b55d	yes	Superman	all
a426816365182d50dc133ee0c6255b3d	yes	NULL	NULL
a754b629d48ad2c53049c6741e9d4645	no	NULL	NULL
bb7021e8ad7e35be6d75831a2f5c51cd	yes	Spiderman	all
bbe8c56090359bb4eb37e58b95b31316	yes	Spider Man	marvel



Technologies of surveydown



surveydown is feature-packed!



The screenshot shows the surveydown.org website. The navigation bar includes links for About, Documentation, Templates, Blog, FAQ, and search. The left sidebar lists various documentation sections, with 'Features & Roadmap' highlighted. The main content area is titled 'Features' and contains a table listing various features, their documentation links, versions, and discussion links. The right sidebar shows a 'On this page' section with links to 'surveydown package', 'Features', 'To Do', and 'sdstudio package'.

Feature	Docs	Version	Discussion
Wide variety of question types	Question Types	v0.0.1	105 , 109
Conditionally show questions	Conditional Display	v0.0.1	
Markdown formatting for options and buttons	Markdown Formatting	v0.0.1	
Require specific questions or all questions be answered	Required Questions	v0.0.2	
Support for bootstrap themes	Themes	v0.0.4	
Customizable scss theme file	Themes	v0.0.4	
Ability to Ignore the database connection	Supabase Ignore	v0.0.8	
Time stamps recorded for each question and page interaction		v0.0.9	
Progress bar that updates on each question interaction	Progress Bar	v0.0.9	
Customizable progress bar color and position on page	Progress Bar	v0.0.9	
Ability to use latest survey results in the survey itself	Fetching Data	v0.1.1	
Pass parameters through the url	Reactive	v0.2.2	92

On this page

- surveydown package
- [Features](#)
- To Do
- sdstudio package
- Features
- To Do

Site made with , , and  quarto



surveydown is highly flexible and customizable
to user needs



Randomization: Conjoint question

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

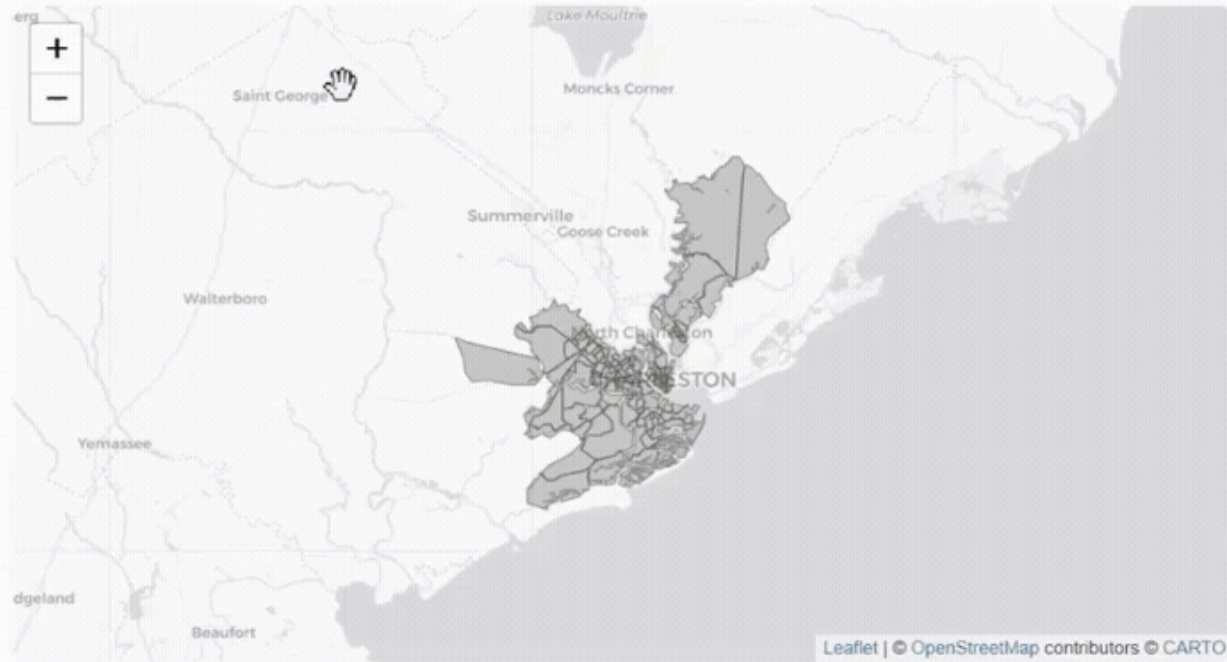
Option 1	Option 2	Option 3
		
Type: Fuji	Type: Pink Lady	Type: Honeycrisp
Price: \$ 2 / lb	Price: \$ 1.5 / lb	Price: \$ 2 / lb
Freshness: Average	Freshness: Excellent	Freshness: Poor



Shiny compatibility: leaflet map

Question 1: Social Vulnerability is how likely people are to face greater harm or impact on their lives after disruptive hazard events like flooding based on social or economic conditions like income or transportation access.

Please review the map of the City of Charleston, South Carolina, and select the areas you believe are more socially vulnerable to the impacts of hazardous events.



Next Question



surveydown vs other platforms

Platform	User Interface	Cost	Reproducible	Open Source	Data Control	Programmable
Google Forms	GUI	Free	☐	☐	☐	☐
REDCap	GUI	Free/Paid	☒	☐	☒	☒
Qualtrics	GUI	Paid	☒	☐	☐	☒
Sawtooth	GUI	Paid	☒	☐	☒	☒
CASIC Builder	GUI	Paid	☐	☐	☒	☐
SurveyCTO	GUI	Paid	☒	☐	☒	☒
QDS	GUI	Paid	☐	☐	☐	☐
LimeSurvey	GUI	Free/Paid	☒	☒	☐	☒
Open Data Kit	XLSForms	Free/Paid	☒	☒	☒	☒
oTree	GUI, Python	Free/Paid	☒	☒	☒	☒
SurveyJS	GUI, JavaScript	Free/Paid	☒	☒	☒	☒
formr	XLSForms, markdown, R	Free	☒	☒	☒	☒
shinysurveys	R, CSV	Free	☒	☒	☒	☐
surveydown	markdown (Quarto), R	Free	☒	☒	☒	☒
Legend: ☒ = Yes, ☒ = Partially, ☐ = No						



surveydown works with AI agents



Create Survey



Connect Database



Deploy Online

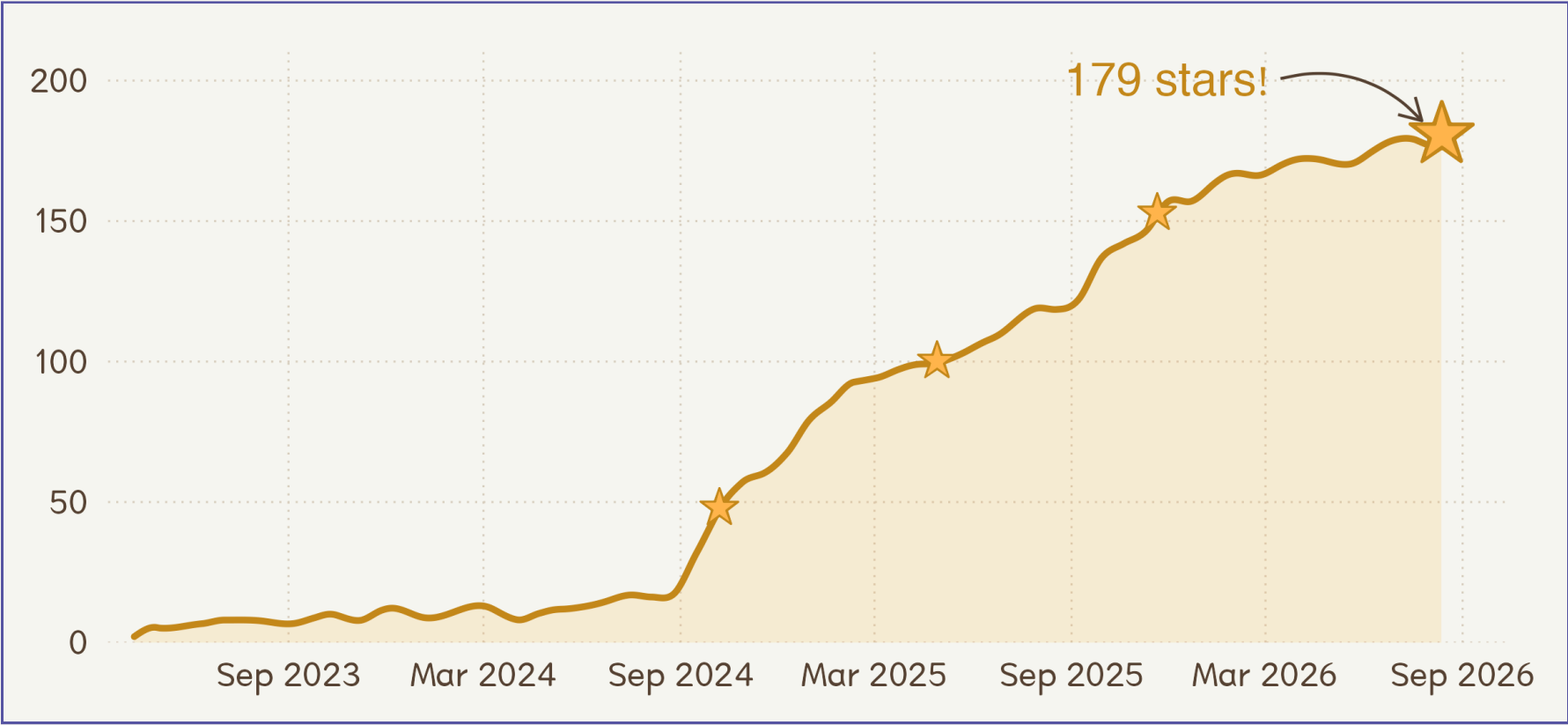


Record Video

`/surveydown-skill`



Star Count on GitHub



 [surveydown-dev/surveydown](#) ↗



The companion **sdstudio** package

The screenshot displays the **surveydown Studio** application window. The top navigation bar includes tabs for **Build**, **Preview**, and **Responses**. The main interface is divided into two primary panels: **Structure** on the left and **Code** on the right.

Structure Panel: This panel shows a hierarchical view of the survey structure. It includes three main sections: **Page: welcome**, **Page: hero_details**, and **Page: powers**. Each section contains a list of survey elements with their types and labels. For example, under **Page: welcome**, there is a text element **# Welcome to the...**, a multiple choice question **has_fav_hero** with the label *Do you have a favorite super hero?*, and another multiple choice question **fav_hero_name** with the label *Who is your favorite super hero?*. The **Page: hero_details** section includes a text element **# Tell us about your...**, a multiple choice question **hero_universe** with the label *Which superhero universe do you prefer?*, and a multiple choice question **hero_qualities** with the label *What qualities do you find most appealing in superheroes? (Select all that apply)*. The **Page: powers** section starts with a text element **# If you could have...**.

Code Panel: This panel shows the R code for the survey. The code is organized into sections for **survey.qmd** and **app.R**. The **survey.qmd** section includes a header with format settings (html, echo: false, warning: false, theme: [superhero, custom.scss], barcolor: "#e74c3c") and a title **# Welcome to the Ultimate Superhero Survey!**. The **app.R** section contains the **sd_question** function, which defines the **has_fav_hero** question with a multiple choice type and labels for "Yes" and "No".

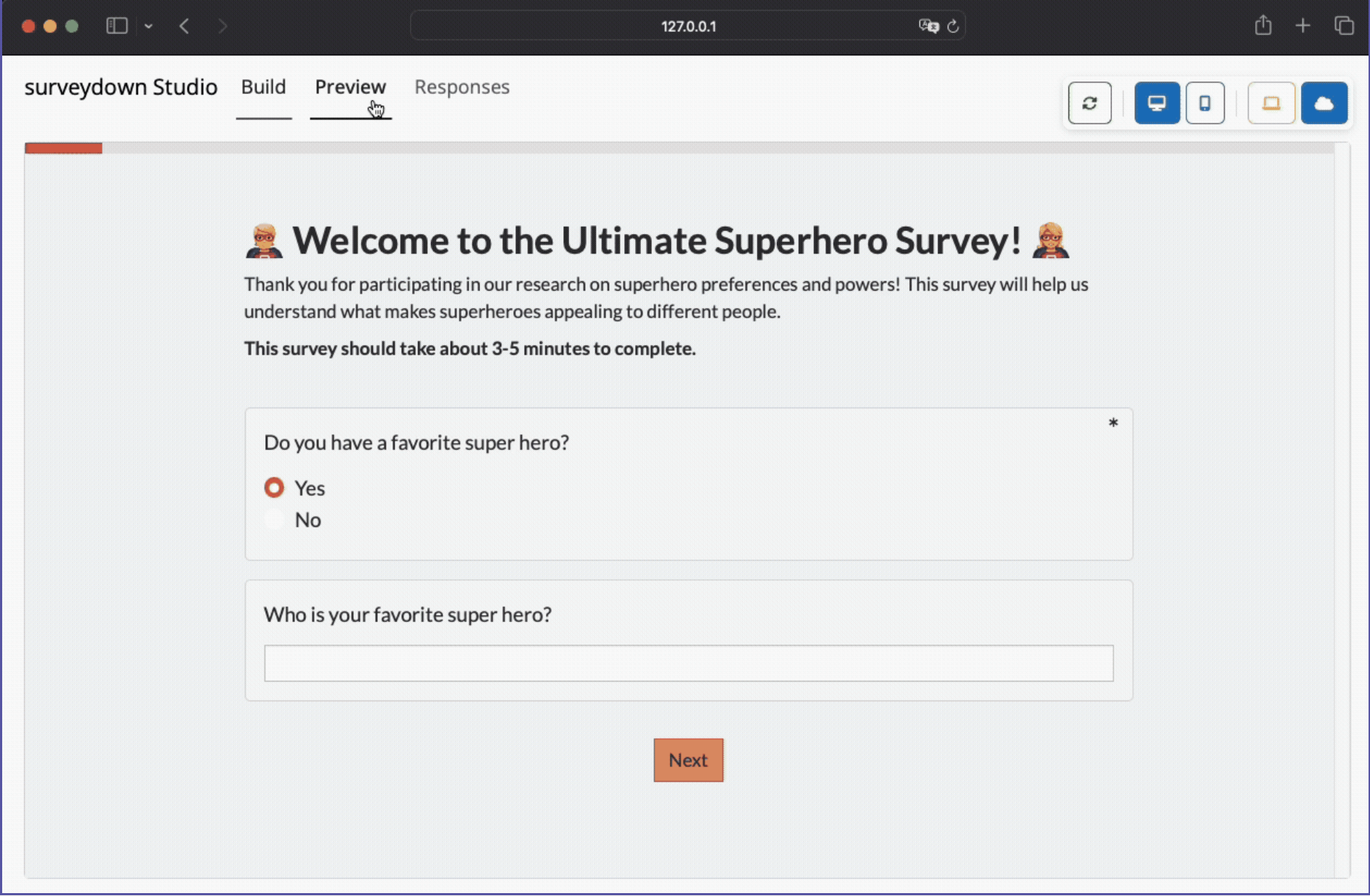
```

1 ---
2 format: html
3 echo: false
4 warning: false
5 theme: [superhero, custom.scss]
6 barcolor: "#e74c3c"
7 ---
8
9 ```{r}
10 library(surveydown)
11 ```
12
13 ::: {.sd_page id=welcome}
14
15 # 🦸 Welcome to the Ultimate Superhero Survey! 🦹♀️
16
17 Thank you for participating in our research on superhero preferences and
18 powers! This survey will help us understand what makes superheroes
19 appealing to different people.
20
21 **This survey should take about 3-5 minutes to complete.**
22
23 <br>
24 ```{r}
25 sd_question(
26   type = "mc",
27   id   = "has_fav_hero",
28   label = "Do you have a favorite super hero?",
29   option = c("Yes" = "yes", "No" = "no")
30 )

```



The companion `sdstudio` package



The screenshot shows the 'surveydown Studio' application window. The title bar includes standard macOS window controls and a version number '127.0.0.1'. The interface has a top navigation bar with tabs for 'Build', 'Preview' (which is active), and 'Responses'. To the right of the tabs are icons for refresh, desktop, mobile, tablet, and cloud. The main content area displays a survey titled 'Welcome to the Ultimate Superhero Survey!' with a progress indicator at the top left. The survey text includes a thank you message and an estimated completion time of 3-5 minutes. The first question is a radio button question: 'Do you have a favorite super hero?' with 'Yes' selected. The second question is a text input: 'Who is your favorite super hero?'. A 'Next' button is located at the bottom center of the survey area.

surveydown Studio Build Preview Responses

Welcome to the Ultimate Superhero Survey!

Thank you for participating in our research on superhero preferences and powers! This survey will help us understand what makes superheroes appealing to different people.

This survey should take about 3-5 minutes to complete.

Do you have a favorite super hero? *

☒ Yes
☐ No

Who is your favorite super hero?

Next



Research Contributions

- **Study 1:** First *large N* **survey study** of BEV owner *preference sensitivities* to smart charging.
- **Study 2:** Quantifies **peak-shaving** potential and **cost efficiency** of SMC by integrating empirical enrollment with grid simulation.
- **Study 3:** **surveydown**, a free open-source survey platform for programmable, reproducible survey designs.



Workshops & Teaching Experience

	Topic	Venue & Time
Workshops	Agentic Workflows with Claude Code	GWTAI, 2026
	surveydown: Open-source survey platform	Quant UX Con, 2025
Teaching Assistant	EMSE 4572/6572: Exploratory Data Analysis	GWU, Fall 2025
	EMSE 4571: Programming for Analytics	GWU, Spring 2025

Mentored students through substantial **R programming** and **data analysis** projects.



Thanks for listening!



Pingfan Hu

PhD Candidate, Systems Engineering

pingfan.org



About



Blog



Research



Works



Appendix - Study 1

Smart Charging Adoption



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
Override Allowance	5
Min Guaranteed  080160200 miles	
(Range determined by stated vehicle they own)	



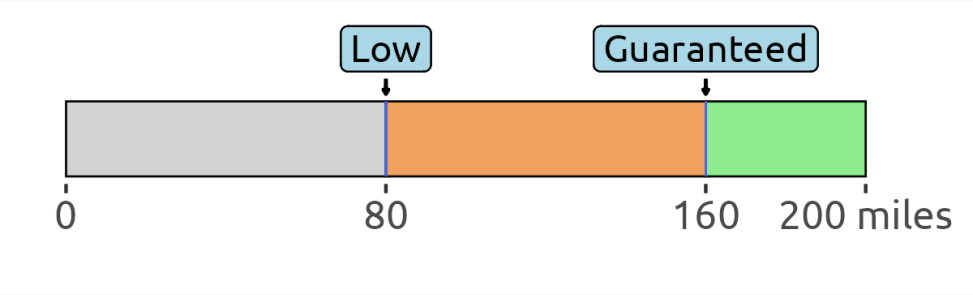
V2G Programs

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



(Range determined by stated vehicle they own)



Survey Question - Car Ownership

Car Ownership

1. What is your ZIP code?

22180

2. How many cars do you have?

☐ 1

☒ 2

☐ 3

☐ 4

☐ 5 or more

3. What is the **make** of your primary car?

3.1 What is the **model** of your primary car?

4. What is the **model year** of your primary car?

5. What is the **make** of your secondary car?

5.1 What is the **model** of your secondary car?

6. What is the **model year** of your secondary car?

Next Page

Other

✓ Acura

Alfa Romeo

Aston Martin

Audi

Bentley

BMW

Bugatti

Buick

Cadillac

Chevrolet

Chrysler

Daewoo

Dodge

Ferrari

FIAT

Fisker

Ford

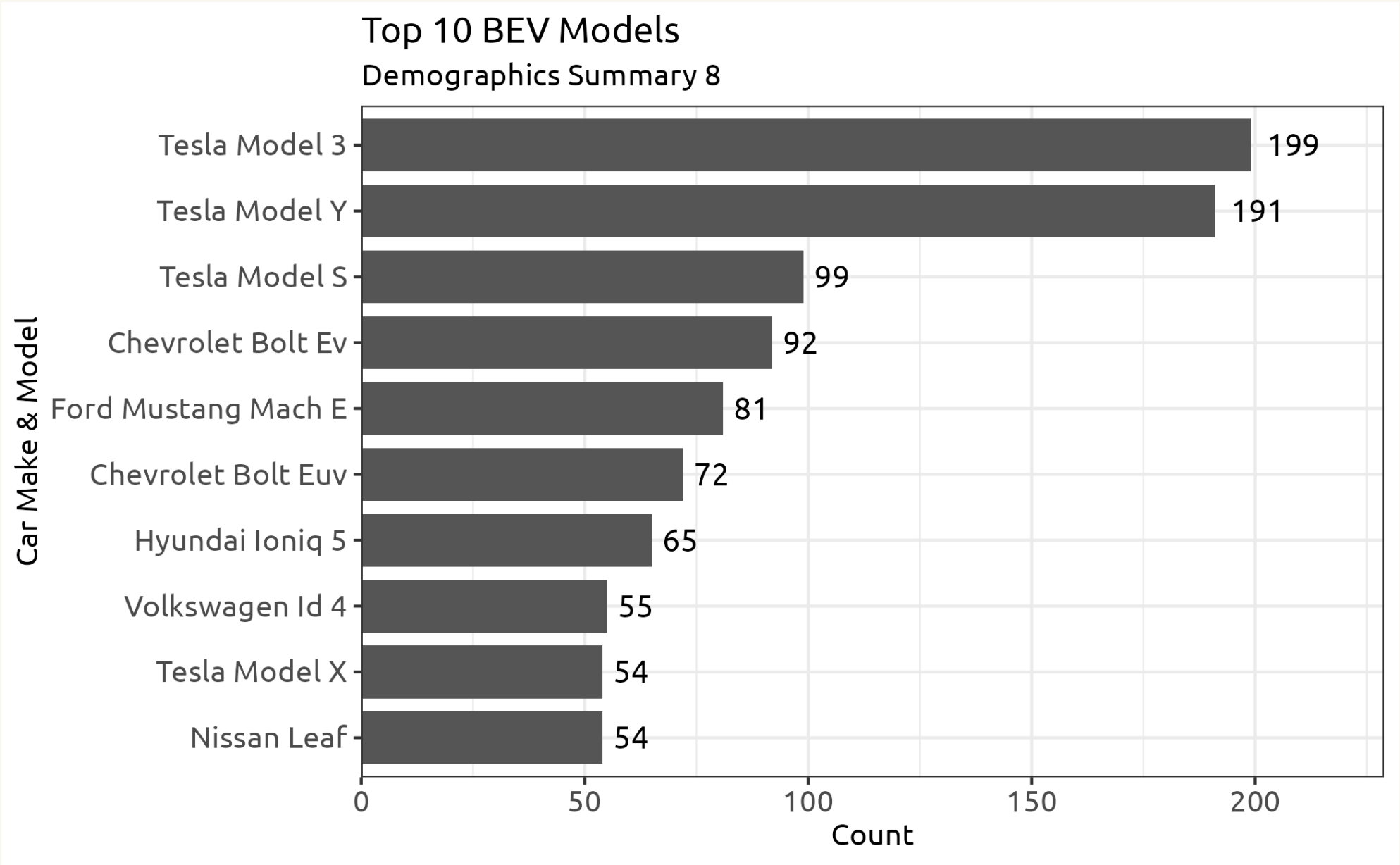
Genesis

GMC

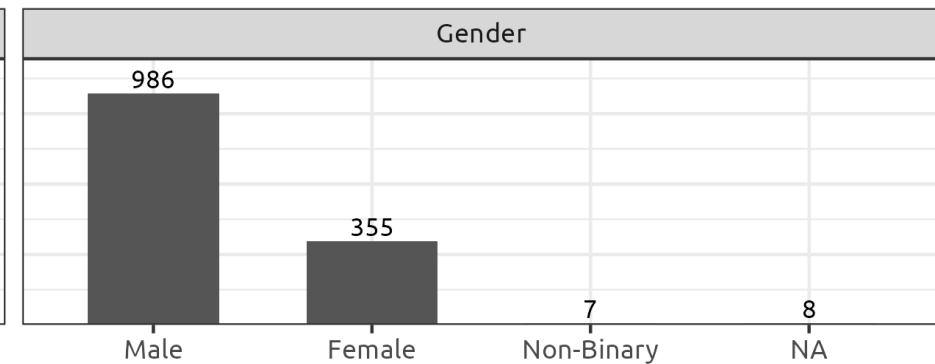
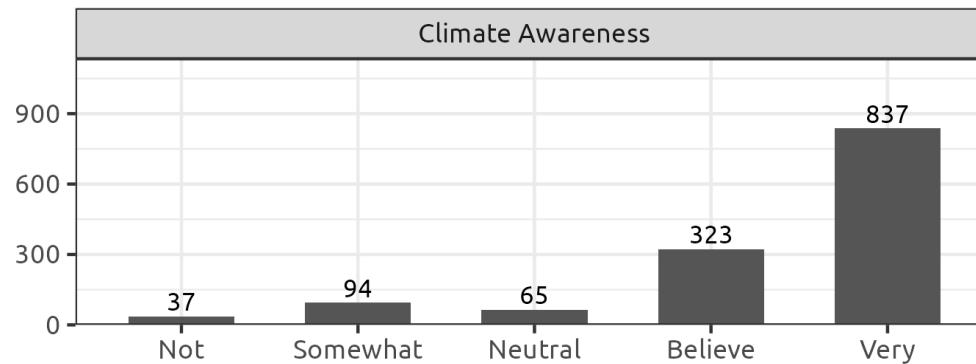
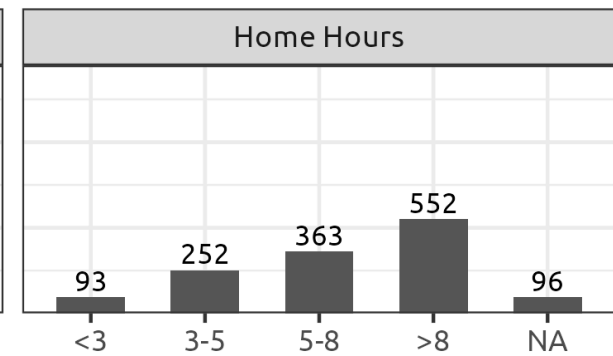
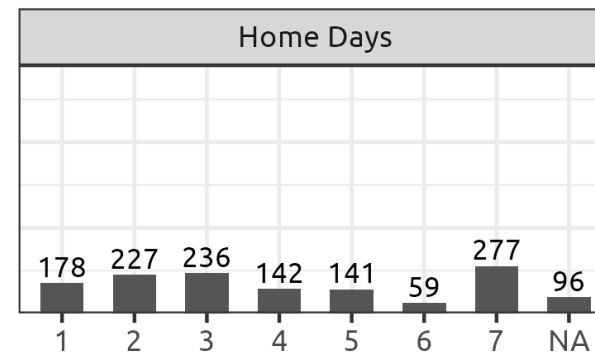
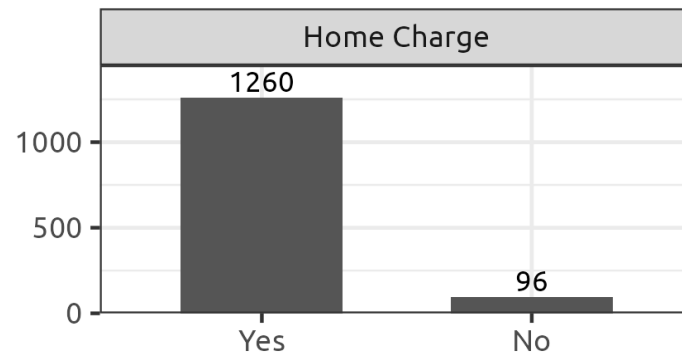
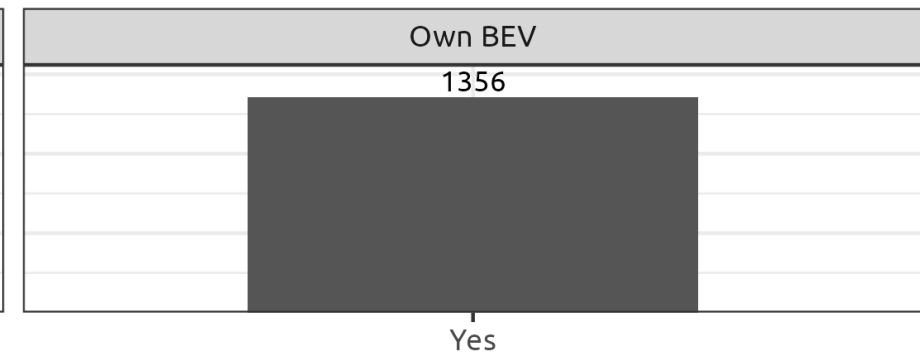
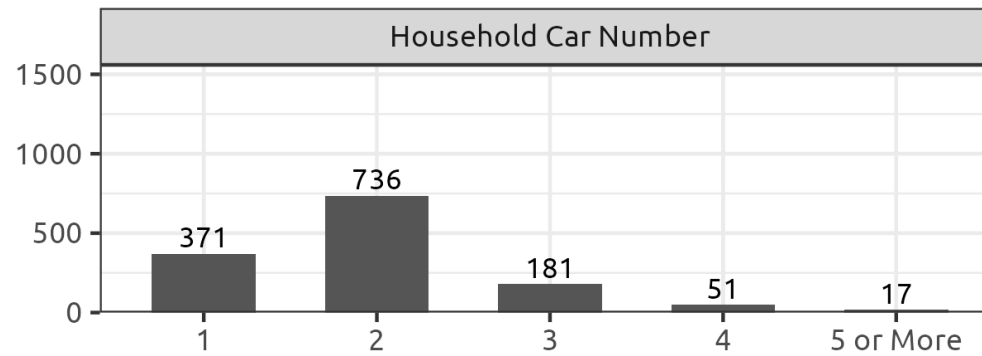
Honda



Survey Results - Top 10 BEV

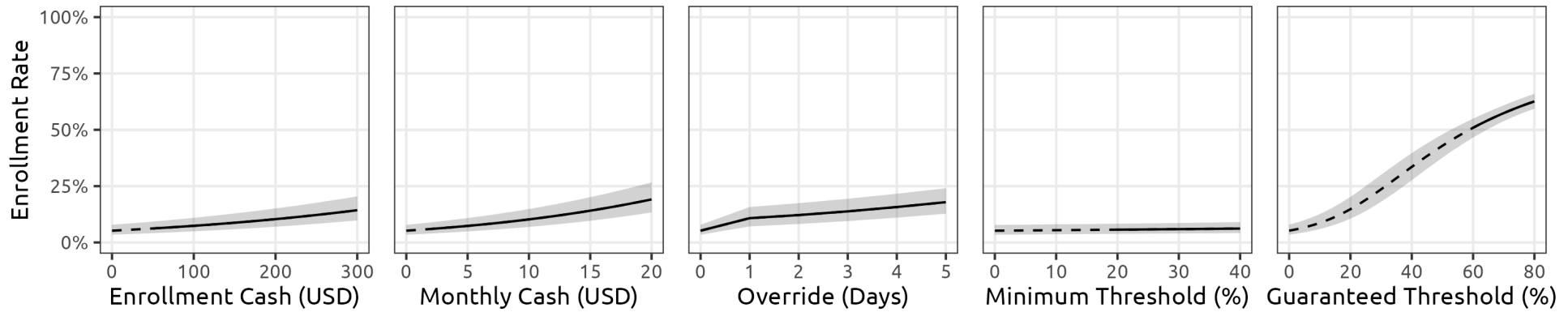


Survey Results - Demographics

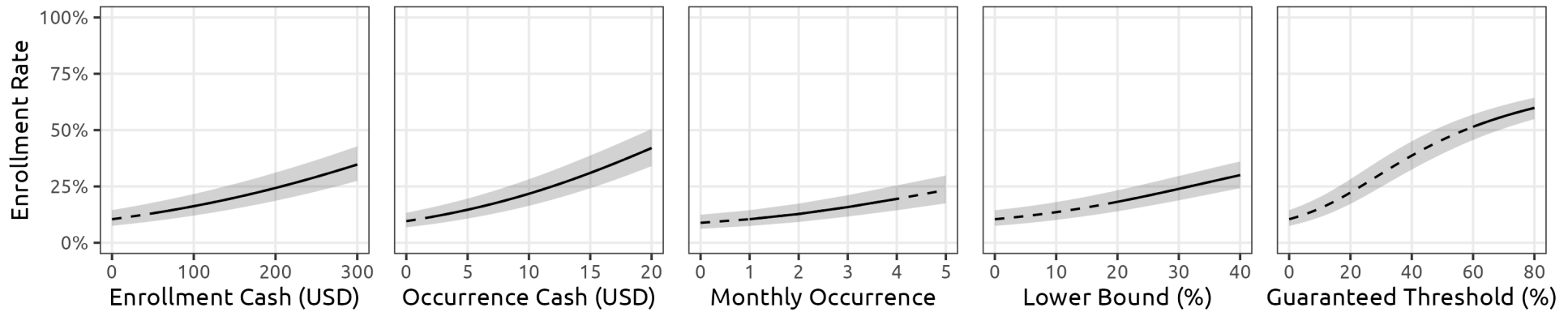


Enrollment Sensitivity

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	77.7	\$
Monthly Cash	4.0	\$
Override Days	2.5	Days
Minimum Threshold	65.5	%
Guaranteed Threshold	6.3	%

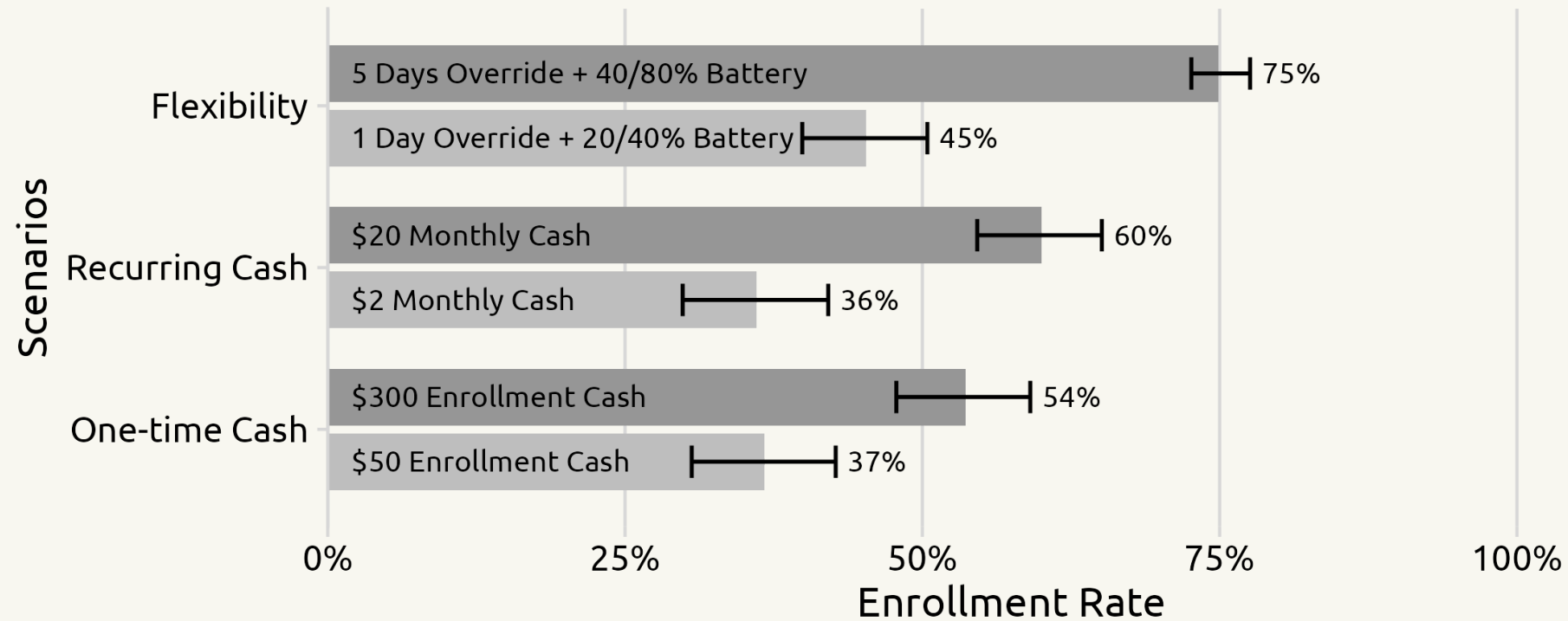
V2G

Attribute	Equivalence Value	Unit
Enrollment Cash	55.7	\$
Occurrence Cash	2.9	\$
Monthly Occurrence	1.9	Times
Lower Bound	11.7	%
Guaranteed Threshold	9.1	%

1. **Smaller** value indicates higher efficiency.
2. **Monetary** incentives are valued more in V2G than SMC.
3. **Guaranteed** thresholds are highly efficient, indicating range anxiety.
4. Attribute equivalencies can be used to inform incentive design.



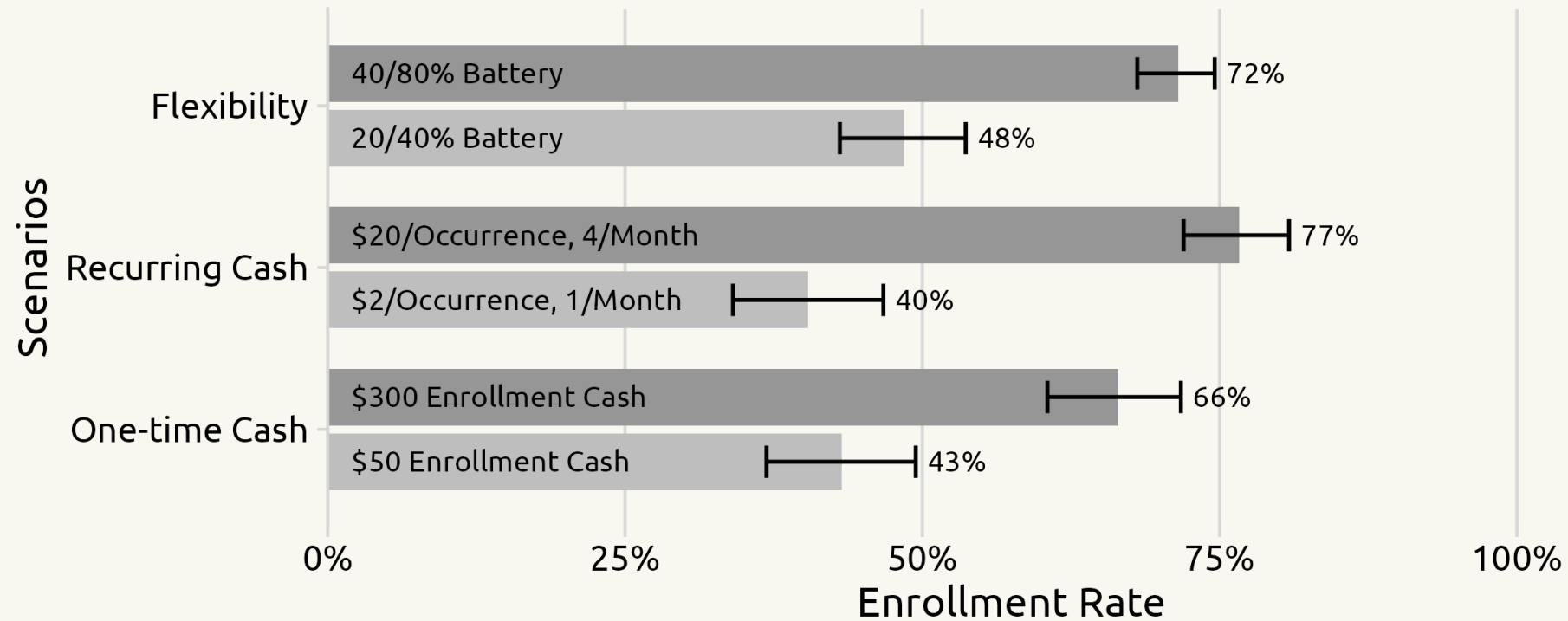
SMC Scenario Analysis



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



V2G Scenario Analysis



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



SMC Logit Model

$$u_j = \beta_1 x_j^{\text{enroll_cash}} + \beta_2 x_j^{\text{monthly_cash}} + \beta_3 \delta_j^{\text{override_allowed}} + \beta_4 x_j^{\text{num_overrides}} \\ + \beta_5 x_j^{\text{min_threshold}} + \beta_6 x_j^{\text{guaranteed_threshold}} + \beta_7 \delta_j^{\text{no_choice}} + \epsilon_j$$

Attribute	Coef.	Est.	SE	Level	Unit
Enrollment Cash	β_1	0.0037	0.0002	50, 100, 200, 300	USD
Monthly Cash	β_2	0.0728	0.0031	2, 5, 10, 15, 20	USD
Override Days	β_3	0.1191	0.0140	0, 1, 3, 5	Days
Override Flag	β_4	0.4357	0.0654	Yes, No	-
Minimum Threshold	β_5	0.0044	0.0023	20, 30, 40	%
Guaranteed Threshold	β_6	0.0490	0.0028	60, 70, 80	%
No Choice	β_7	2.8984	0.2215	-	-



V2G Logit Model

$$u_j = \beta_1 x_j^{\text{enroll_cash}} + \beta_2 x_j^{\text{occur_cash}} + \beta_3 x_j^{\text{num_occurrences}} + \beta_4 x_j^{\text{lower_threshold}} + \beta_5 x_j^{\text{guaranteed_threshold}} + \beta_6 \delta_j^{\text{no_choice}} + \epsilon_j$$

Attribute	Coef.	Est.	SE	Level	Unit
Enrollment Cash	β_1	0.0051	0.0003	50, 100, 200, 300	USD
Occurrence Cash	β_2	0.0972	0.0045	2, 5, 10, 15, 20	USD
Monthly Occurrence	β_3	0.1595	0.0262	1, 2, 3, 4	Times
Lower Threshold	β_4	0.0263	0.0036	20, 30, 40	%
Guaranteed Threshold	β_5	0.0368	0.0037	60, 70, 80	%
No Choice	β_6	2.4283	0.1964	-	-



Appendix - Study 2

Grid Peak-Shaving Quantification



Simulation Assumptions

Vehicle & Charging

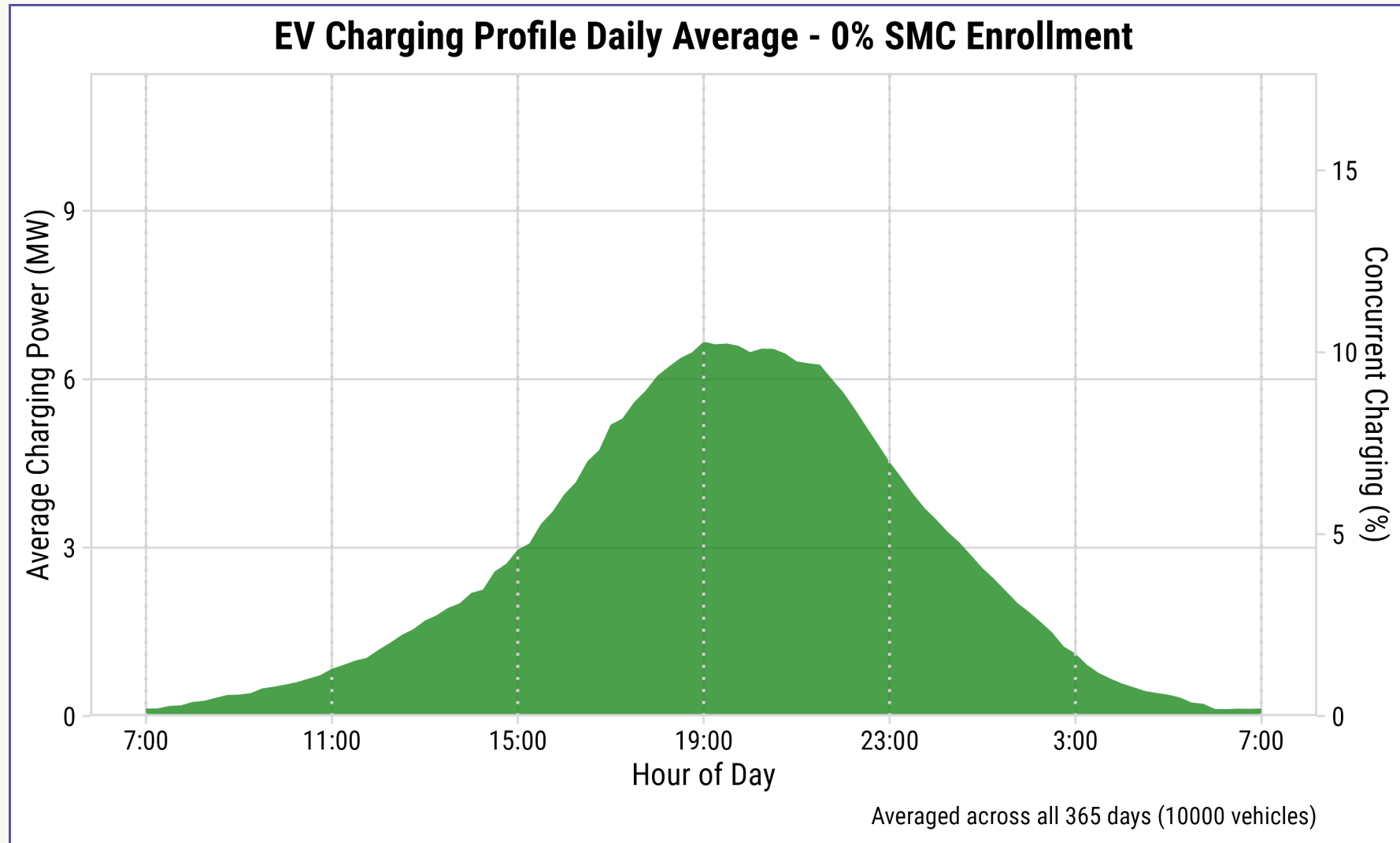
BEV range	200 miles
Charging	Level 2 (6.48 kW)
Battery SOC	20% – 80%
Travel needs	Guaranteed
Overrides	2 – 3 per month

Program & Scenarios

BEV : Household	1 : 1
Enrollment	0% – 100%
Valley start	8 PM – 12 AM
Best valley	11 PM
Time spans	Year / day / season



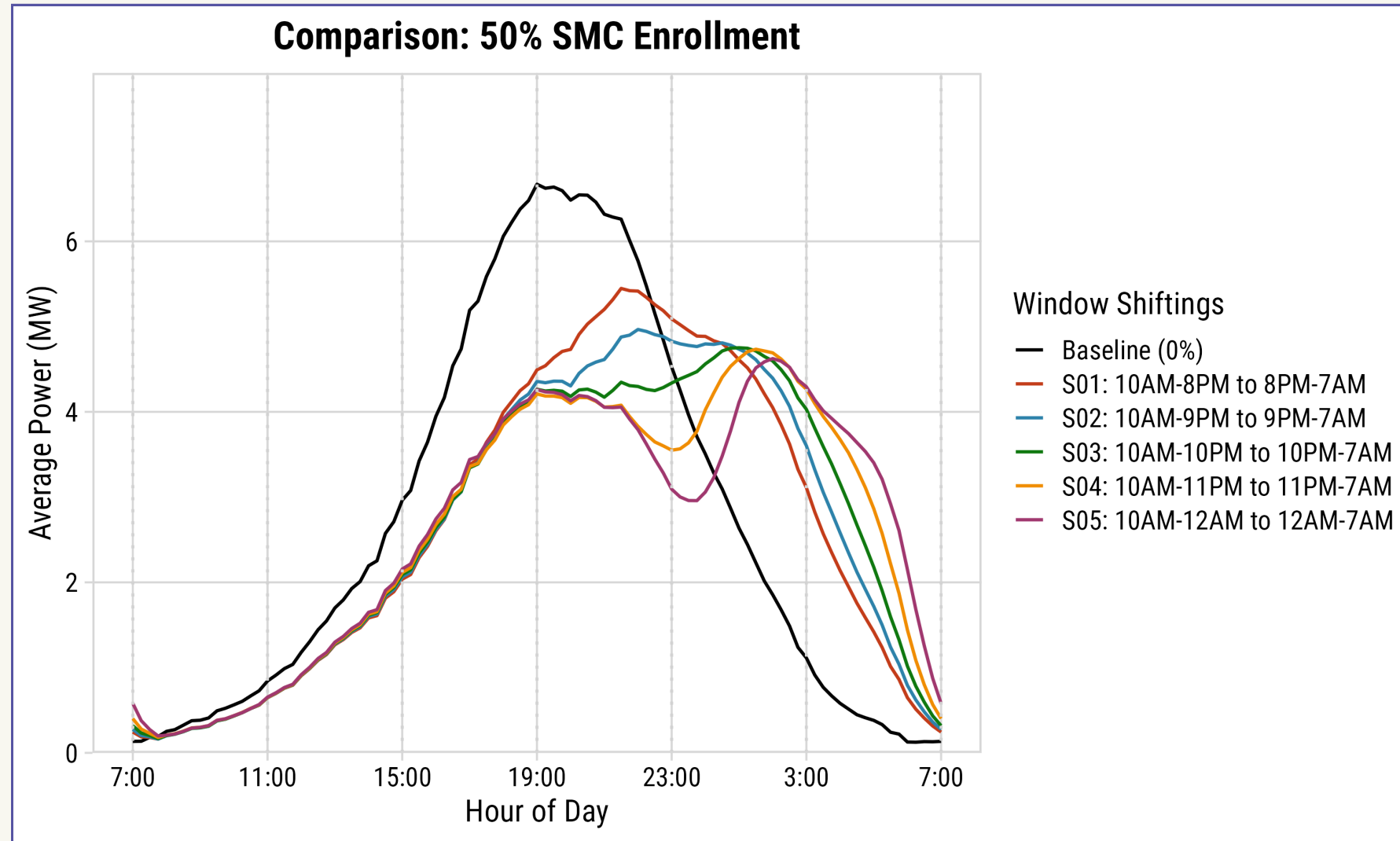
Step 1: BEV Charging Load Profile



Simulation results based on ~26,000 survey responses from 2022 NHTS.



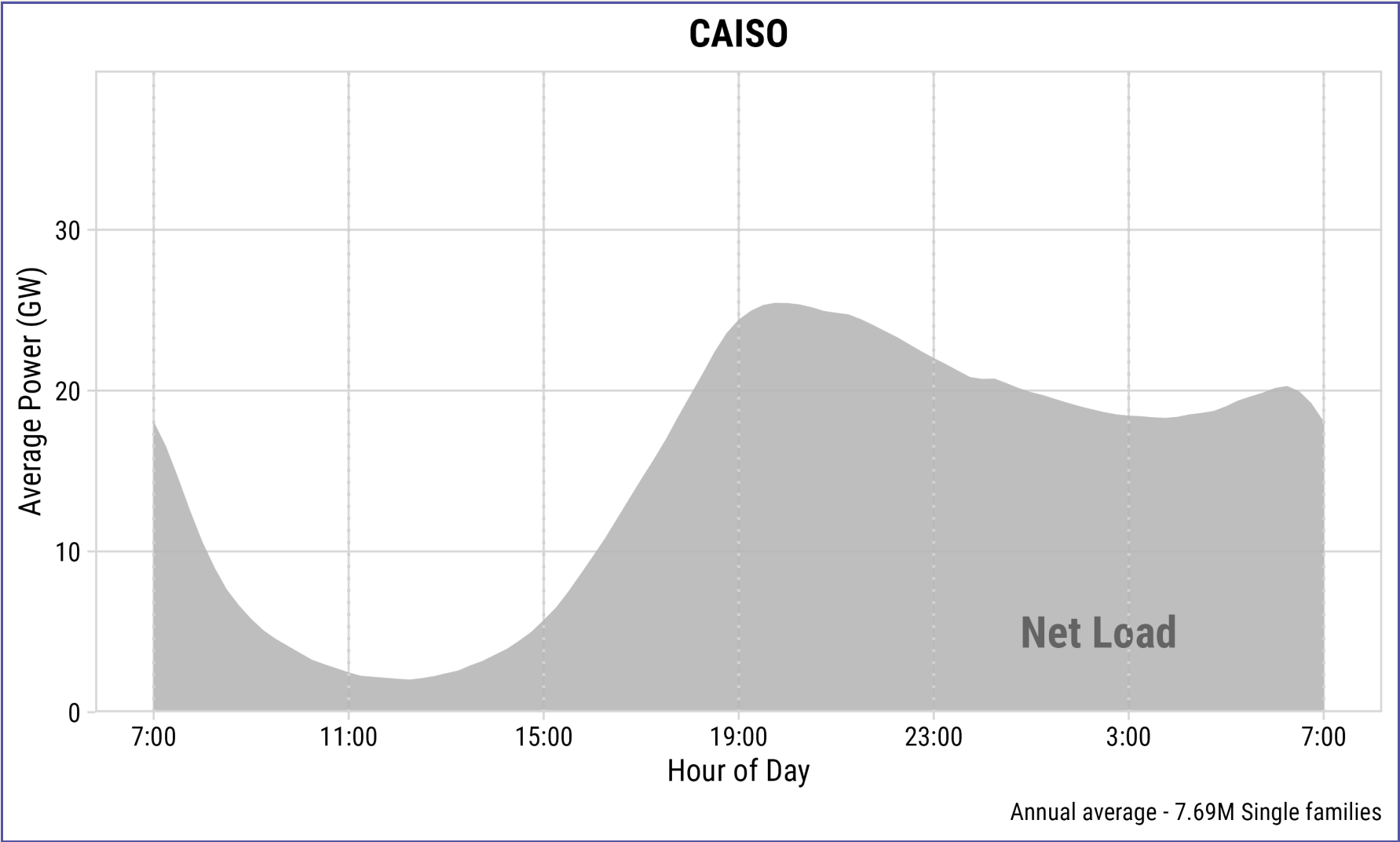
Step 2: BEV Load Peak Shaving



Five configurations with different peak/valley windows.



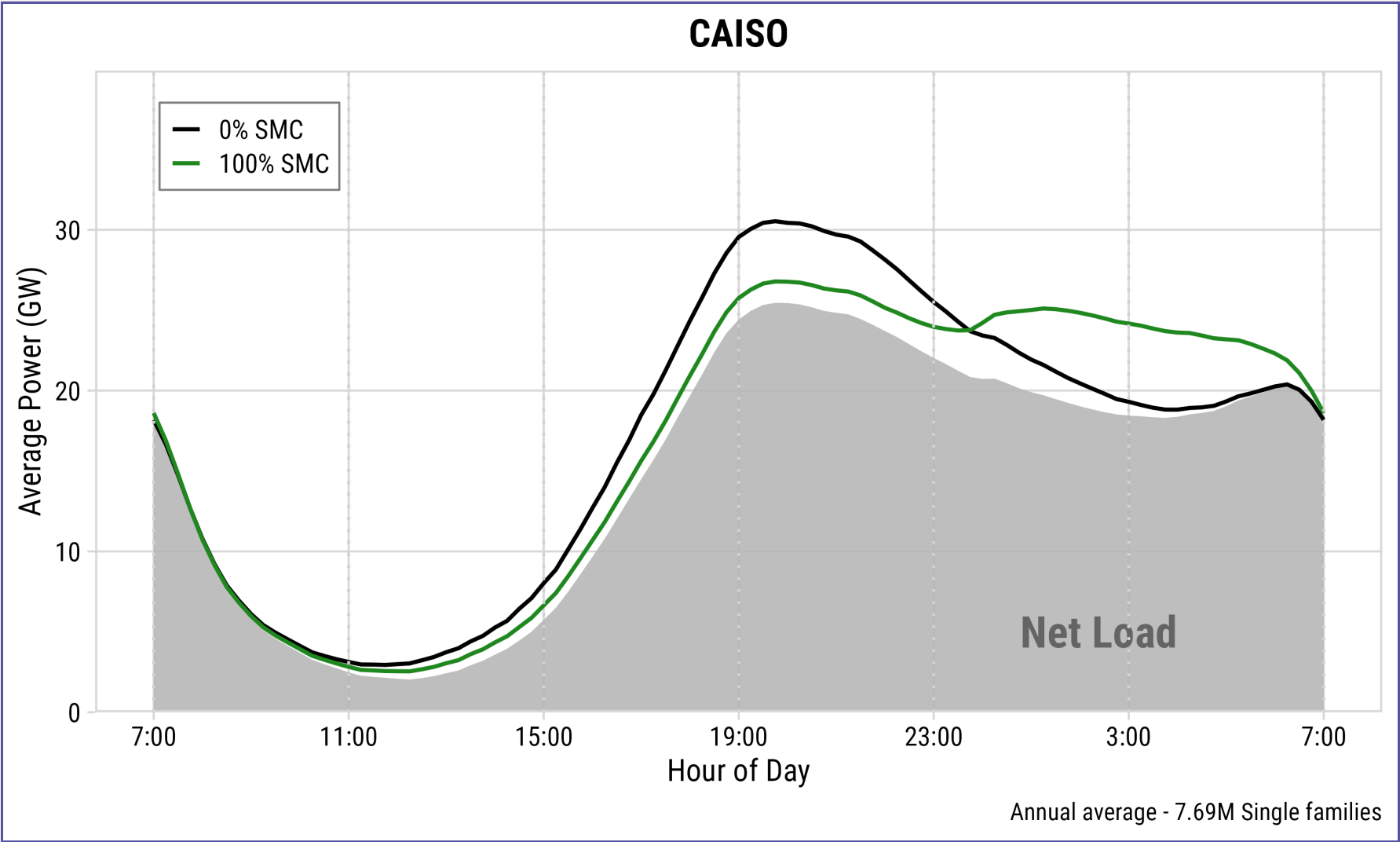
Step 3: Grid Net Load Profile



$$\text{Net Load} = \text{Grid Supply} - \text{Variable Sources}$$



Step 4: Net Load + BEV & Peak Shaving

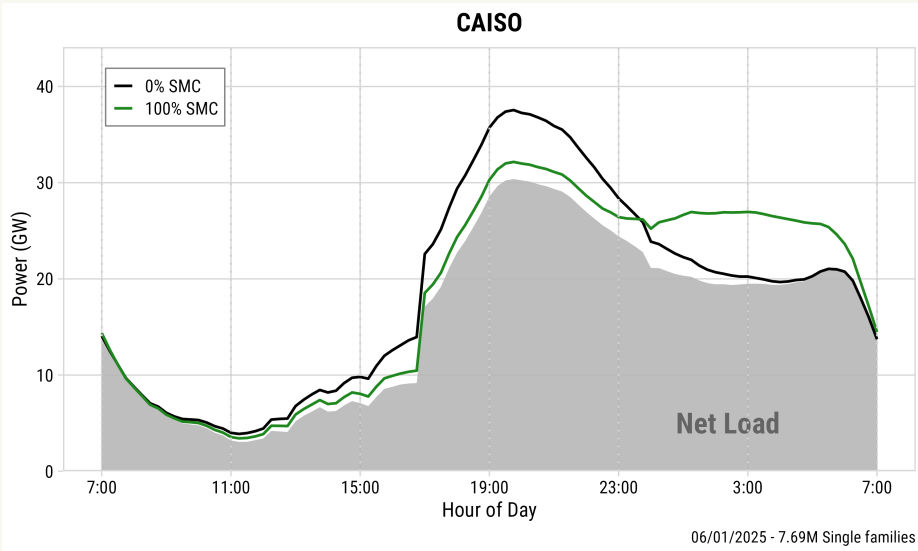


BEV load scaled to fleet size and stacked on net load.



Peak Shaving: CAISO Extreme Days

Best Day (Jun 1)



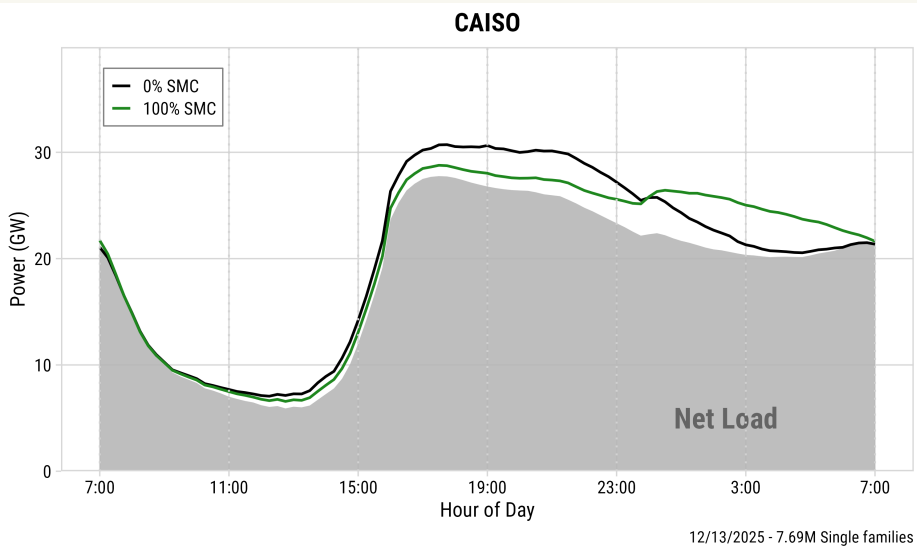
Peak shave

5.4 GW (37.6 → 32.2)

Percentage

14.4%

Worst Day (Dec 13)



Peak shave

1.9 GW (30.7 → 28.8)

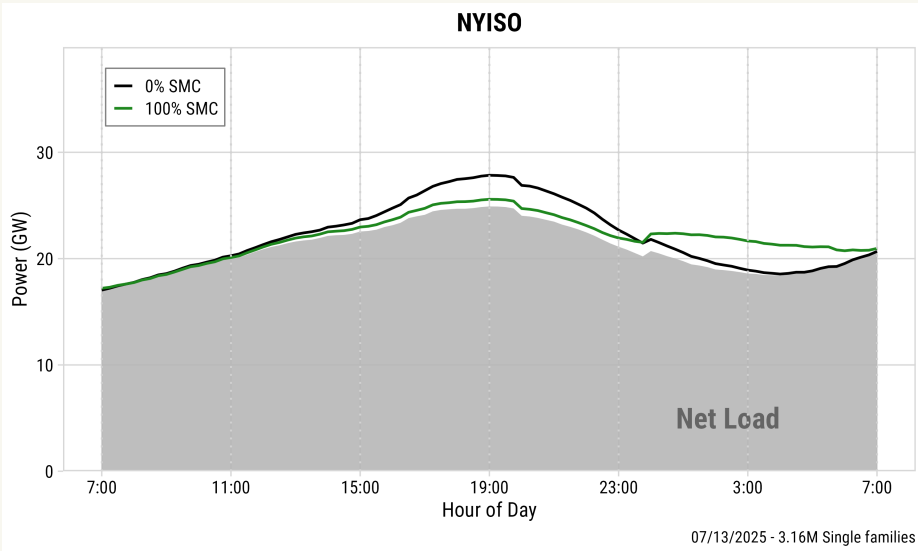
Percentage

6.2%



Peak Shaving: NYISO Extreme Days

Best Day (Jul 13)



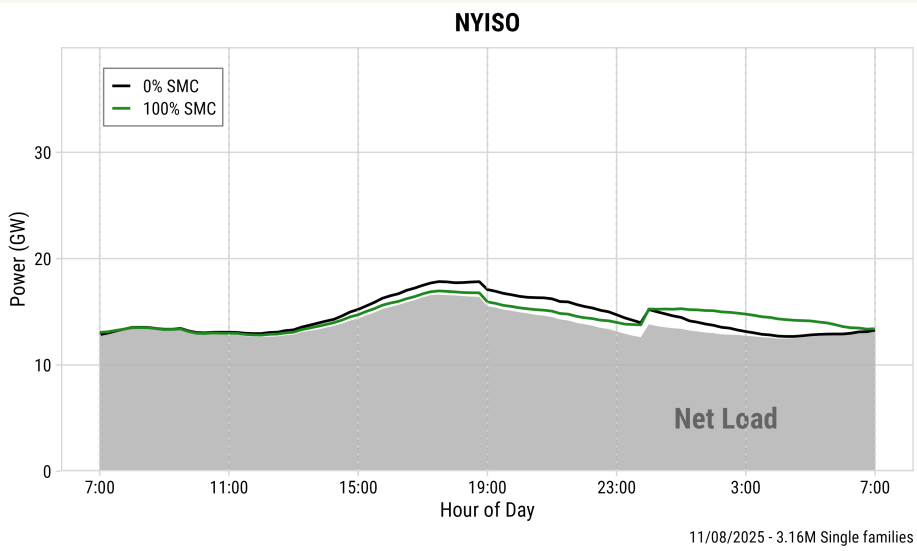
Peak shave

2.2 GW (27.8 → 25.6)

Percentage

7.9%

Worst Day (Nov 8)



Peak shave

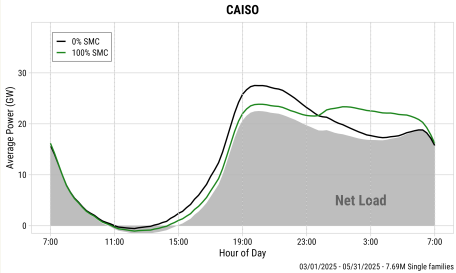
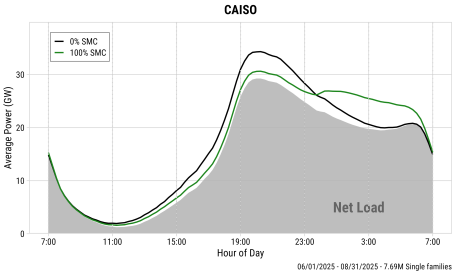
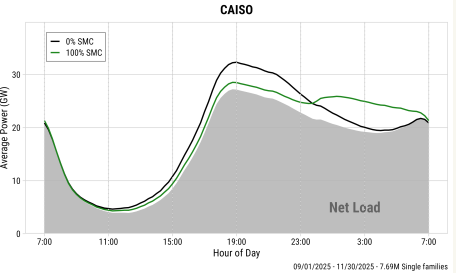
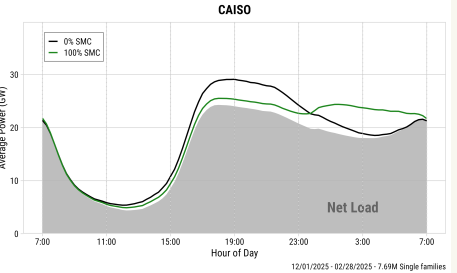
0.8 GW (17.8 → 17.0)

Percentage

4.5%

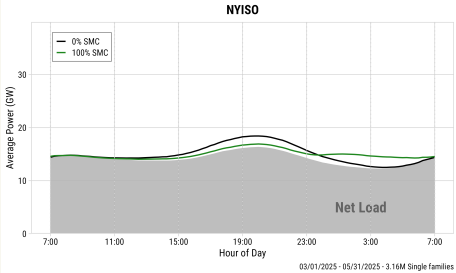
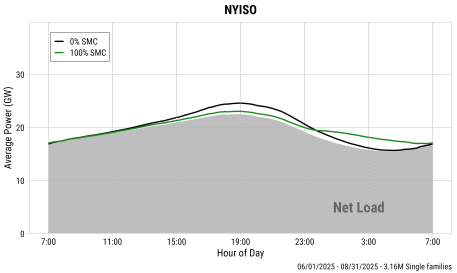
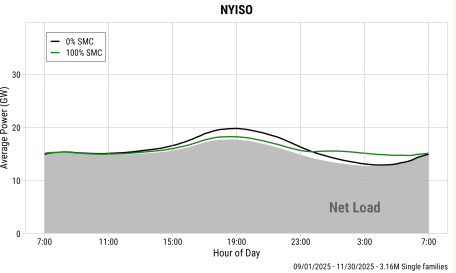
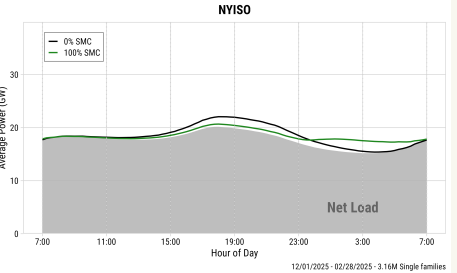


Seasonal Patterns: CAISO

Spring	Summer	Fall	Winter
			
3.7 GW (27.5 → 23.8)	3.7 GW (34.3 → 30.6)	3.8 GW (32.3 → 28.5)	3.6 GW (29.1 → 25.5)
13.5%	10.8%	11.8%	12.4%
Peak shave for all seasons: 3.6–3.8 GW (10.8–13.5%)			

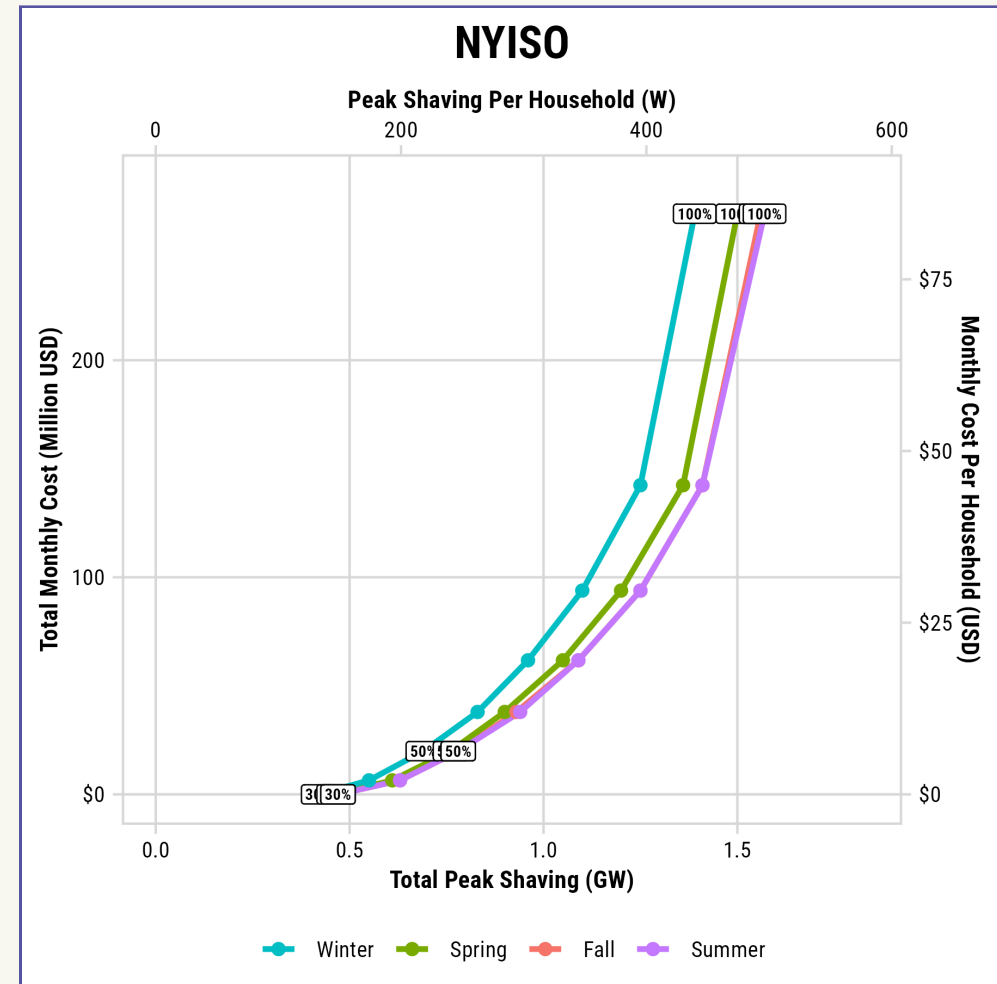
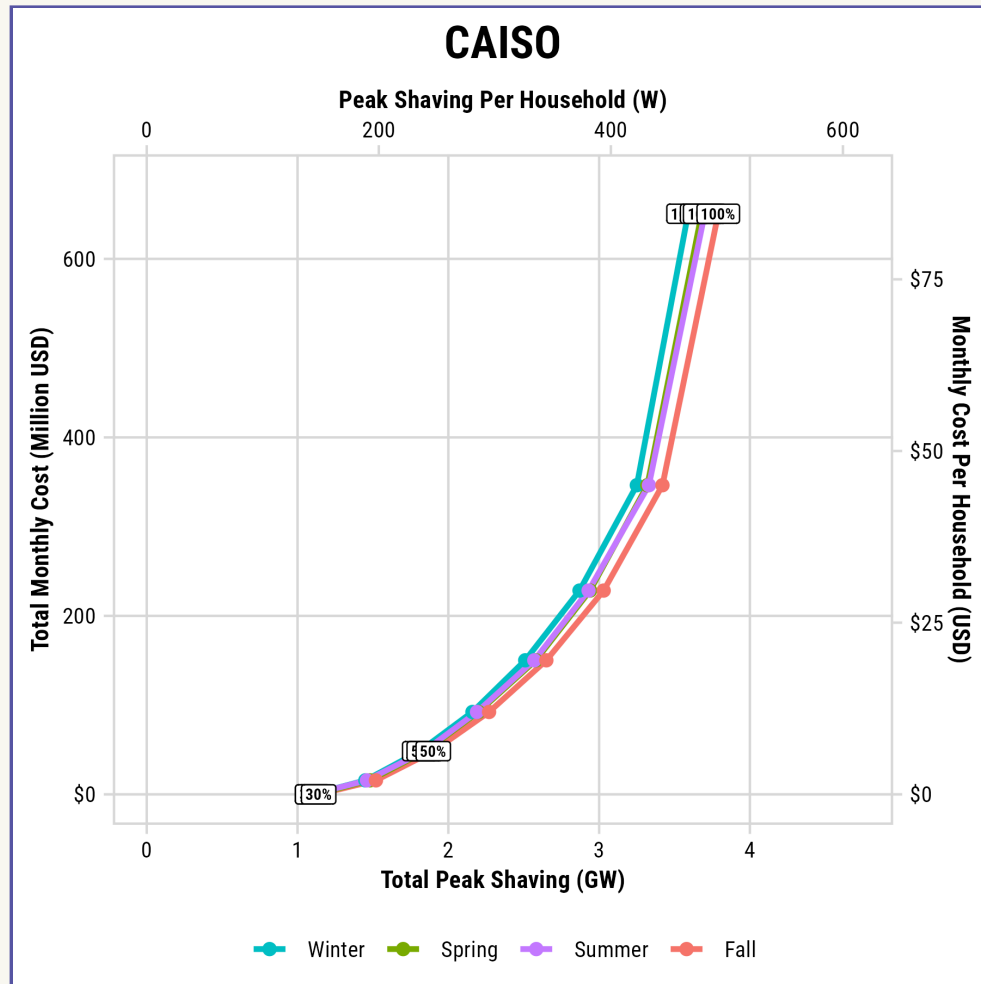


Seasonal Patterns: NYISO

Spring	Summer	Fall	Winter
			
1.5 GW (18.4 → 16.9)	1.6 GW (24.6 → 23.0)	1.5 GW (19.8 → 18.3)	1.4 GW (22.1 → 20.7)
8.2%	6.5%	7.6%	6.3%
Peak shave for all seasons: 1.4–1.6 GW (6.3–8.2%)			



Seasonal cost efficiency is consistent in CAISO, but varies in NYISO.



How Do Pilot Programs Compare?

Program	Incentive	Enrollment
PCE Managed Charging (CAISO)	\$0 → \$40 per month	1.4% → 10.6%
MCE Sync (CAISO)	\$50 bonus + \$10 per month	10% of serviceable market
SmartCharge New York (NYISO)	Up to \$400 per year	~7% of registered EVs (731 vehicles)

- Smart charging programs motivated EV owners to **charge off-peak**.
- More incentive results in more enrollment.
- Stated preference surveys are not calibrated against current pilot programs.



Appendix - Study 3

The **surveydown** Survey Platform



surveydown Feature Highlights

Question types

Conditional logic



12 Built-in Question Types

text

textarea

numeric

mc

mc_multiple

mc_buttons

mc_multiple_buttons

select

slider

slider_numeric

date

daterange



Question Type: text

```
1 sd_question(  
2   type = "text",  
3   id   = "fav_hero_name",  
4   label = "Who is your favorite super hero?"  
5 )
```



Who is your favorite super hero?



Question Type: mc_buttons

```

1 sd_question(
2   type = "mc_buttons",
3   id   = "dream_power",
4   label = "If you could have ONE superpower, which would
5   option = c(
6     "🕸 Web-slinging" = "webslinging",
7     "🦾 Super Strength" = "strength",
8     "✈ Flight" = "flight",
9     "🧠 Telepathy" = "telepathy",
10    "⚡ Super Speed" = "speed"
11  ),
12  direction = "vertical"
13 )

```



If you could have ONE superpower?

 Web-slinging Swing through cities
 Super Strength Lift anything
 Flight Soar through the skies
 Telepathy Read minds
 Super Speed Faster than lightning



Conditional logic

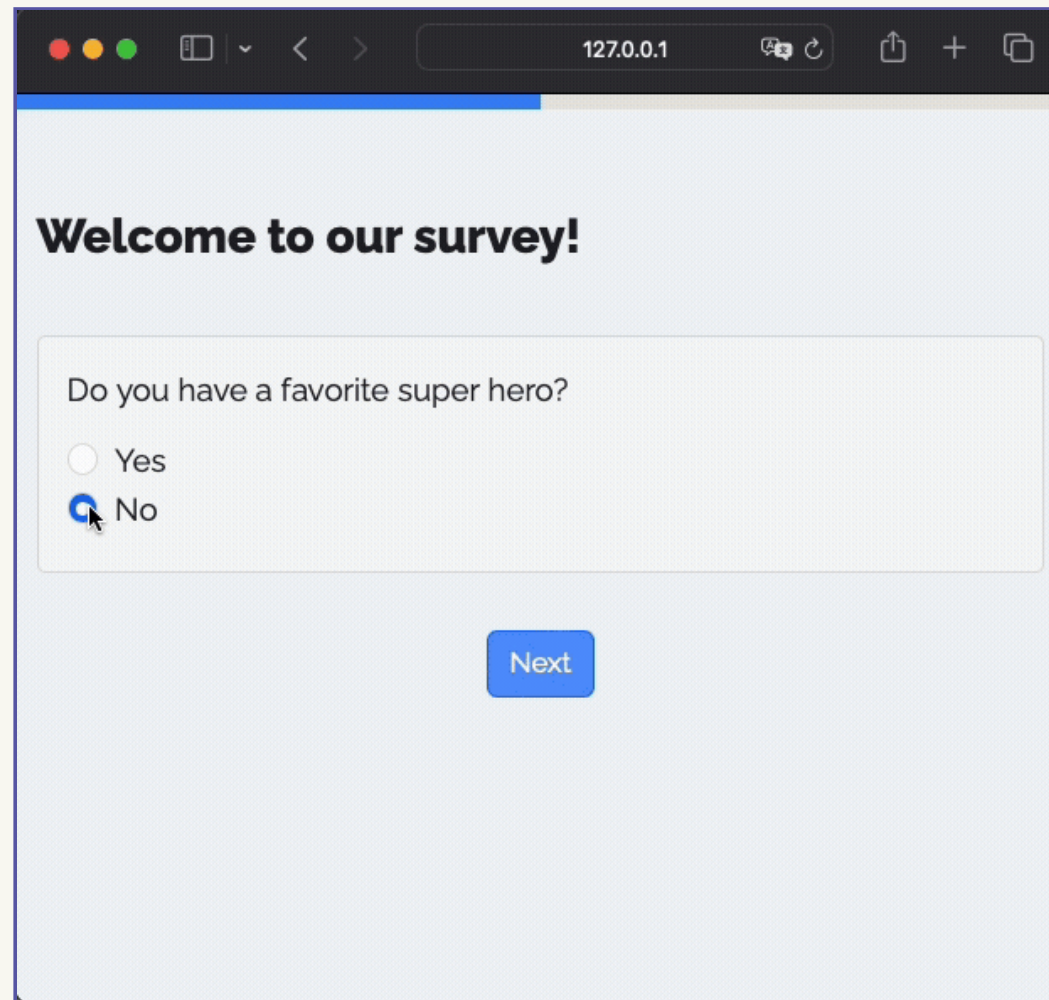
Conditional showing

Conditional skipping

Conditional stopping



Conditional showing - `sd_show_if()`



A screenshot of a web browser window displaying a survey. The browser's address bar shows the URL `127.0.0.1`. The survey content is as follows:

Welcome to our survey!

Do you have a favorite super hero?

☐ Yes

☒ No

Next



Conditional showing - `sd_show_if()`

survey.qmd

```
1 # Conditional Question
2 sd_question(
3   type = "mc",
4   id   = "has_fav_hero",
5   label = "Do you have a favorite hero?",
6   option = c("Yes" = "yes", "No" = "no")
7 )
8
9 # Target Question
10 sd_question(
11   type = "text",
12   id   = "fav_hero",
13   label = "Who is your favorite super hero?"
14 )
```

app.R

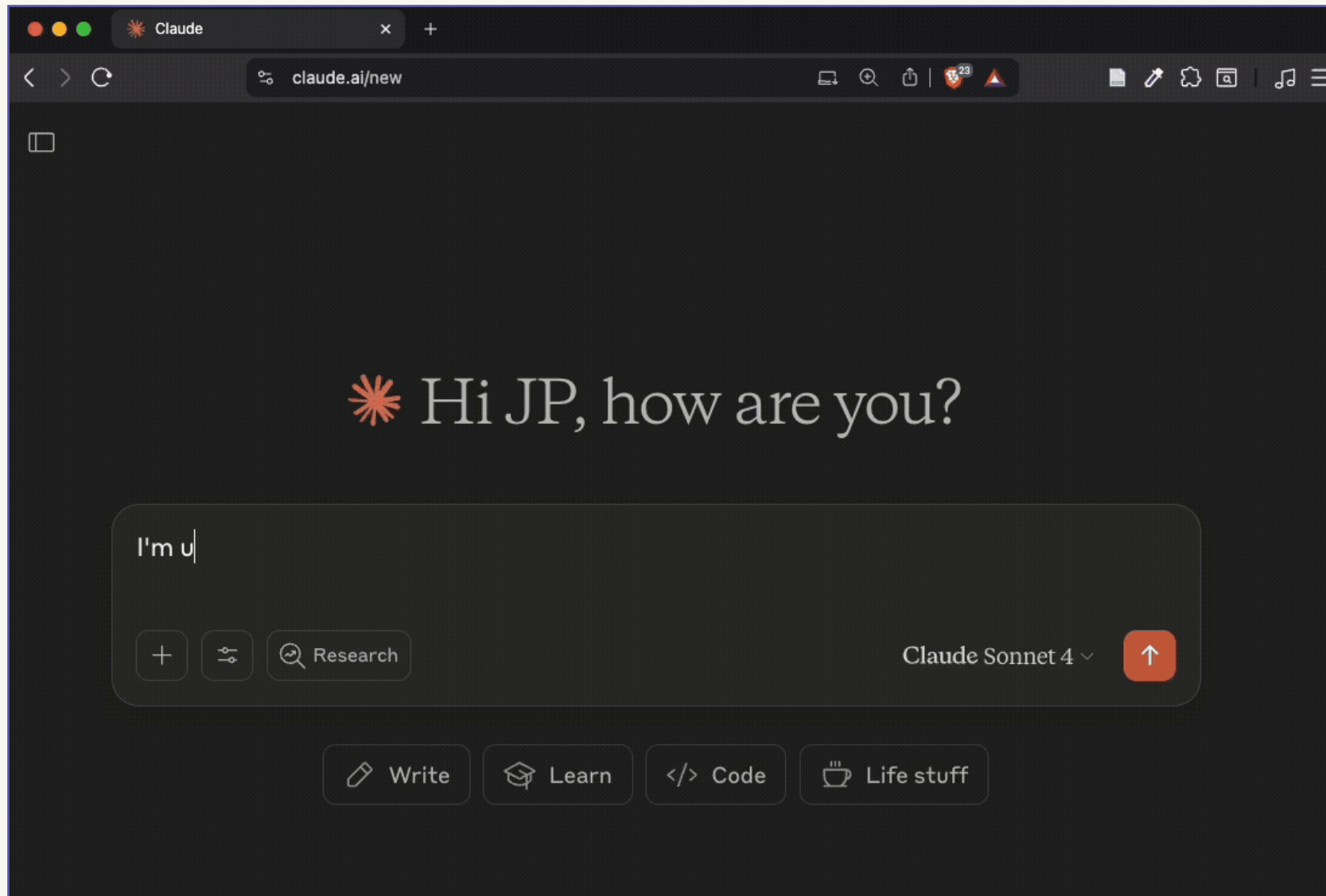
```
1 # Inside server
2 sd_show_if(
3   input$has_fav_hero == "yes" ~ "fav_hero"
4 )
```

Condition ~ Target

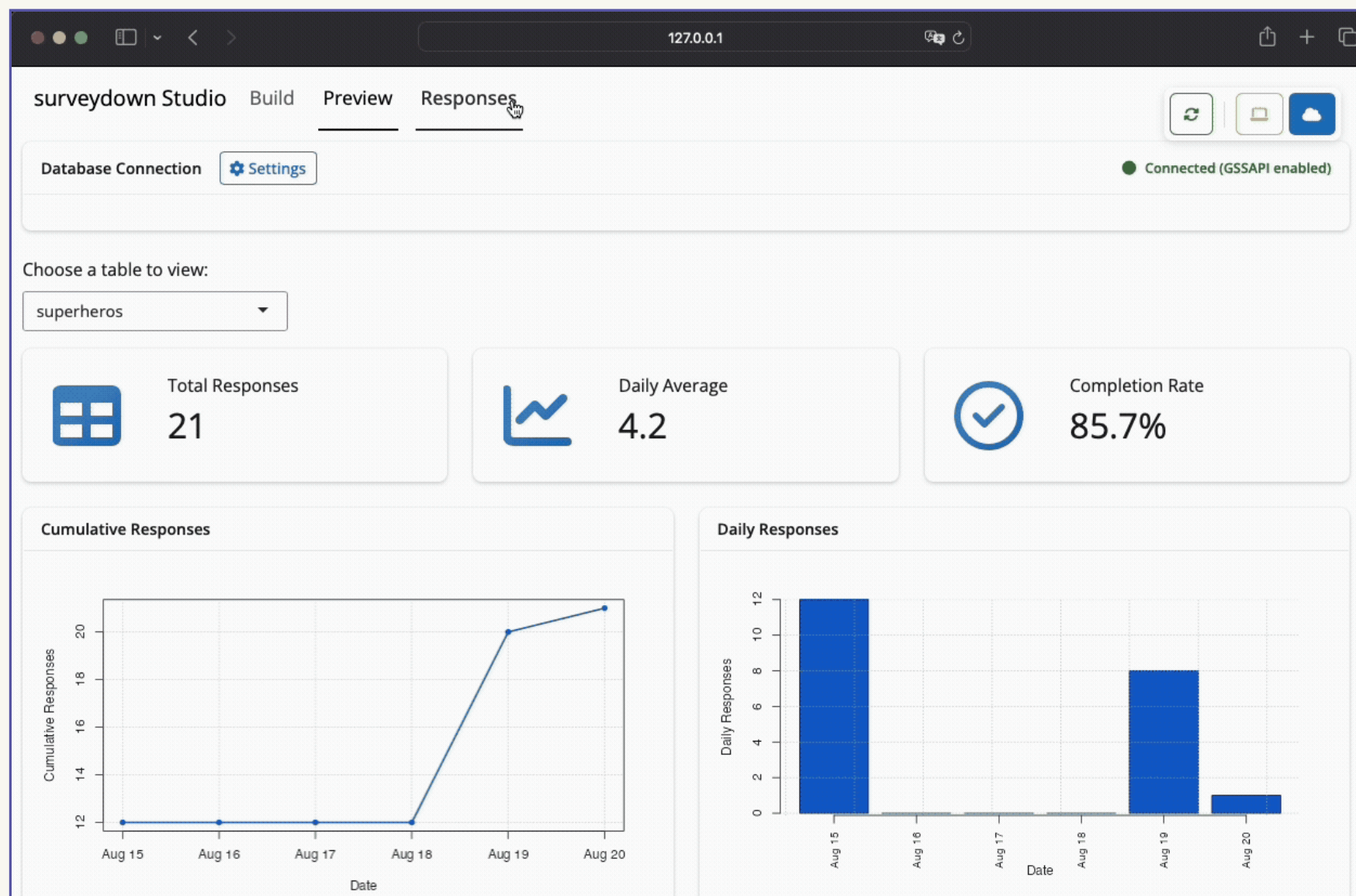
“If {condition}, then show {target}”



Generate surveys with LLMs!



The companion `sdstudio` package



Reference List

- Bailey, M. R., Brown, D. P., Shaffer, B. C., & Wolak, F. A. (2023). *Show Me the Money! Incentives and Nudges to Shift Electric Vehicle Charge Timing* [Working {Paper}]. National Bureau of Economic Research. <https://doi.org/10.3386/w31630>
- Huang, B., Meijssen, A. G., Annema, J. A., & Lukszo, Z. (2021). Are electric vehicle drivers willing to participate in vehicle-to-grid contracts? A context-dependent stated choice experiment. *Energy Policy*, 156, 112410. <https://doi.org/10.1016/j.enpol.2021.112410>
- Philip, T., & Whitehead, J. (2024). *Consumer Preferences Towards Electric Vehicle Smart Charging Program Attributes: A Stated Preference Study*. <https://doi.org/10.2139/ssrn.4812923>
- Tarroja, B., Shaffer, B., & Samuelsen, S. (2015). The importance of grid integration for achievable greenhouse gas emissions reductions from alternative vehicle technologies. *Energy*, 87, 504–519. <https://doi.org/10.1016/j.energy.2015.05.012>
- Wong, S. D., Shaheen, S. A., Martin, E., & Uyeki, R. (2023). Do incentives make a difference? Understanding smart charging program adoption for electric vehicles. *Transportation Research Part C: Emerging Technologies*, 151, 104123. <https://doi.org/10.1016/j.trc.2023.104123>

