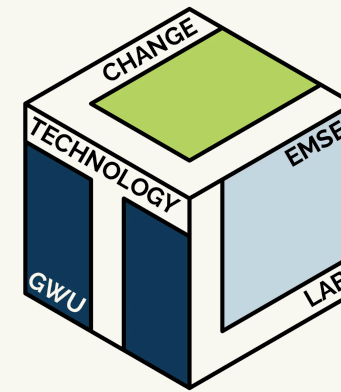


PhD Proposal Defense:

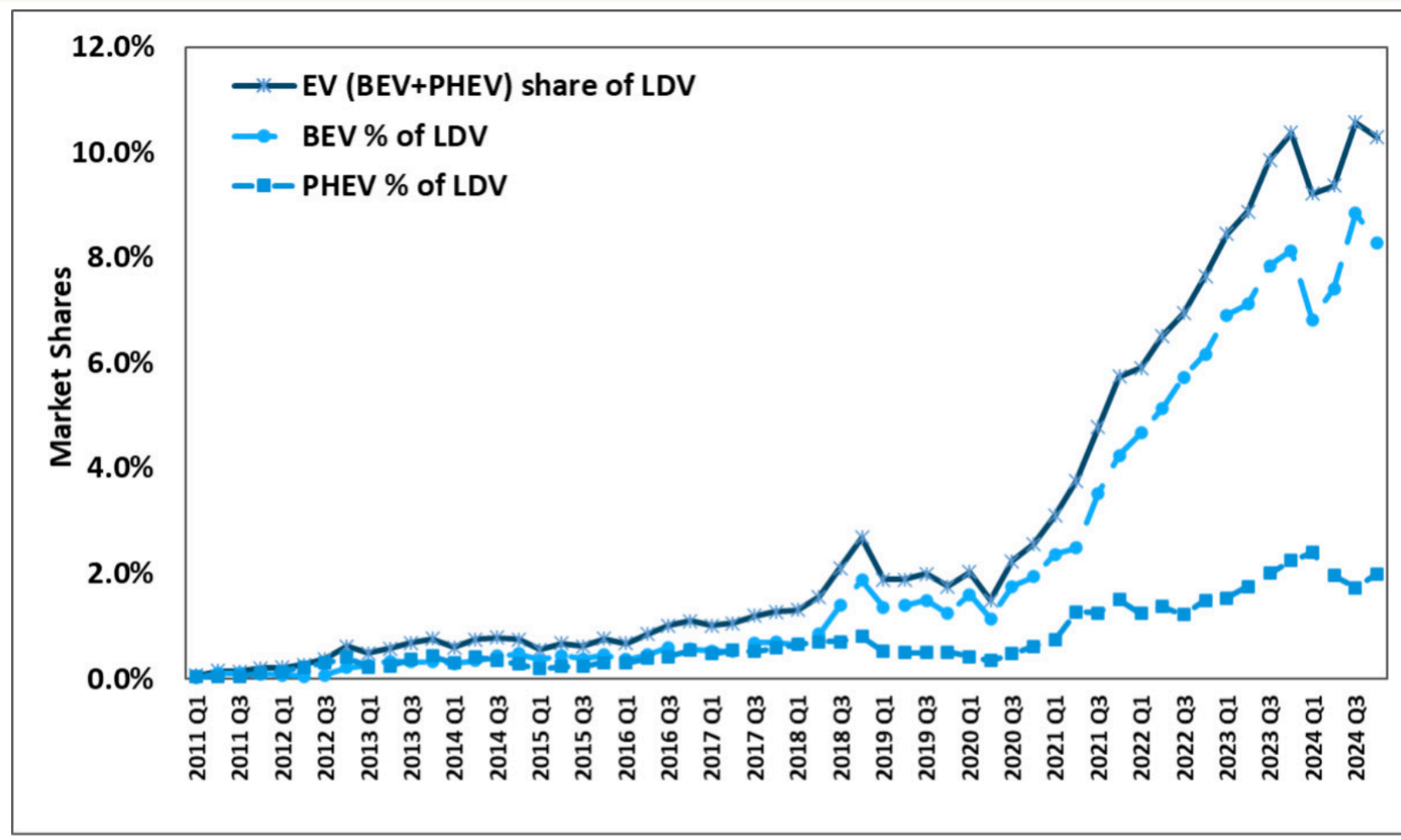
Electric Vehicle Smart Charging Adoption,
Grid Peak-Shaving Quantification, and
The **surveydown** Survey Platform

Pingfan Hu

George Washington University



EV sales in US reaching ~10% of sales

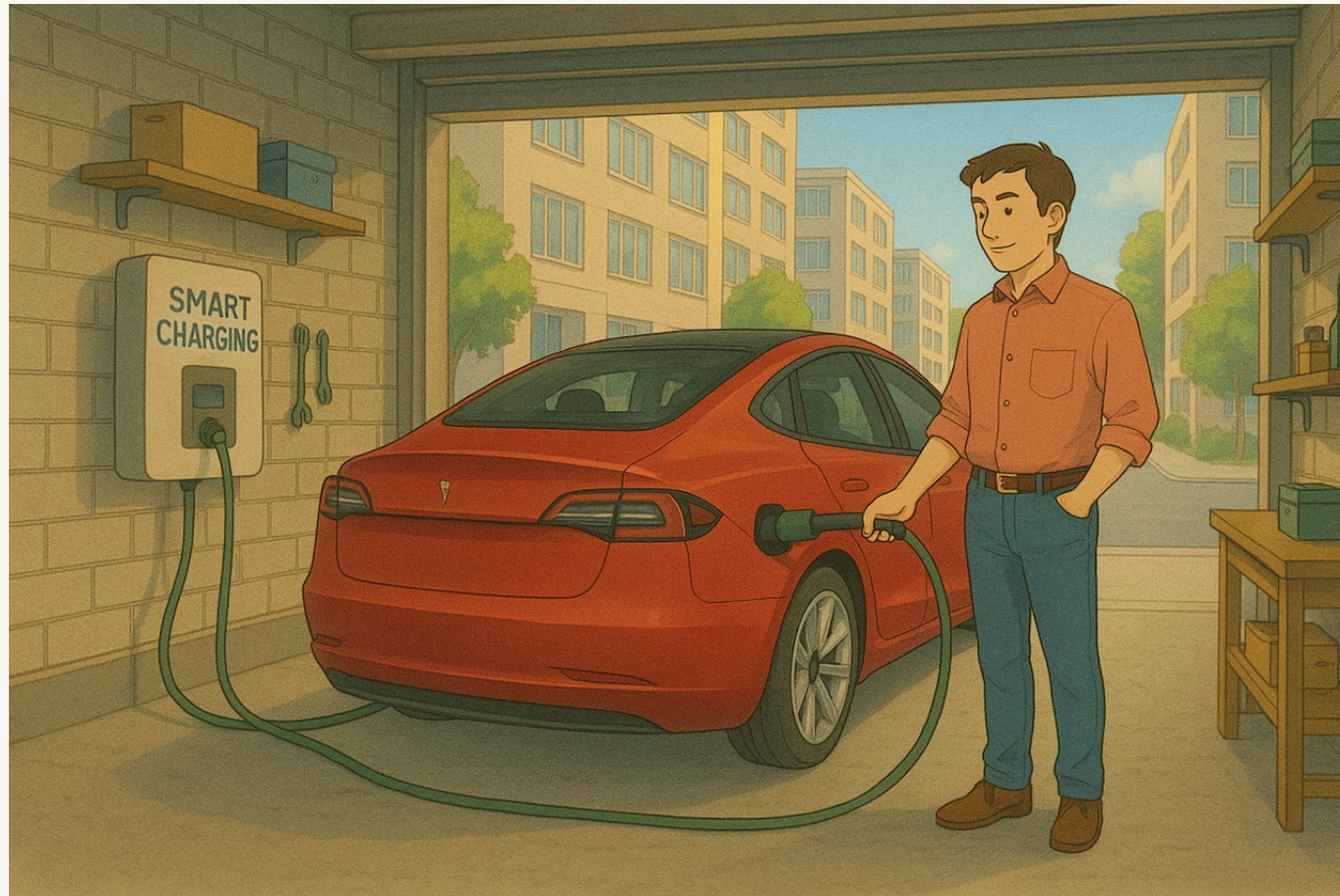


Source: Argonne National Lab, www.anl.gov/ev-facts/model-sales



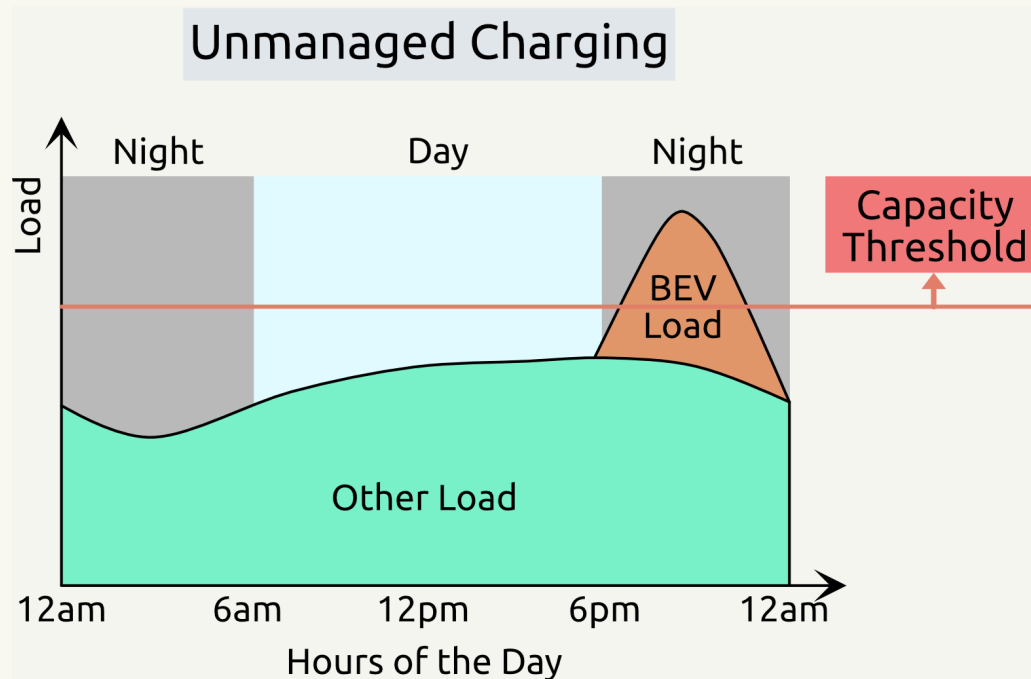
Introduction

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



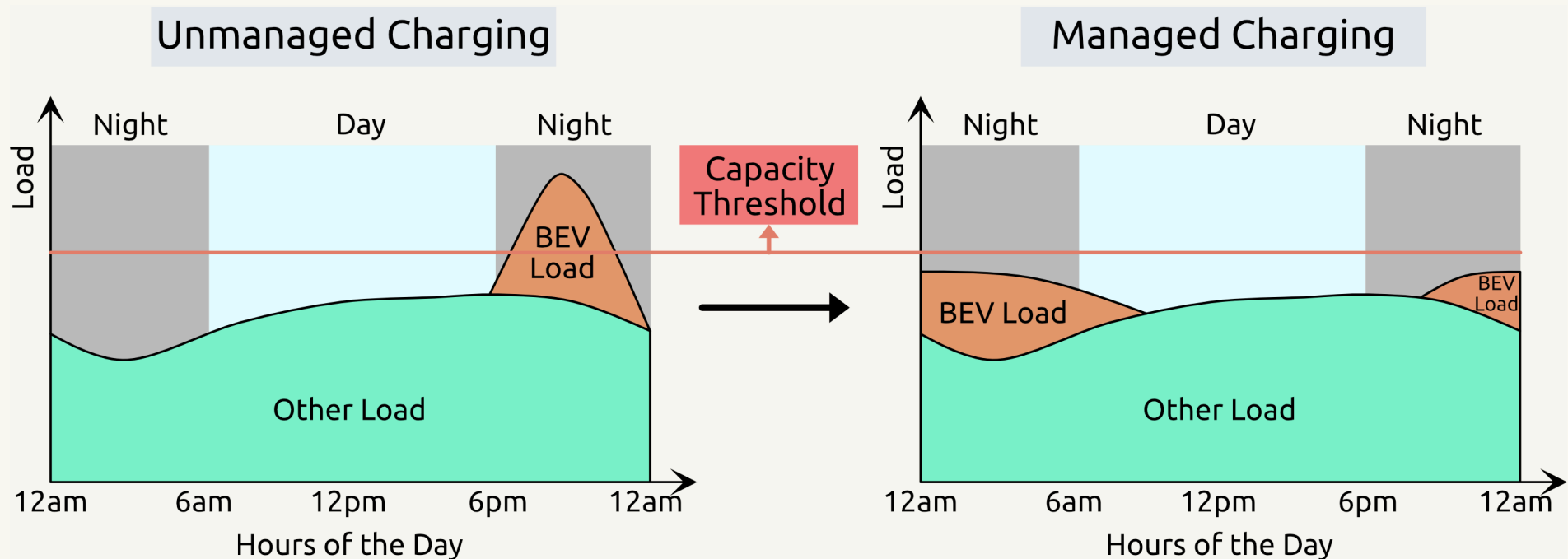
SMC - Supplier Managed Charging

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



SMC - Supplier Managed Charging

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



Managed charging avoids overload caused by BEV charging.



V2G - Vehicle-to-Grid

Non-V2G (Single Direction)

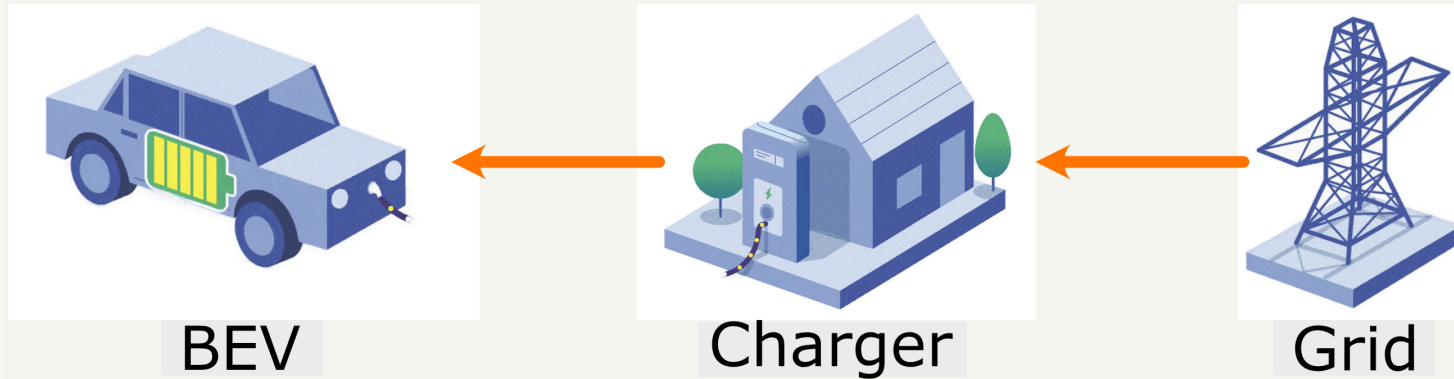
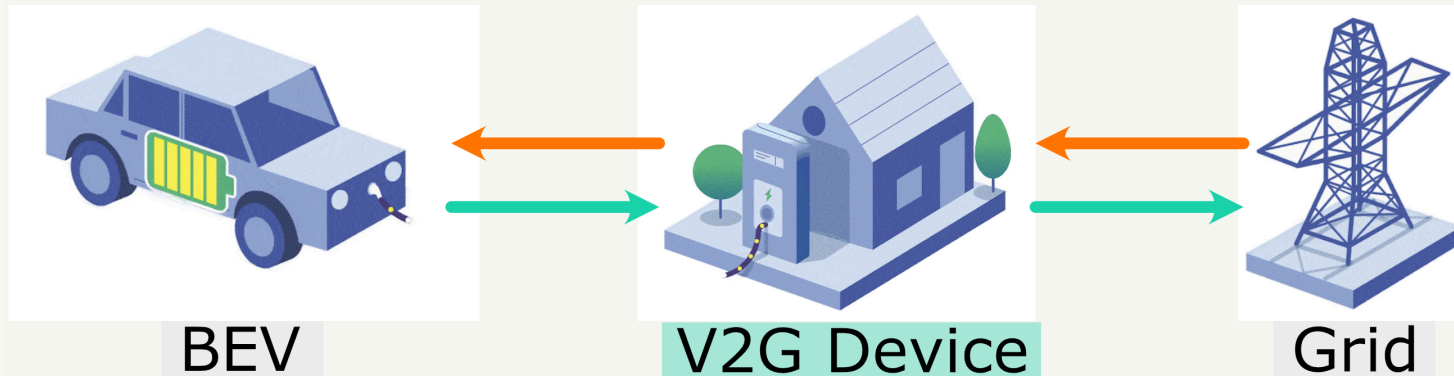


Figure Source: wri.org

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

Electric Vehicle Smart Charging Adoption

Simulation Research

Grid Peak-Shaving
Quantification

Software Development

The surveydown Survey
Platform



Study 1

Electric Vehicle Smart Charging Adoption

Under second round of reviews:

Hu, Pingfan, Tarroja, B., Dean, M., Forrest, K., Hittinger, E., Jenn, A. & Helveston, J.P. (2024) “Measuring Electric Vehicle Owners’ Willingness to Participate in BEV Smart Charging Programs” *Environmental Research Letters*.



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 and 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 EV ownership & 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?

Conjoint survey to collect BEV owners' willingness.

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.



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

0 80 160 200 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

A horizontal bar chart representing a range of miles from 0 to 200. The bar is divided into three segments: a grey segment from 0 to 80 miles, an orange segment from 80 to 160 miles, and a green segment from 160 to 200 miles. Above the 80-mile mark is a blue box labeled 'Low' with a downward arrow. Above the 160-mile mark is a blue box labeled 'Guaranteed' with a downward arrow.

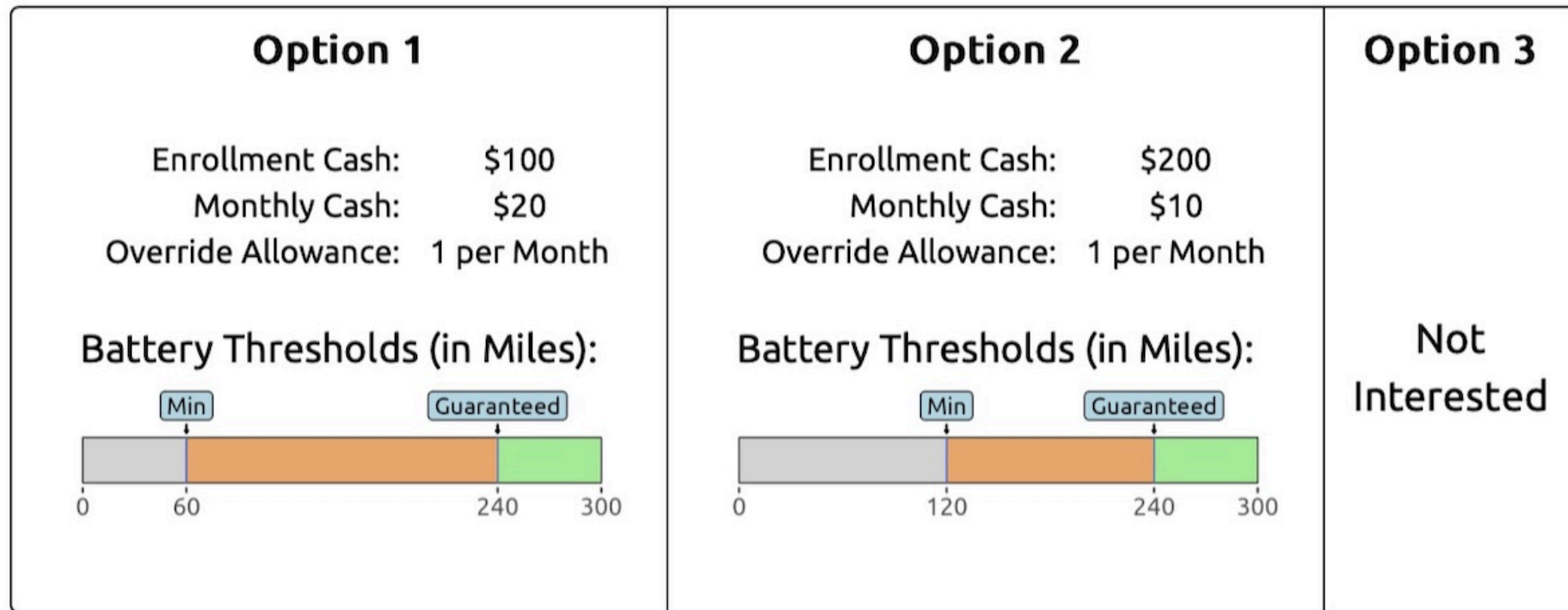
(Range determined by stated vehicle they own)



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](#)



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



Survey Fielding - 1,356 in Total



GWU Vehicle Lab
Sponsored · 🌐

Do you own an EV? We are a research lab at GWU and we want to hear from you. Click this link to take our survey!



carsurvey3.formr.org
EV Charging Survey
formr survey framework....

[Learn more](#)

👍 Like 💬 Comment ➦ Share

Meta Ads: Voluntary participants

- 803 responses
- March to July in 2024

Dynata Recruitment: Paid survey

- 553 responses
- September to November in 2024



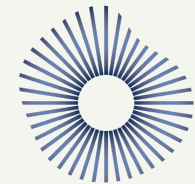
Facebook



Messenger



Instagram



dynata



Survey Question - Car Ownership

Car Ownership

1. What is your ZIP code?

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?

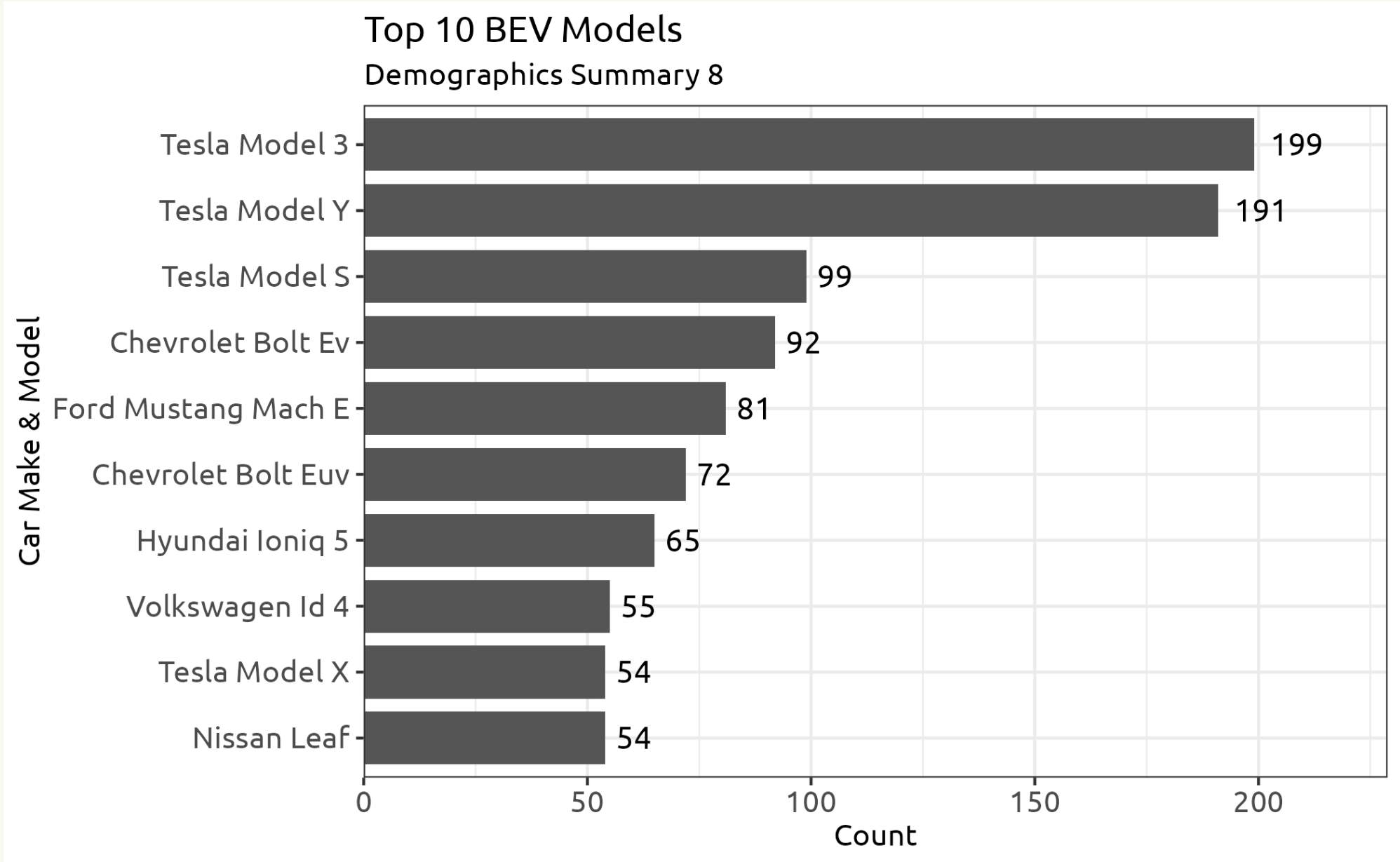
6. What is the **model year** of your secondary car?

Other
✓ Acura
Alfa Romeo
Aston Martin
Audi
Bentley
BMW
Bugatti
Buick
Cadillac
Chevrolet
Chrysler
Daewoo
Dodge
Ferrari
FIAT
Fisker
Ford
Genesis
GMC
Honda

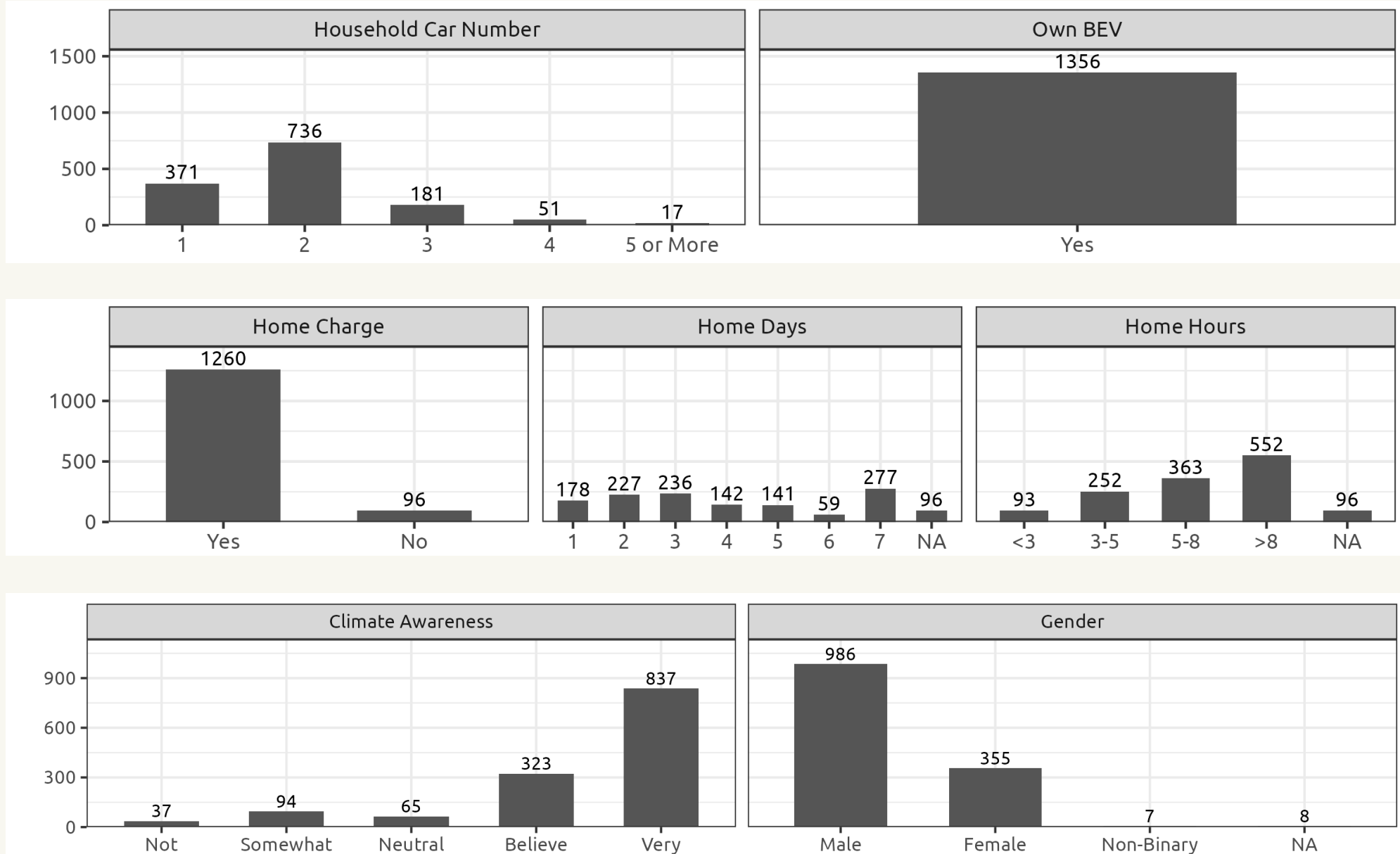
Next Page



Survey Results - Top 10 BEV



Survey Results - Demographics



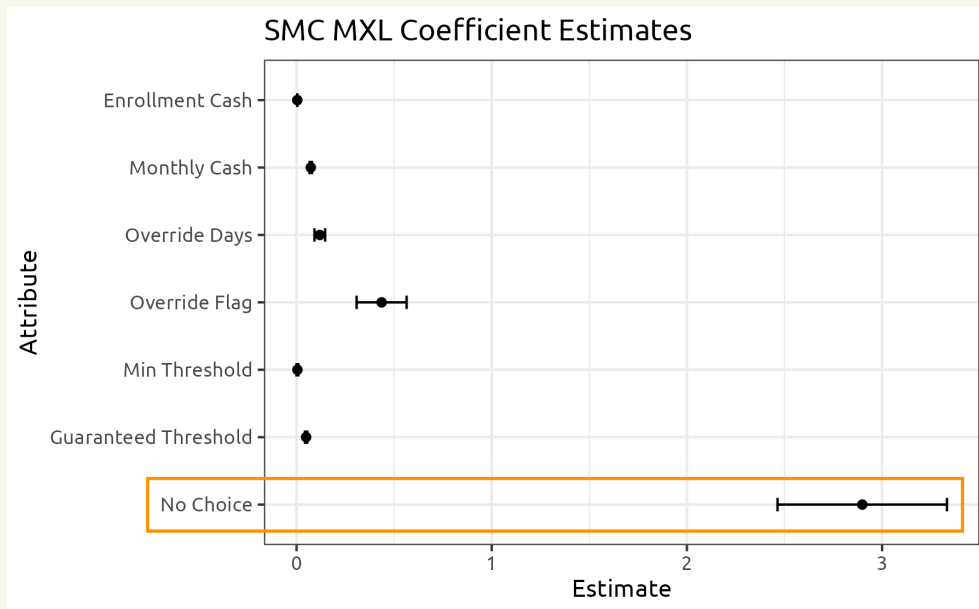
Survey Results - Willingness to Participate

Mixed Logit Models

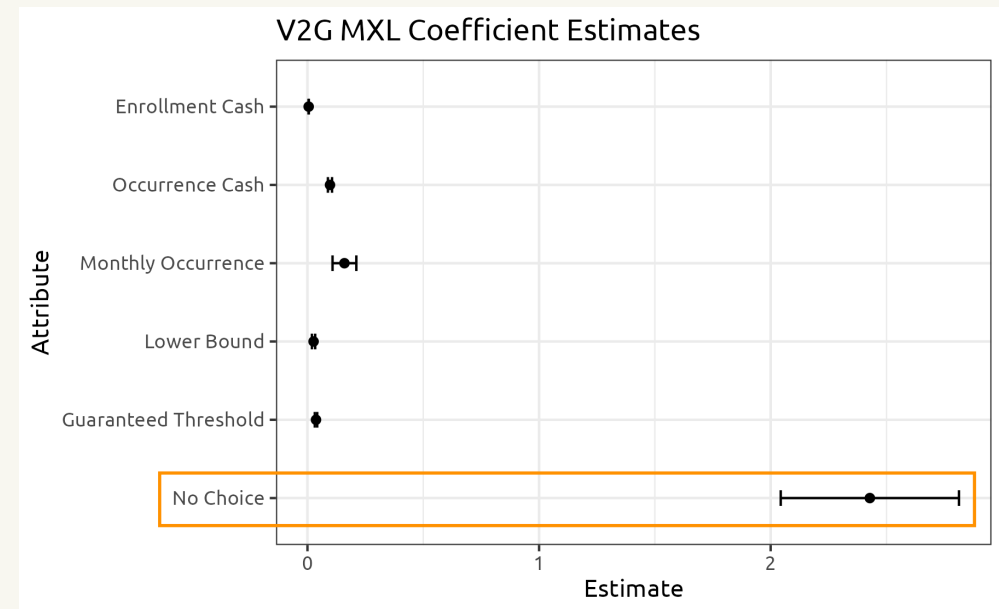
$$u_j = v_j + \epsilon_j = \beta'x + \epsilon_j \quad P_j = \frac{e^{v_j}}{\sum_{k=1}^J e^{v_k}}$$

Utility estimated using maximum likelihood estimation (MLE).

SMC Estimates



V2G Estimates



Without compensation, users will not participate.



Enrollment Sensitivity

Baseline Simulation

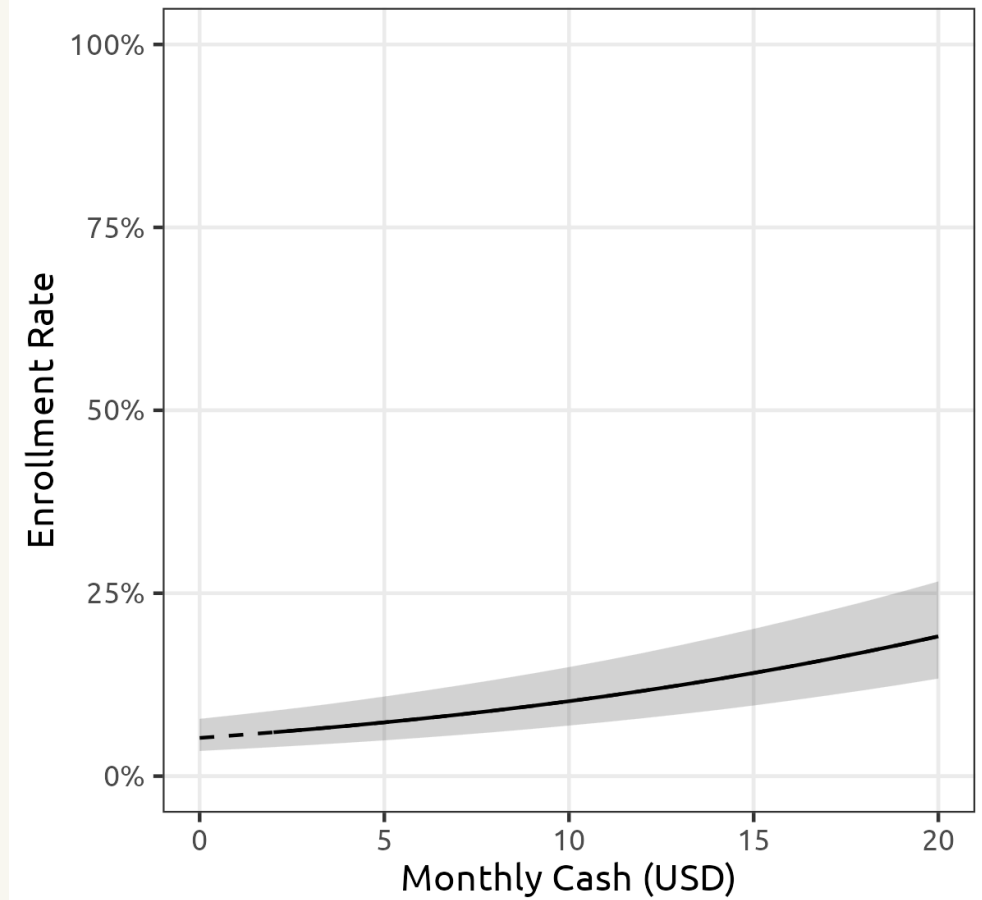
Choice between “None” and this program:

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

0 40 120 200 miles

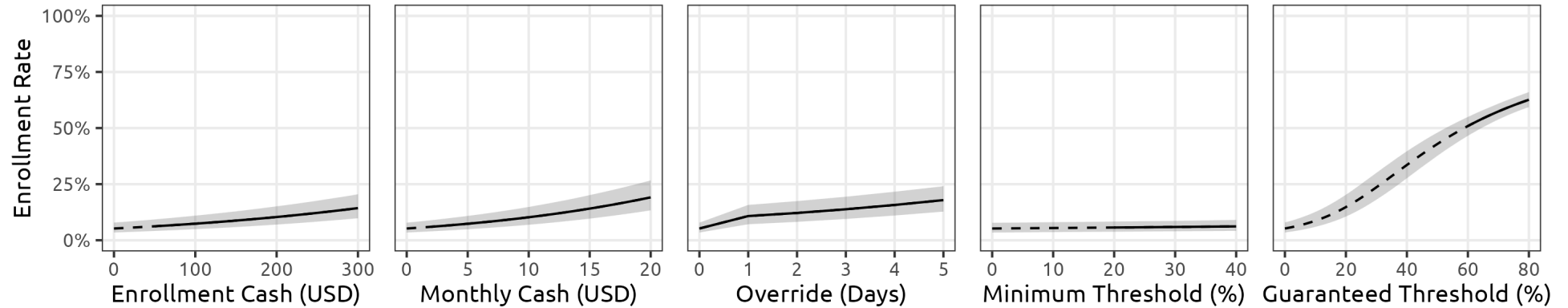
Sensitivity Plot

SMC Sensitivity of Monthly Cash

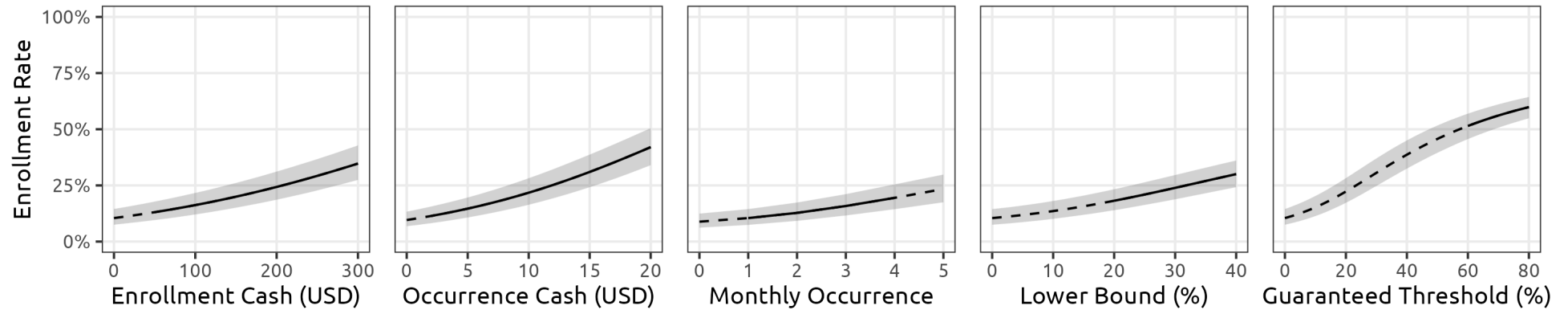


Enrollment Sensitivity

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 in high efficiency, indicating range anxiety.
4. Attribute equivalencies can be used to inform incentive design.



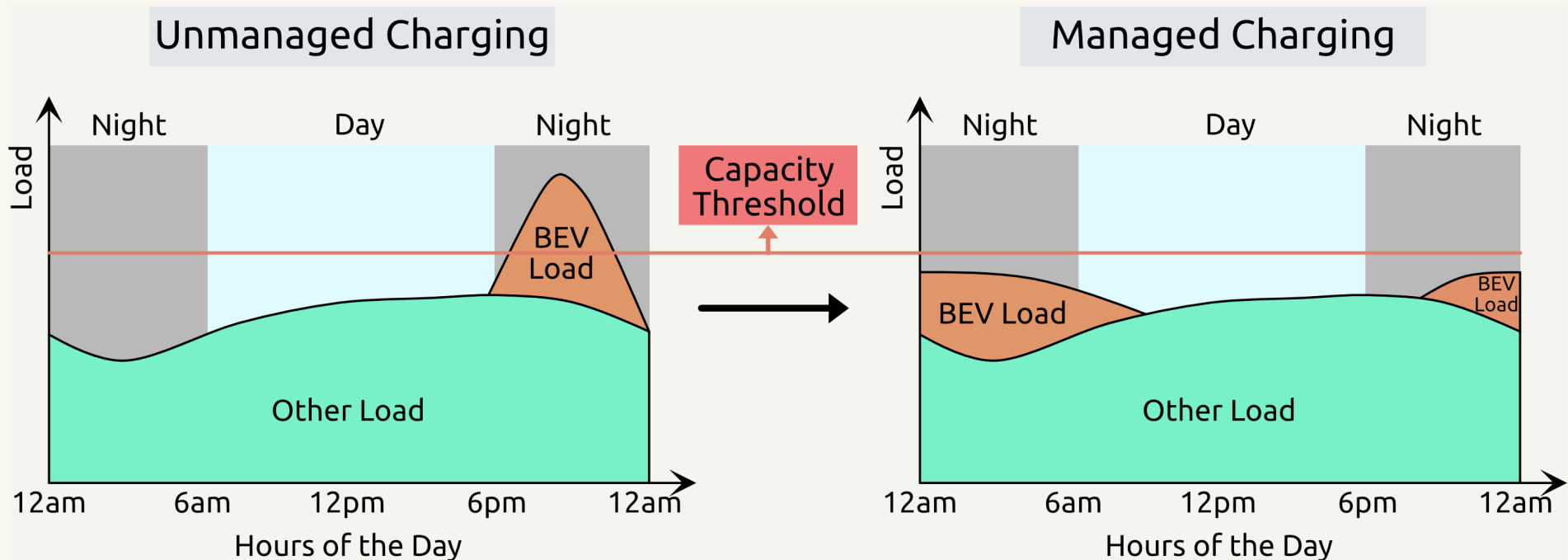
Study 2

Quantifying the supply of peak-shaving from
controlled EV charging



Recall the SMC Peak-shaving

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



Managed charging avoids overload caused by BEV charging.



Research Questions

1. **Peak-shaving:** How much does peak-shaving from controlled EV charging cost utilities?
2. **Variations:** How do peak-shaving results change based on regions, seasons, EV-to-house ratios, and enrollment rates.

Data collection from NHTS, NREL, and U.S. Census.

Peak-shaving simulation using model from study 1.



Plan of Action

Step 1: Data Collection

- **NHTS:** Charging behavior data
- **NREL:** Household electricity consumption data
- **U.S. Census:** Count of single family households
- **Study 1:** MXL model of SMC enrollment utilities

Step 2: Simulation

- Simulate grid demand profiles with different EV charging loads
- Simulate peak load reduction under different levels of SMC enrollment

Step 3: Sensitivity Analysis

- Compare the peak-shaving results of different scenarios
- Summarize and provide policy implications

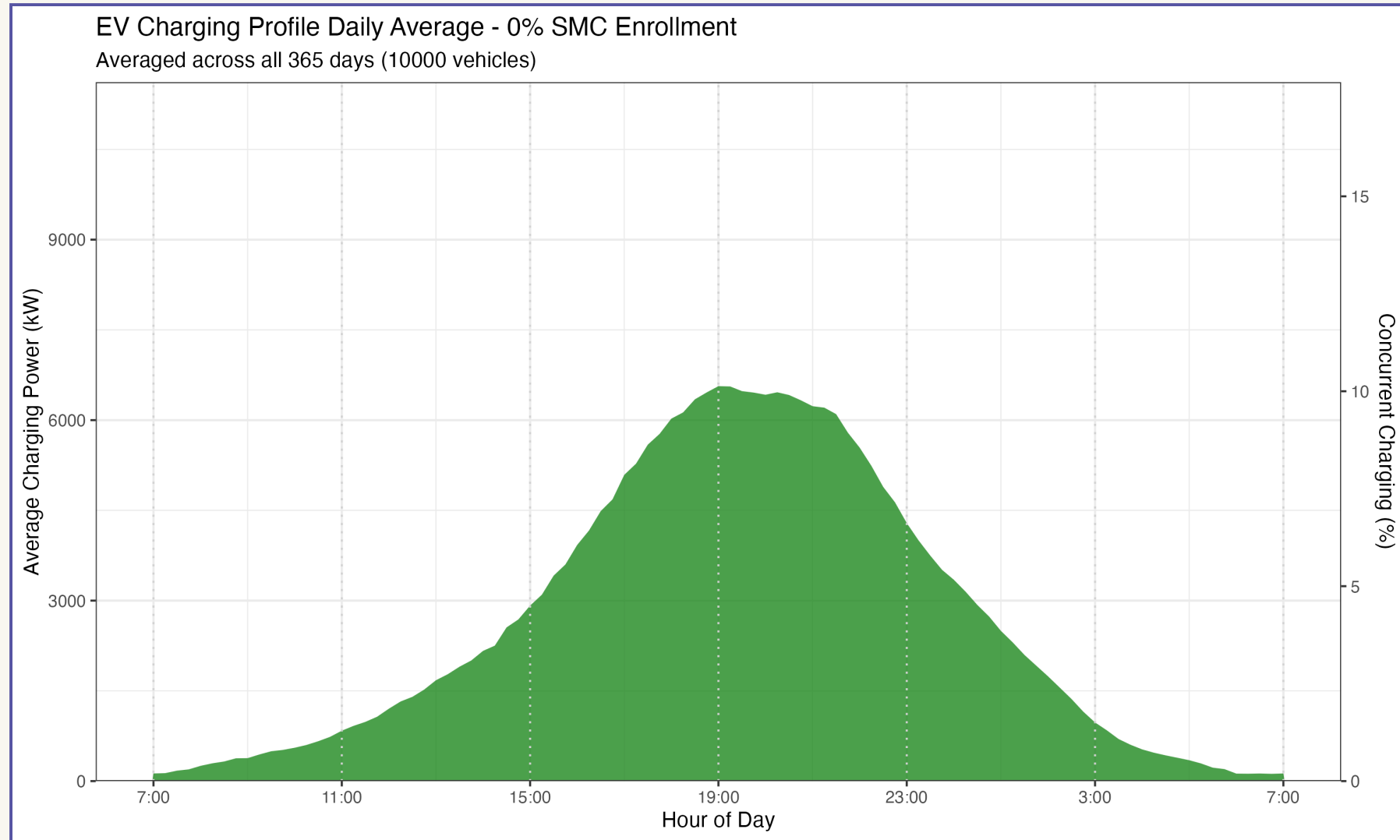


NHTS - National Household Travel Survey

Travel patterns of 26,000 vehicle owners.



Simulated EV Charging Profile



Energy consumption and concurrent charging % of 10,000 EVs.



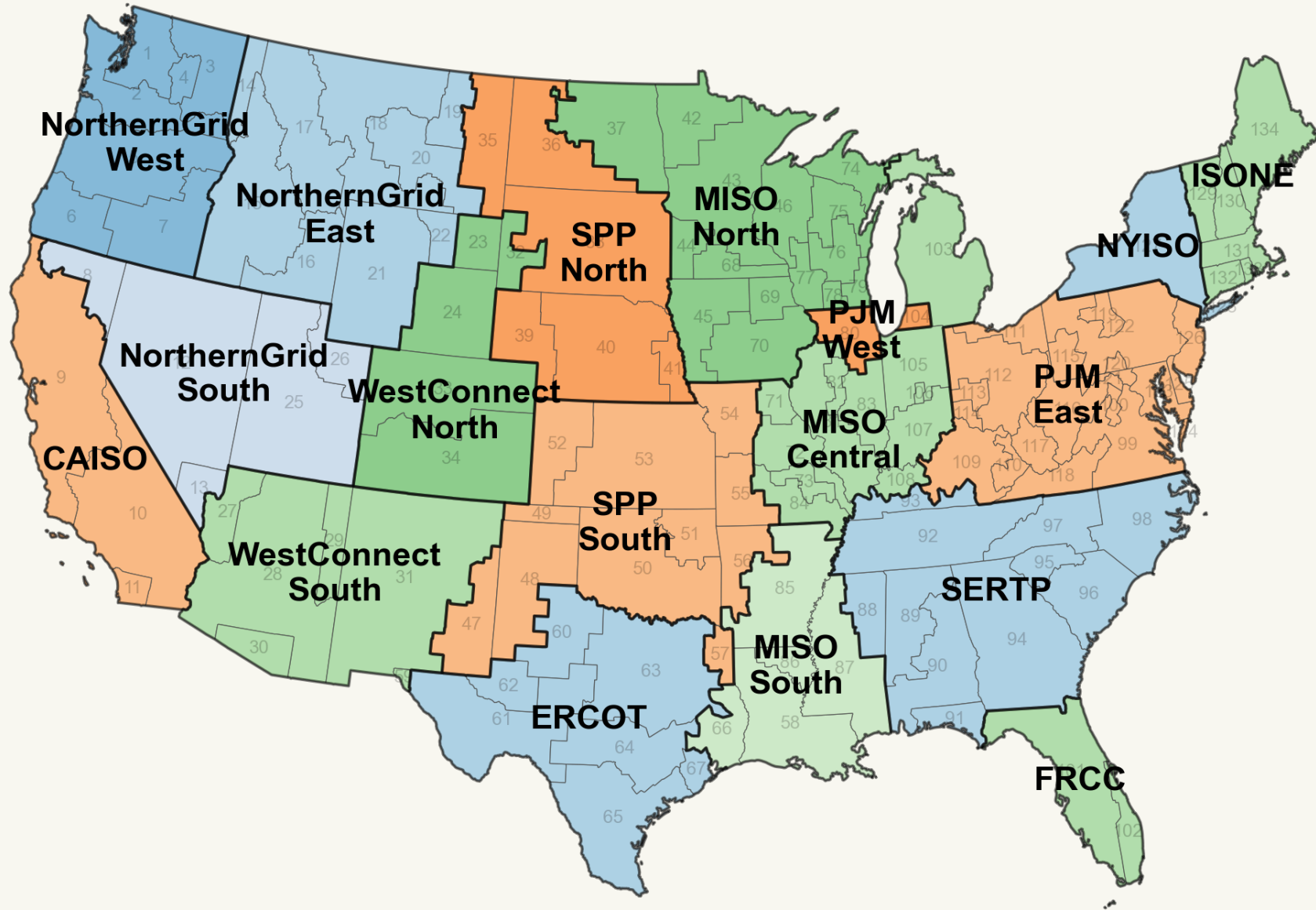
NREL - National Renewable Energy Lab

Data of household electricity consumption in each GEA region.

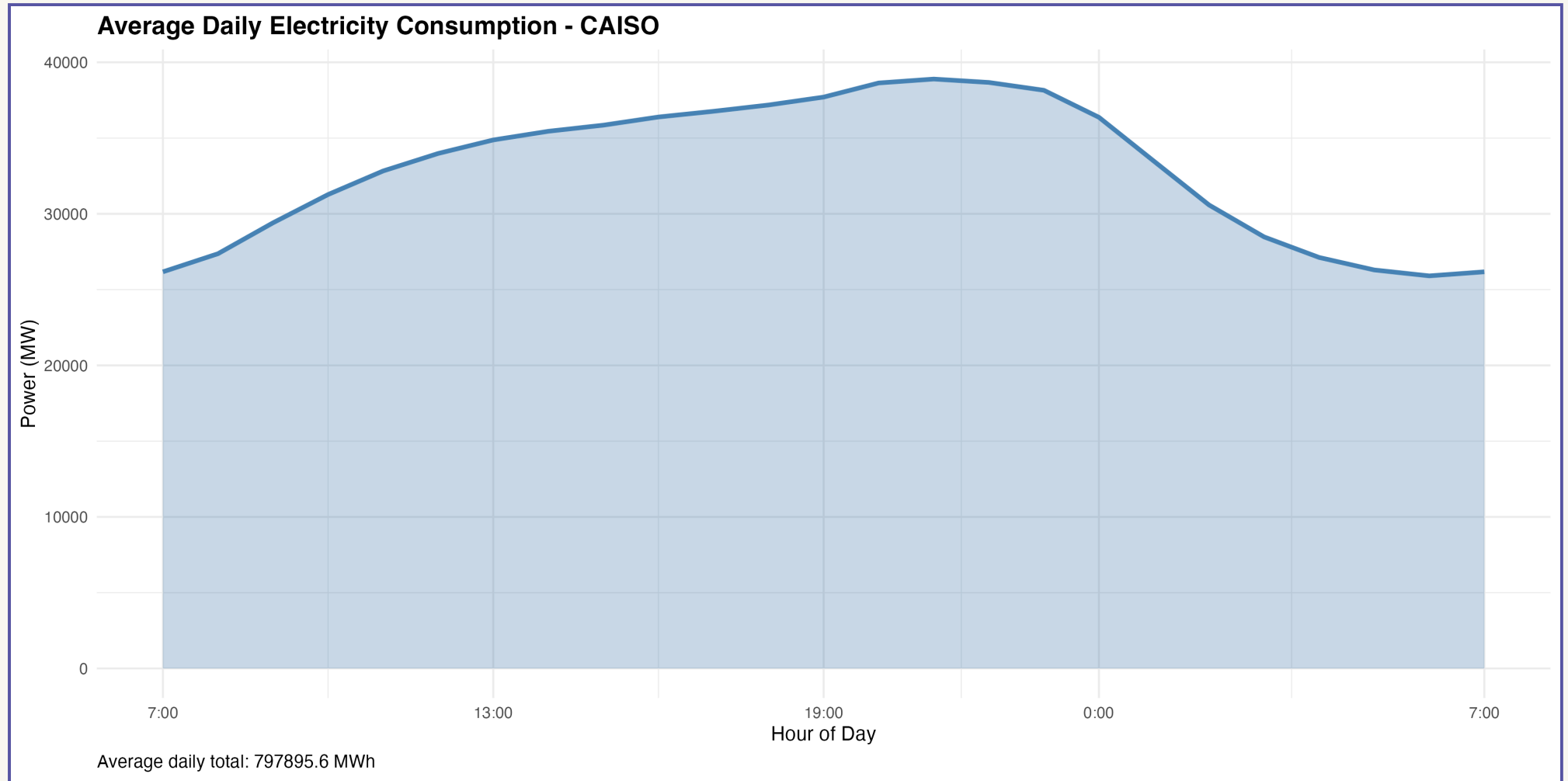


18 GEA Regions





CAISO as an Example



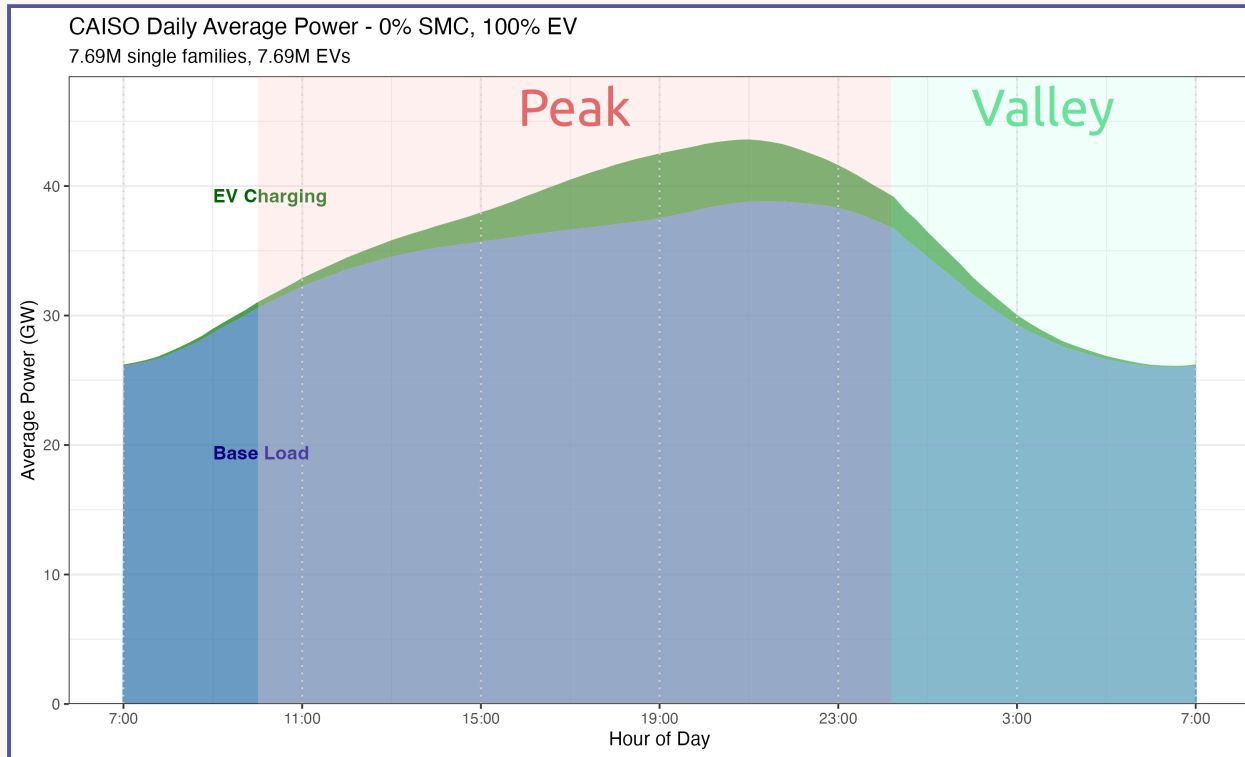
7.69M single-family homes, collected from U.S. Census.



Peak-shaving Simulation



Original Consumption Profile

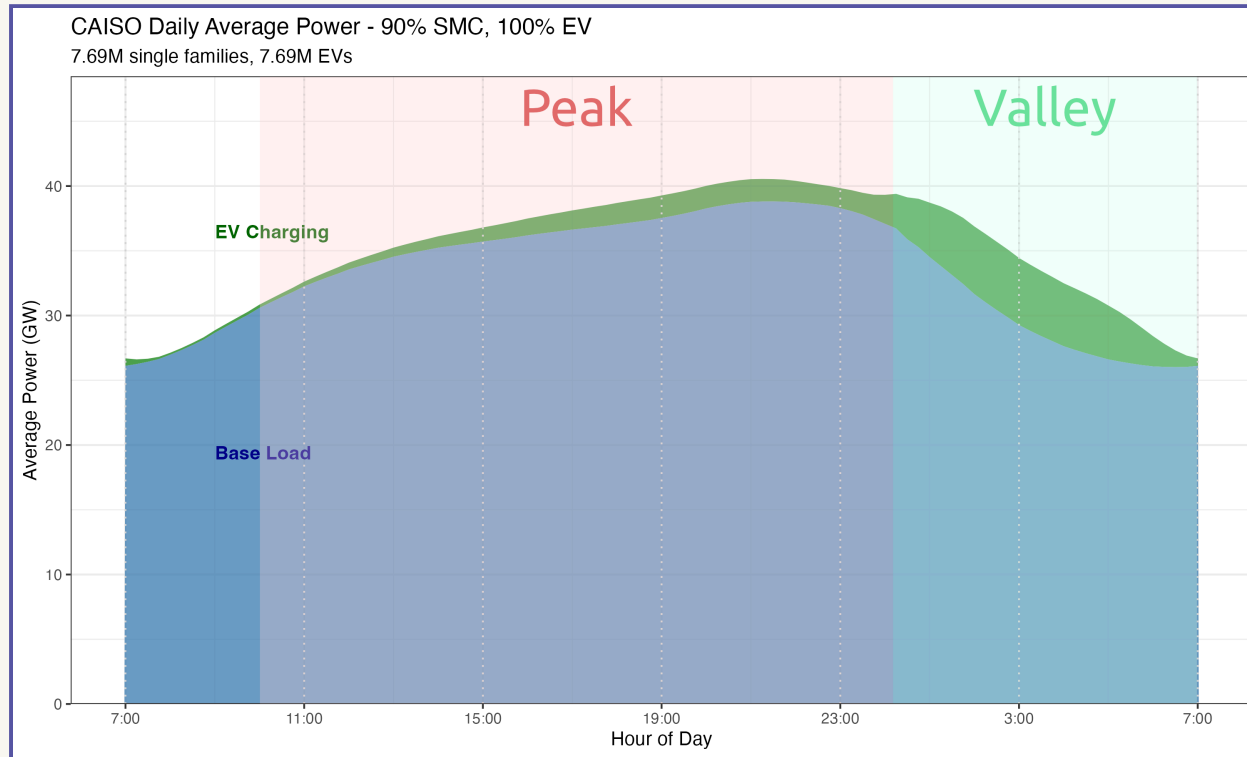


Assumptions

- 200-mile range BEV.
- Level 2 charger.
- Peak: 10AM-12:00AM.
- Valley: 12:00AM-7AM.
- Battery: 20%-80%.
- Auto-override.



Shifted Consumption with Peak-shaving



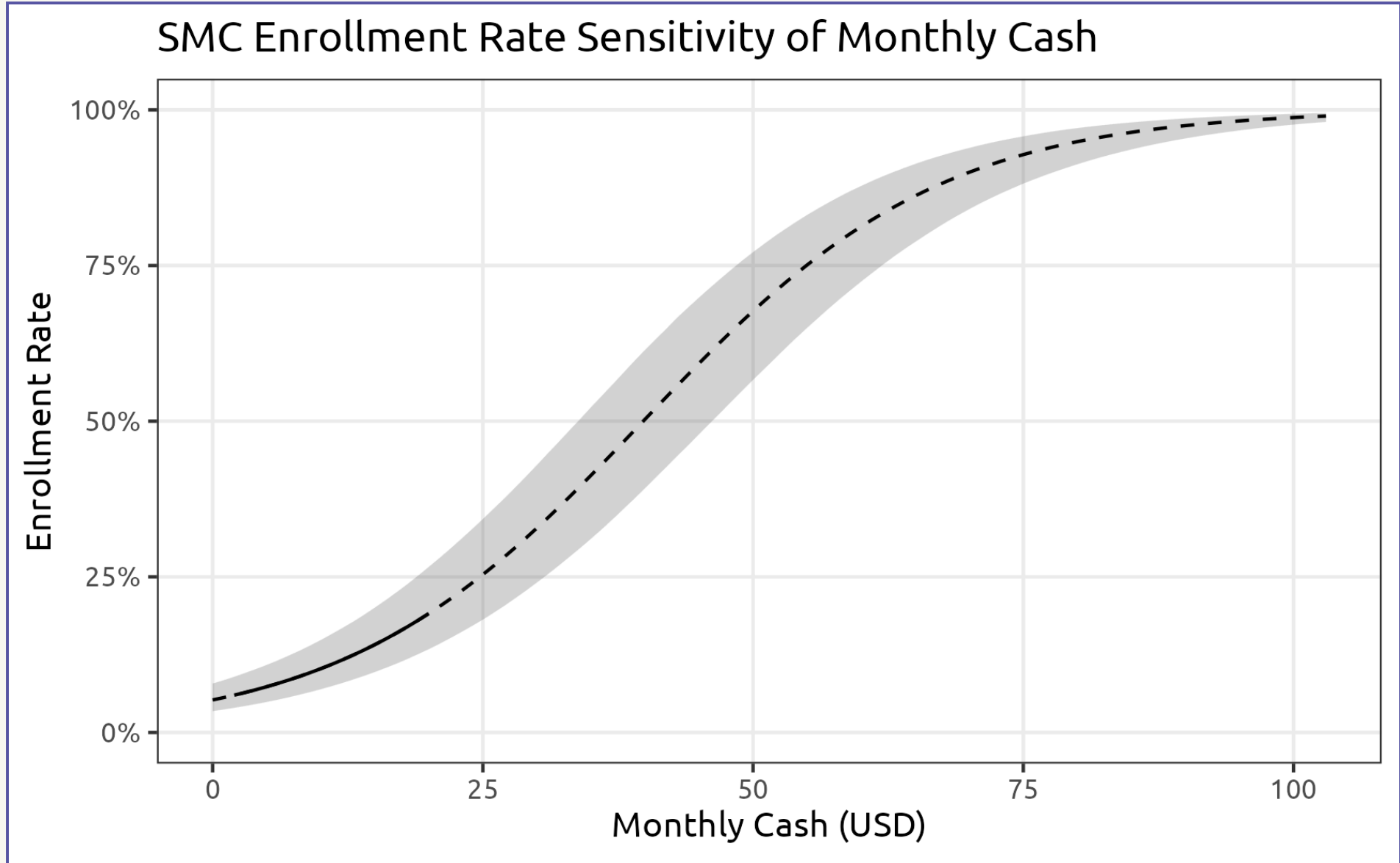
Assumptions

- 200-mile range BEV.
- Level 2 charger.
- Peak: 10AM-12:00AM.
- Valley: 12:00AM-7AM.
- Battery: 20%-80%.
- Auto-override.

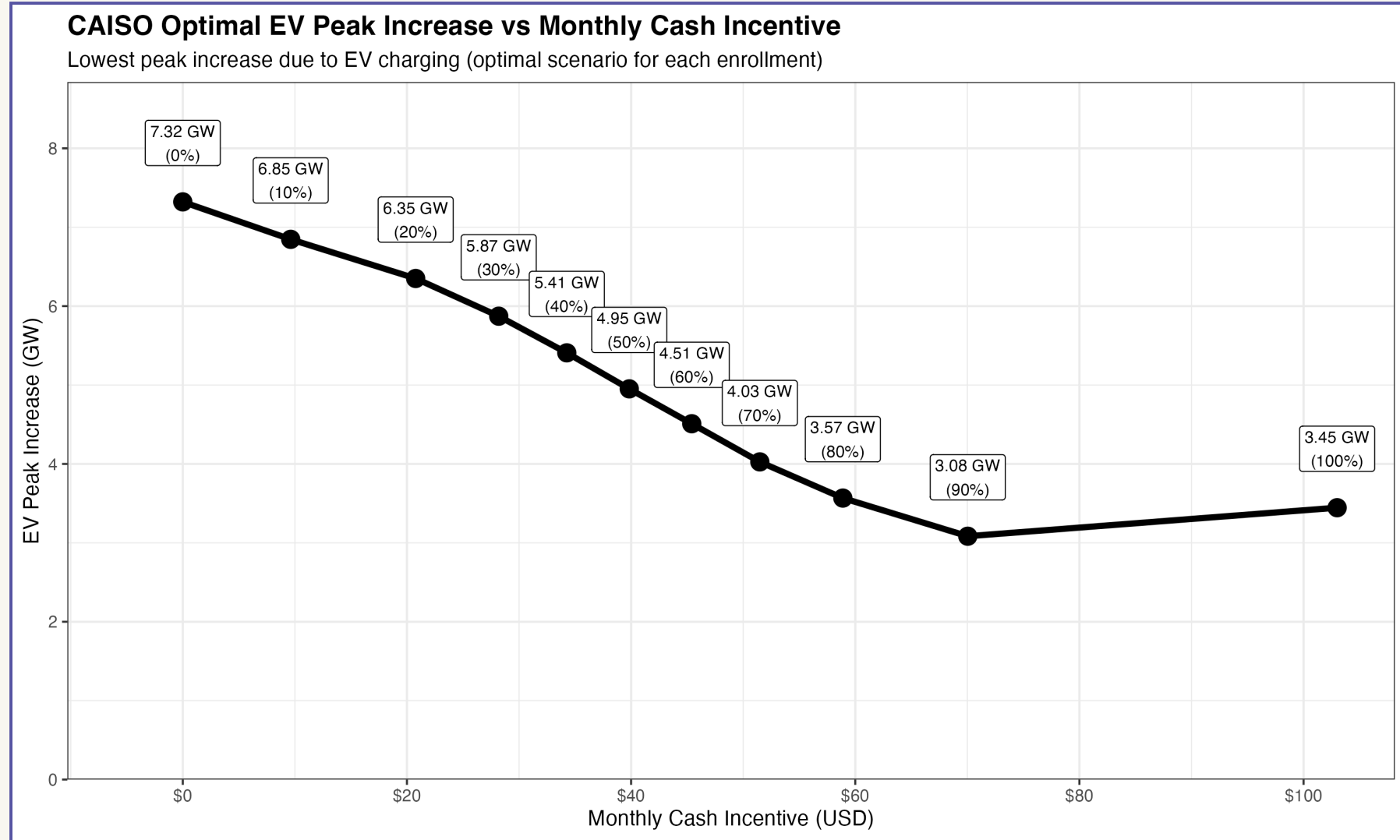
90% SMC enrollment, EV-to-house ratio 1:1.



MXL Model of Monthly Incentives



EV Peak Increase vs Monthly Incentives



More incentives lead to higher SMC enrollment, thus more peak shaving.



Sensitivity Analysis



Different Scenarios

- All 18 GEA regions in all 4 seasons.
- Varying EV-to-house ratios (1:4, 1:2, 1:1).
- Varying SMC enrollment rates (from 0% to 100%).
- Varying peak and valley windows.



Policy Implications

1. Utilities must plan a budget that scales with enrollment levels.
2. Governments could get engaged (e.g. provide subsidies to offset the cost).



Study 3

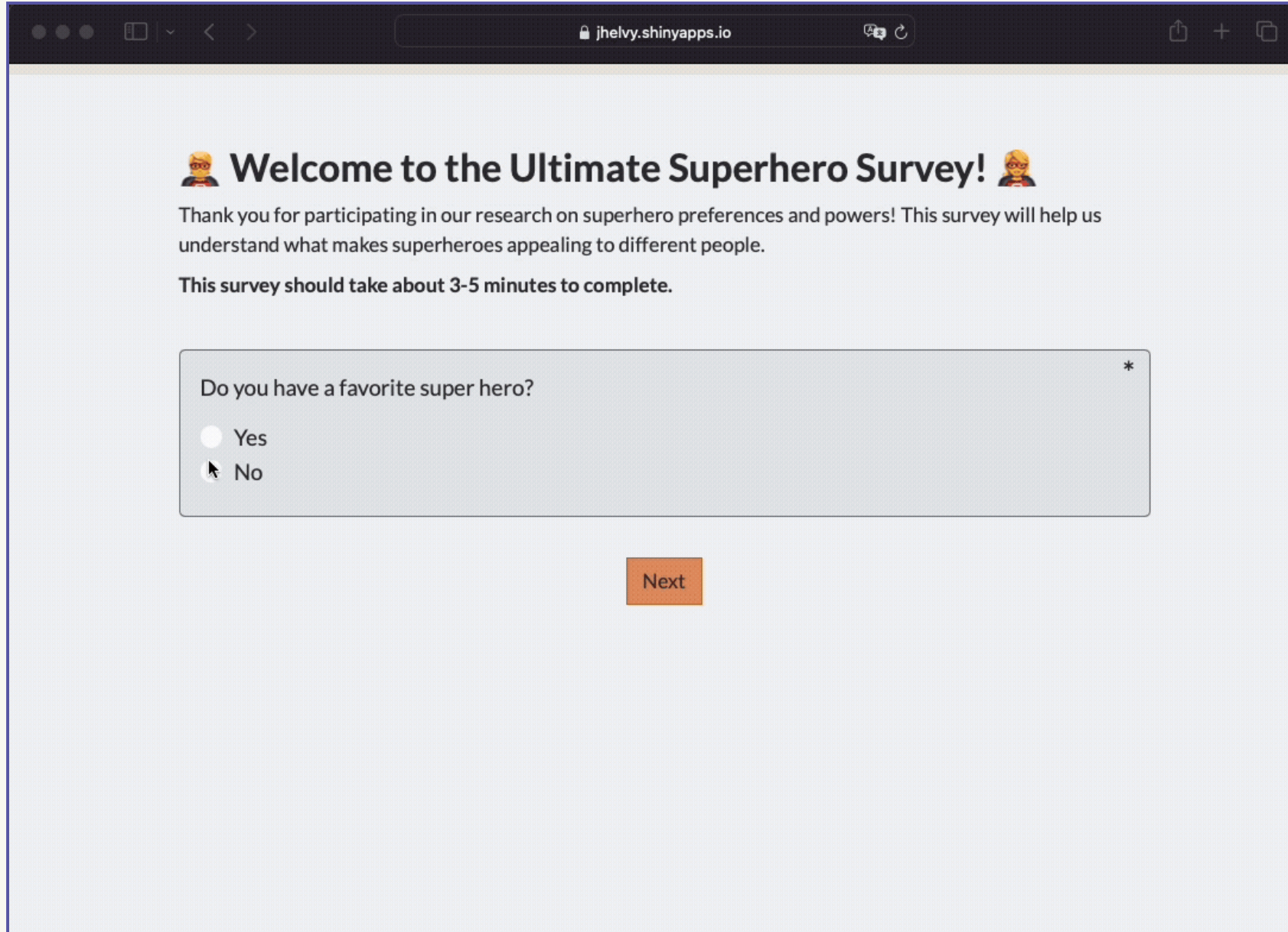
The **surveydown** Survey Platform

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>



Typical Web Survey



The image shows a web browser window with the URL `jhelvy.shinyapps.io`. The page 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

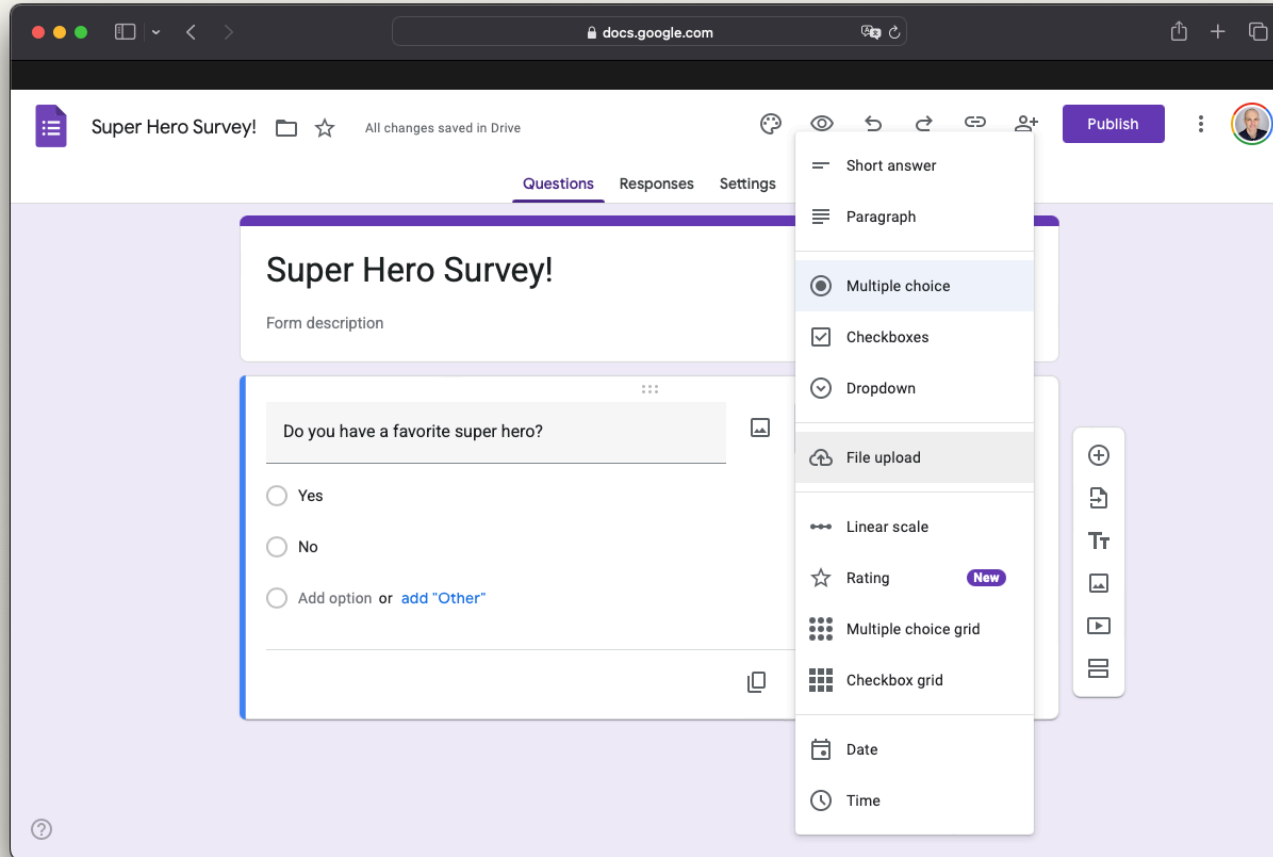


Google Form - GUI Interface

The screenshot shows the Google Forms editor interface. At the top, the browser address bar displays 'docs.google.com'. The page title is 'Super Hero Survey!' with a folder icon and a star icon, and a note 'All changes saved in Drive'. The main navigation includes 'Questions', 'Responses', and 'Settings' tabs. A 'Publish' button is visible in the top right corner. The central area displays the survey title 'Super Hero Survey!' and a 'Form description' field. Below this, a question is added: 'Do you have a favorite super hero?'. The question has three radio button options: 'Yes', 'No', and 'Add option or add "Other"'. A vertical toolbar on the right side of the question card contains icons for adding new questions, deleting, duplicating, and other actions. A dropdown menu is open, showing 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.







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!



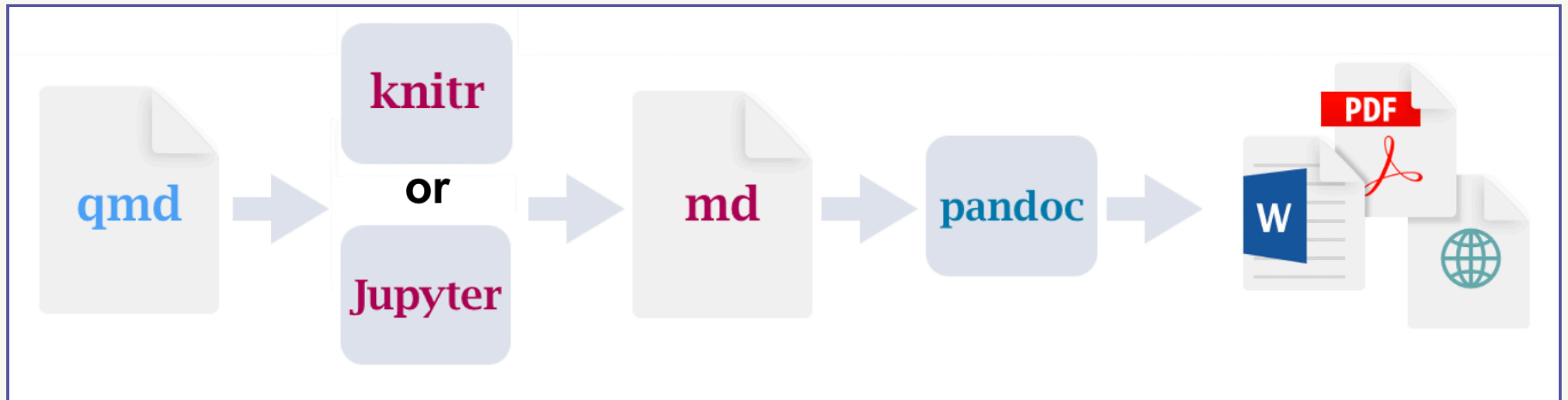
Introducing **surveydown**!



R package that renders Quarto files into surveys



Quarto is a publishing system



Original qmd file

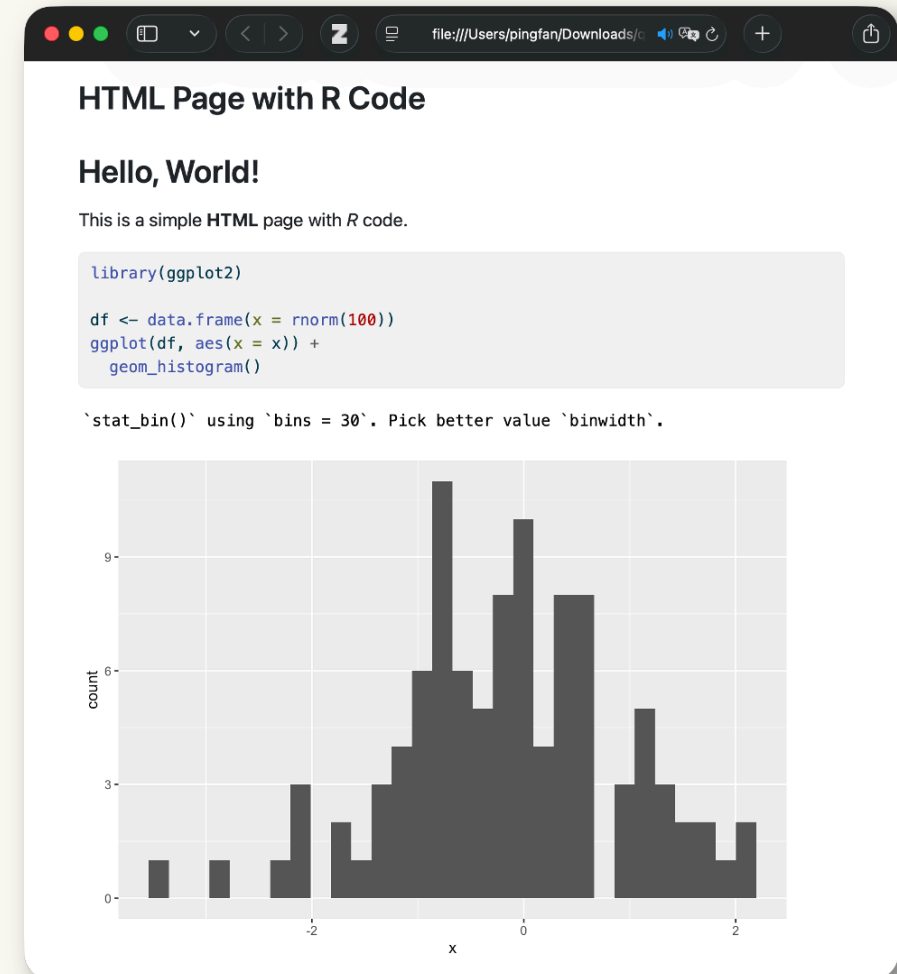
Markdown + R code chunks

```

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



HTML Page with R Code

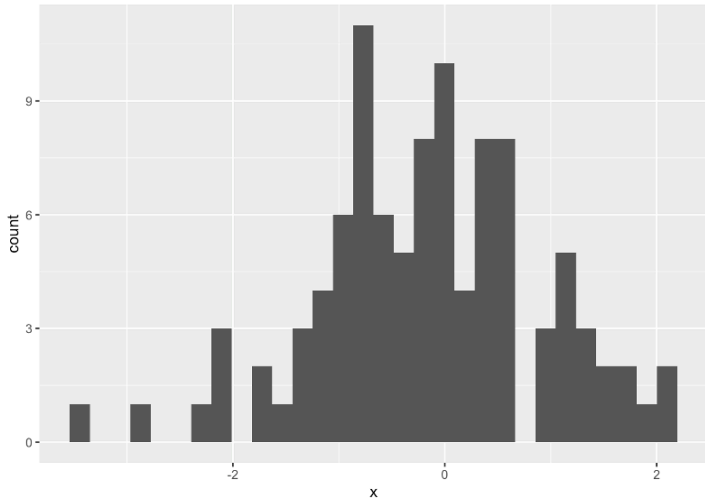
Hello, World!

This is a simple HTML page with R code.

```
library(ggplot2)

df ← data.frame(x = rnorm(100))
ggplot(df, aes(x = x)) +
  geom_histogram()
```

`stat_bin()` using `bins = 30`. Pick better value `binwidth`.

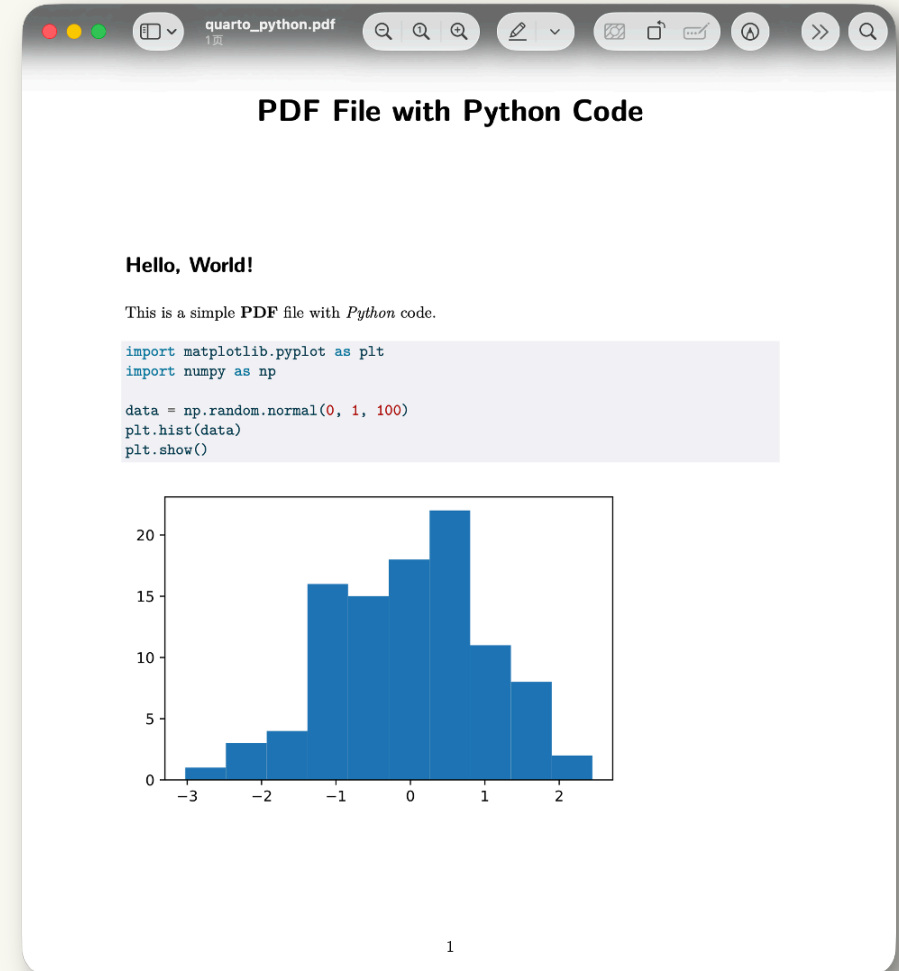



Original qmd file

Rendered PDF

Markdown + Python code chunks

```
1 ---
2 format: pdf
3 title: "PDF File with Python Code"
4 ---
5
6 # Hello, World!
7
8 This is a simple **PDF** file with *Python* code.
9
10 ```{python}
11 import matplotlib.pyplot as plt
12 import numpy as np
13
14 data = np.random.normal(0, 1, 100)
15 plt.hist(data)
16 plt.show()
17 ```
```

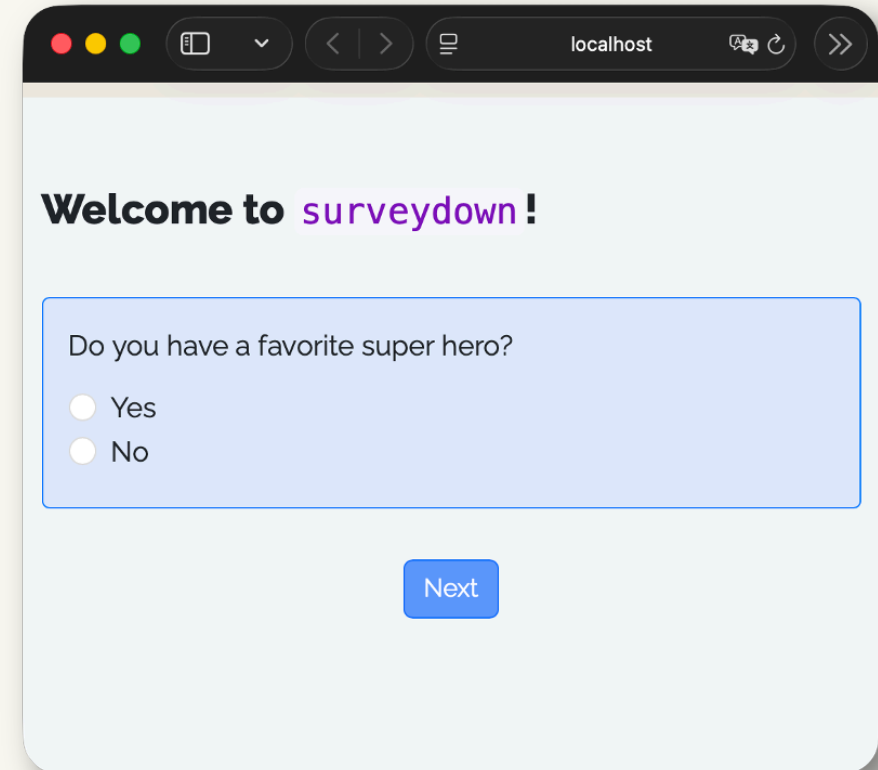




survey.qmd

```
1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 ::: {#welcome .sd-page}
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 :::
```

Rendered Survey



survey.qmd

```
1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
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23   )
24 )
25
26 sd_next()
27 ```
28
29 :::
```

YAML header for a “clean” output



survey.qmd

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22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 :::
```

Load the `surveydown` Package



survey.qmd

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21     "Yes" = "yes",
22     "No"  = "no"
23   )
24 )
25
26 sd_next()
27 ```
28
29 :::
```

Use Quarto fences (:::)
to define survey pages



survey.qmd

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1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
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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 :::
```

Page content

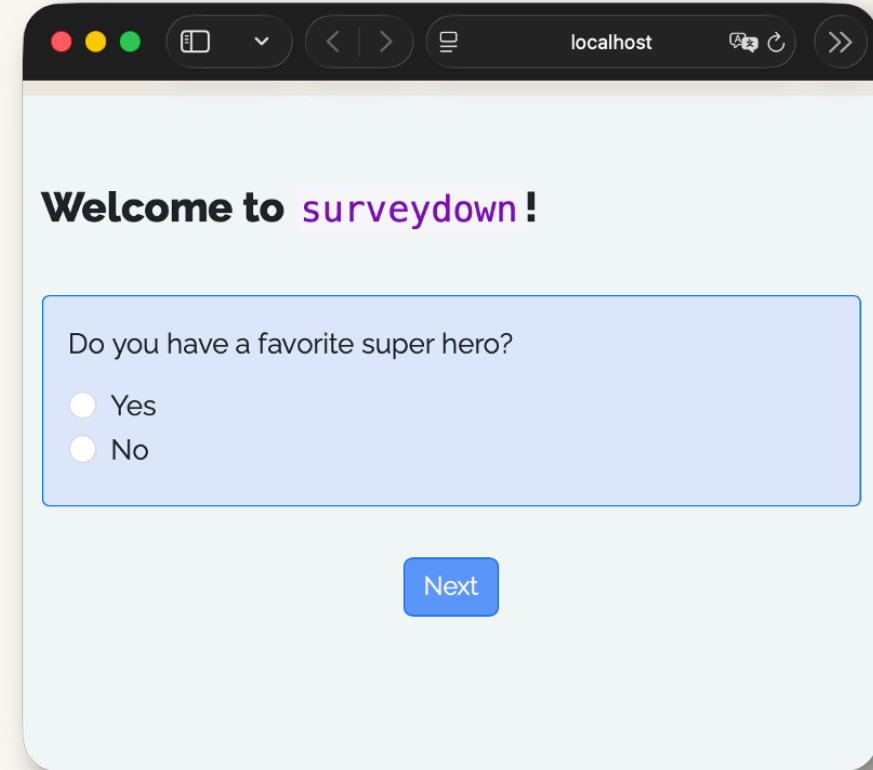
- Markdown for texts, images, etc.
- `sd_question()` for survey questions
- `sd_next()` for page navigation



survey.qmd

```
1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 ::: {#welcome .sd-page}
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 :::
```

Rendered Survey



survey.qmd

```

1 ---
2 format: html
3 echo: false
4 warning: false
5 ---
6
7 ```{r}
8 library(surveydown)
9 ```
10
11 ::: {#welcome .sd-page}
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 :::

```

Rendered Survey

localhost

Welcome to surveydown!

Do you have a favorite super hero?

Yes

No

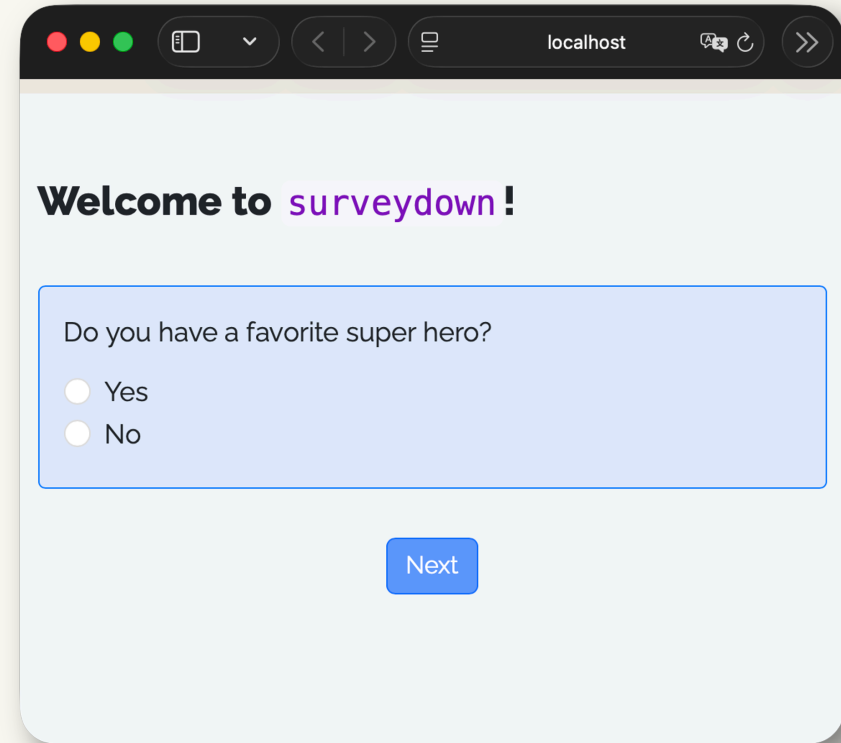
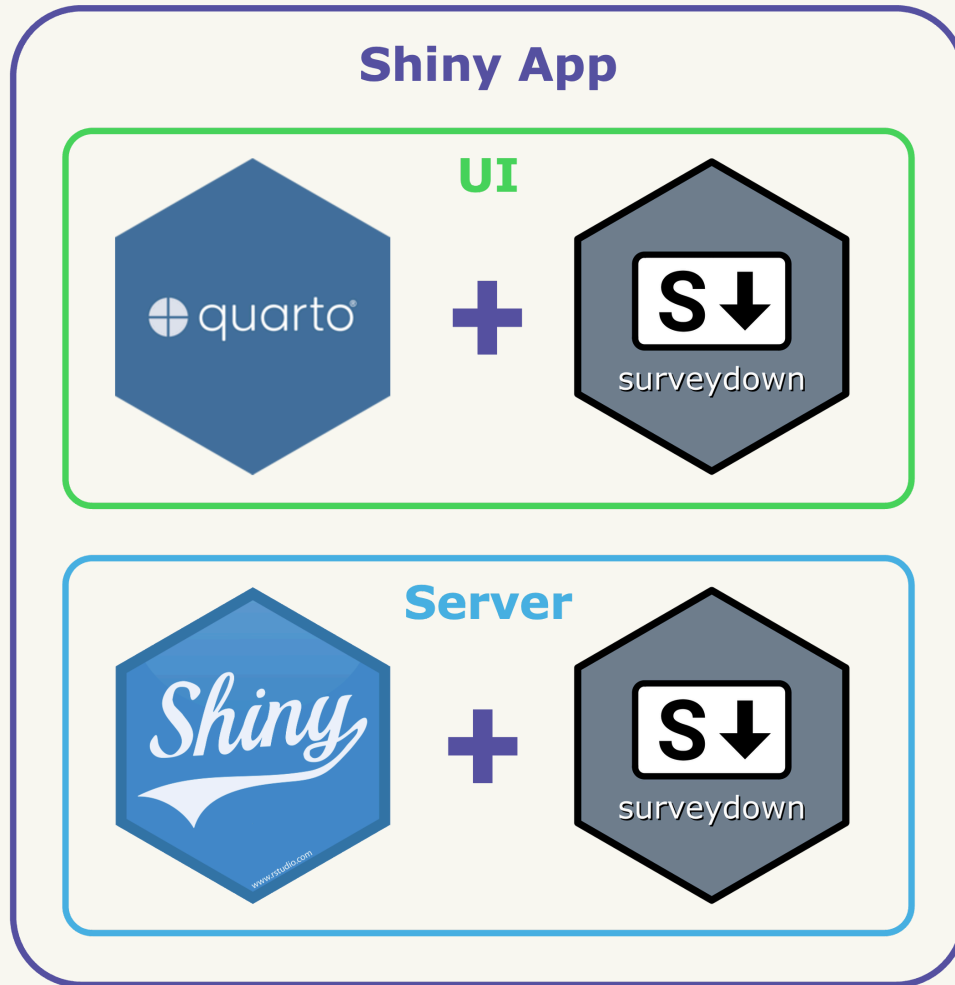
Next

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, texts, images, questions, etc).

`app.R`

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



PostgreSQL for response **data** storage.



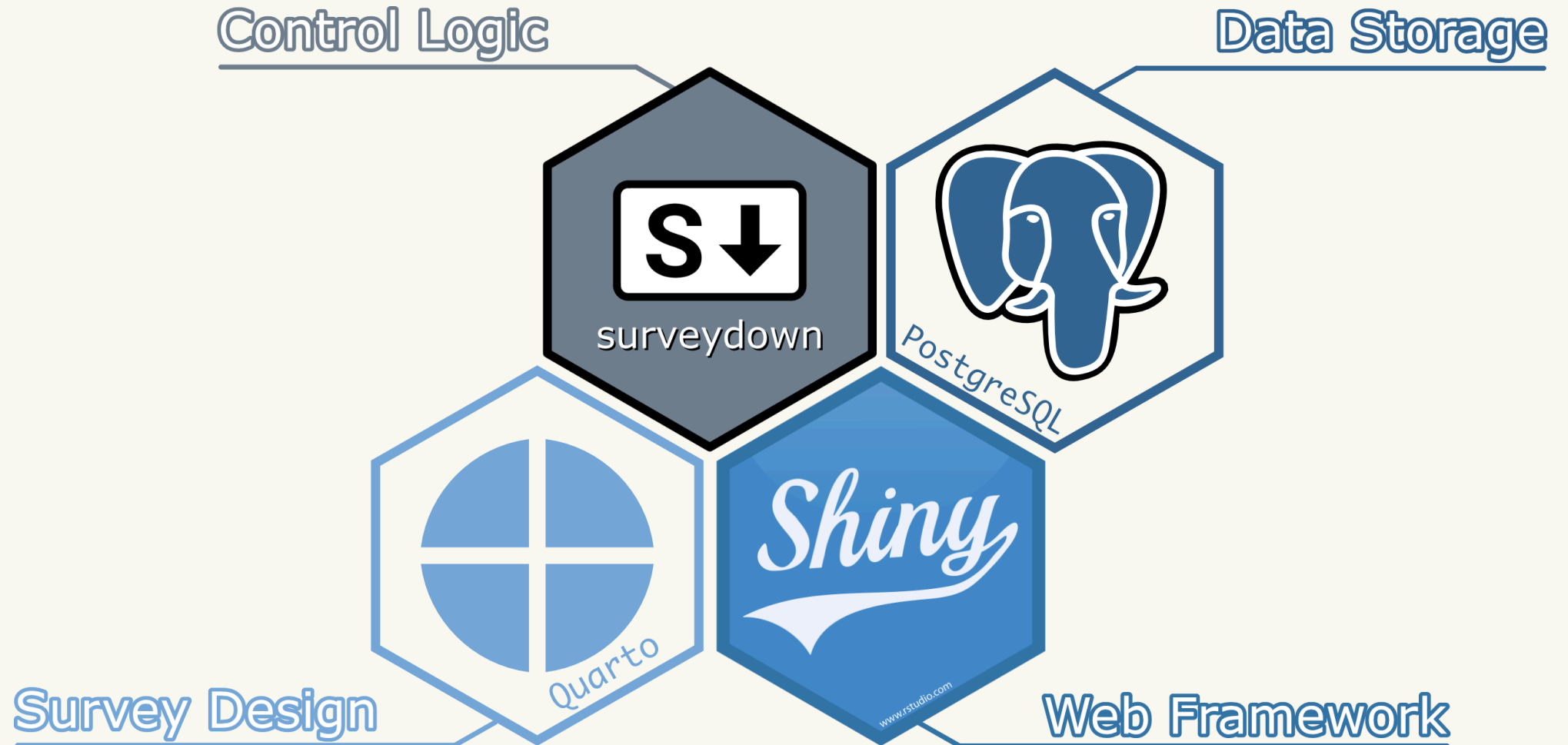
supabase.com

The screenshot shows the Supabase Table Editor interface for a table named 'superheros'. The interface includes a sidebar with a list of tables, a main table view, and a bottom navigation bar. The table data is as follows:

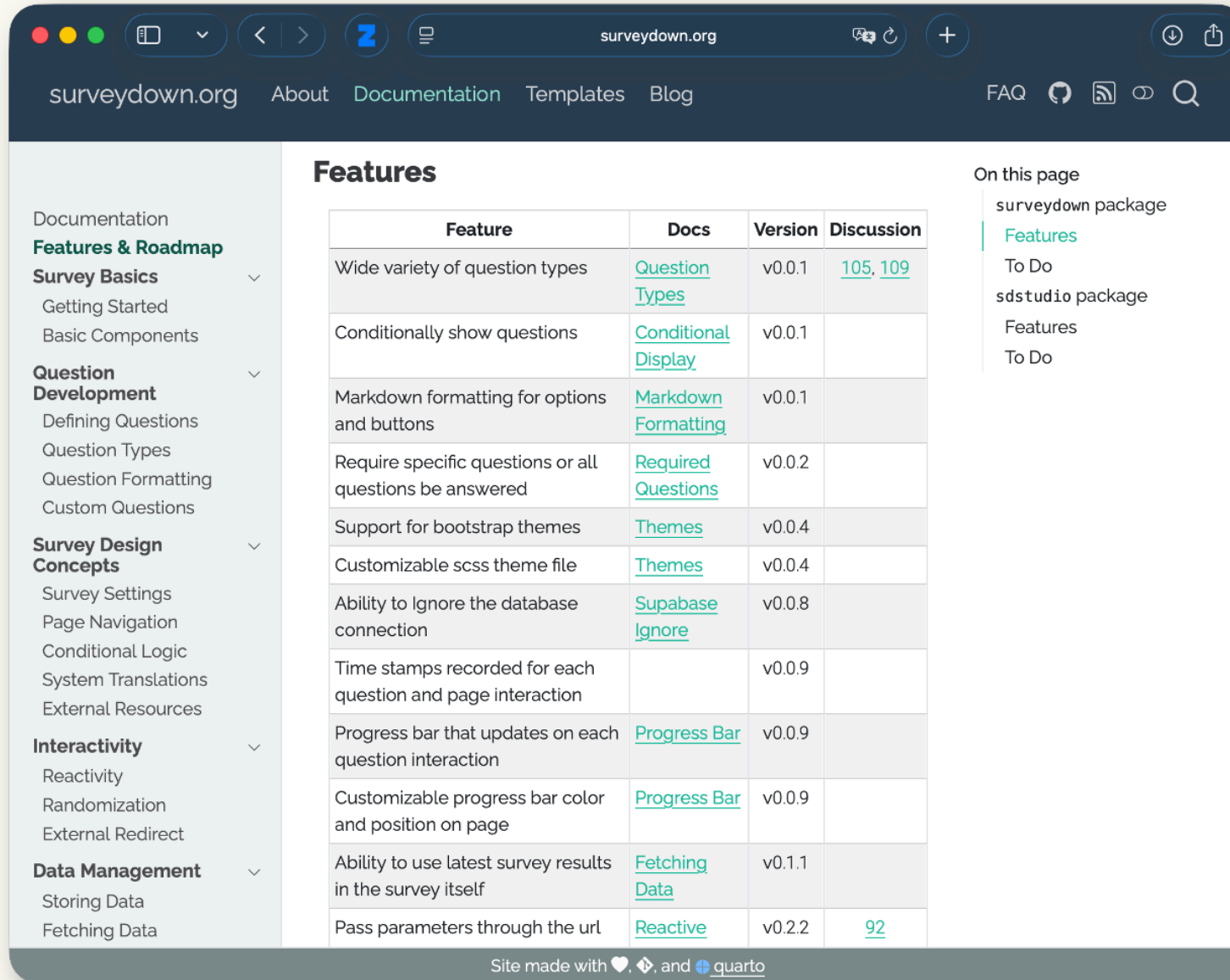
session_id	has_fav_hero	fav_hero_name	hero_universe
064585d4b3ce857a4a24e9dea4a657da	no	NULL	NULL
14d82544a547922107f492e6ee9a67dc	no	NULL	NULL
1eb83f38450cc4fa5b3bc8540d161f38	yes	Superman	dc
4ef1e74ae94737c502edb08db8e27f77	yes	NULL	marvel
5cf0f43d847425de2d015e1145ac3199	yes	Spiderman	all
676ae2ebd611f7fe70586c23af5b53c	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 main content area is titled "Features" and contains a table with the following data:

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 the right side of the page, there is a "On this page" section with a list of links: surveydown package, Features (highlighted), To Do, sdstudio package, Features, and To Do.

At the bottom of the page, it says "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? *

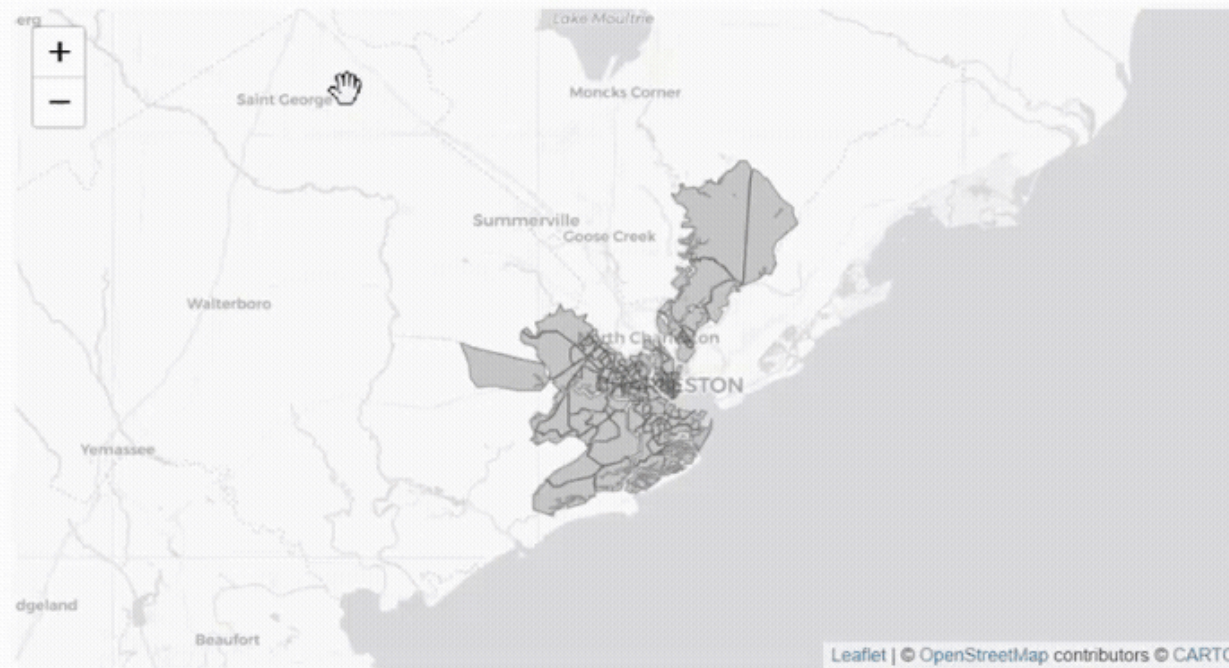
Option 1	Option 2	Option 3
		
Type: Fuji Price: \$ 2 / lb Freshness: Average	Type: Pink Lady Price: \$ 1.5 / lb Freshness: Excellent	Type: Honeycrisp Price: \$ 2 / lb Freshness: Poor



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





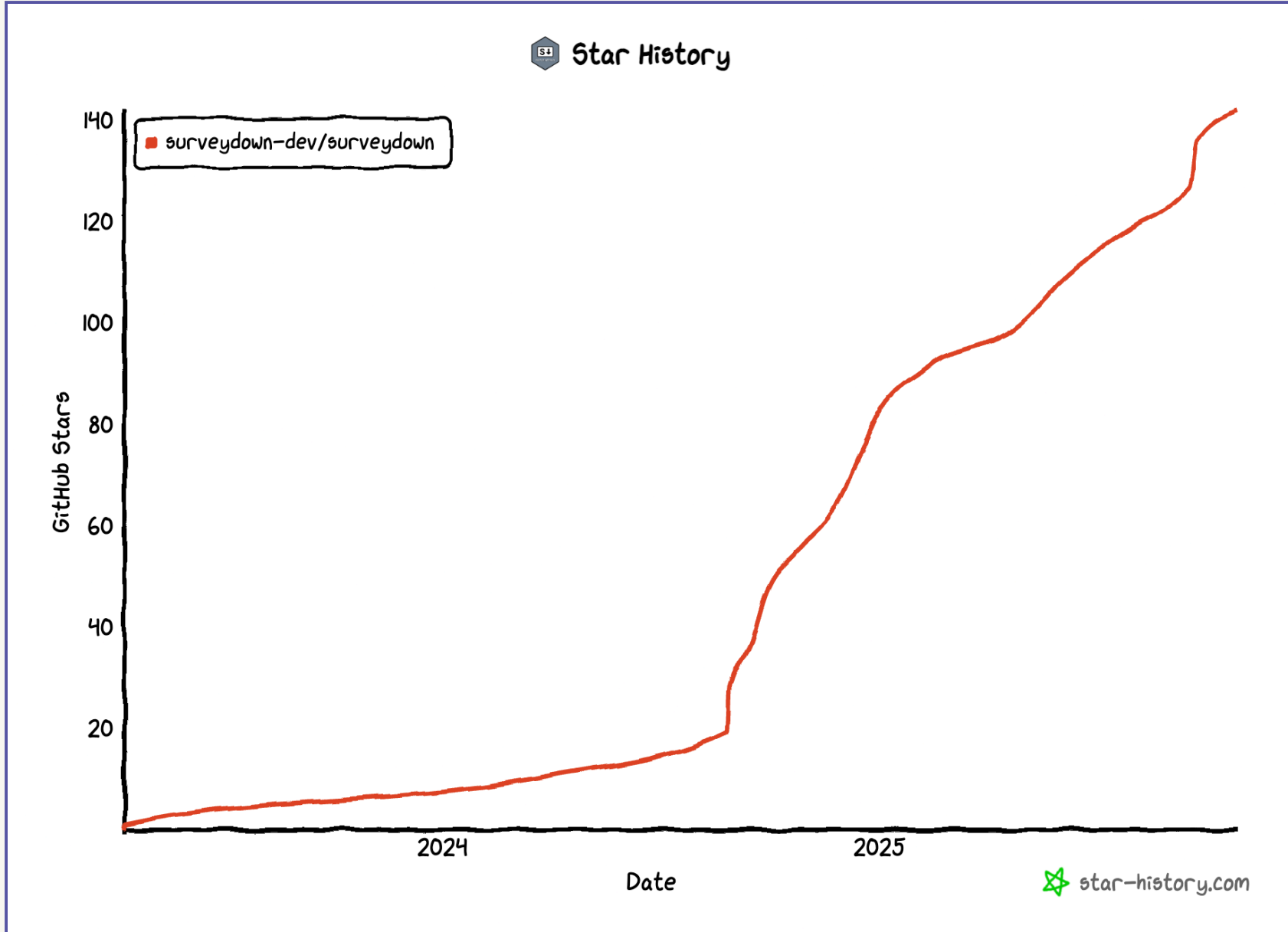
surveydown vs other platforms

Platform	User Interface	Cost	Reproducible	Open Source	Data Control	Programmable
Google Forms	GUI	Free	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
REDCap	GUI	Free/Paid	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Qualtrics	GUI	Paid	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Sawtooth	GUI	Paid	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
CASIC Builder	GUI	Paid	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
SurveyCTO	GUI	Paid	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
QDS	GUI	Paid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
LimeSurvey	GUI	Free/Paid	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Open Data Kit	XLSForms	Free/Paid	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
oTree	GUI, Python	Free/Paid	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SurveyJS	GUI, JavaScript	Free/Paid	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
formr	XLSForms, markdown, R	Free	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
shinysurveys	R, CSV	Free	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
surveydown	markdown (Quarto), R	Free	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Legend: = Yes, = Partially, = No



Star Count on GitHub



surveydown.org



Research Contributions

- **Study 1:** First *large N* survey study of EV owner *preference sensitivities* to smart charging. Introduces *attribute equivalencies* for incentive design.
- **Study 2:** Quantifies grid supply curves for *peak-shaving*, considering regions, seasons, EV-to-house ratios, and enrollment rates.
- **Study 3:** [surveydown](#), a free open-source survey platform for programmable, reproducible survey designs.



Timeline of Study 2

- **Nov 2025:** Sensitivity analysis on various scenarios.
- **Dec 2025:** Complete & submit manuscript for peer review.
- **Mar 2026:** Defend dissertation.



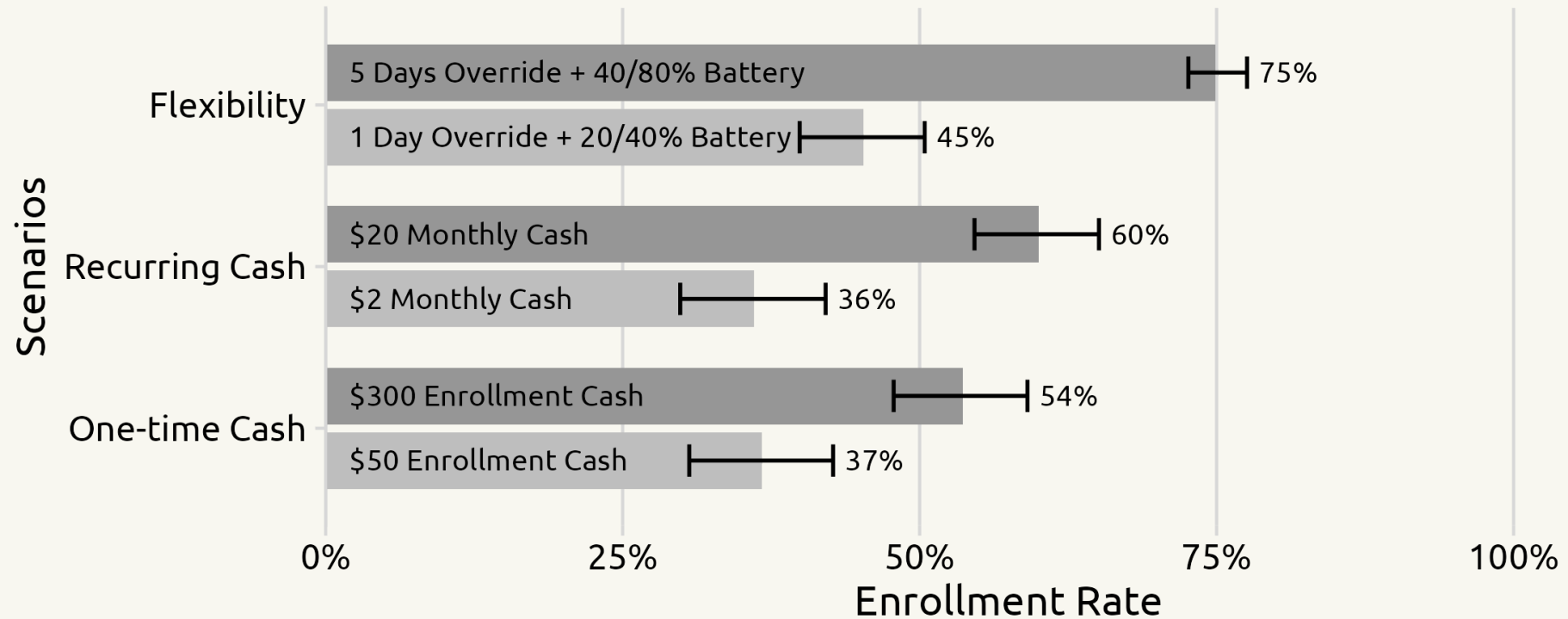
Thanks for listening!



Appendix



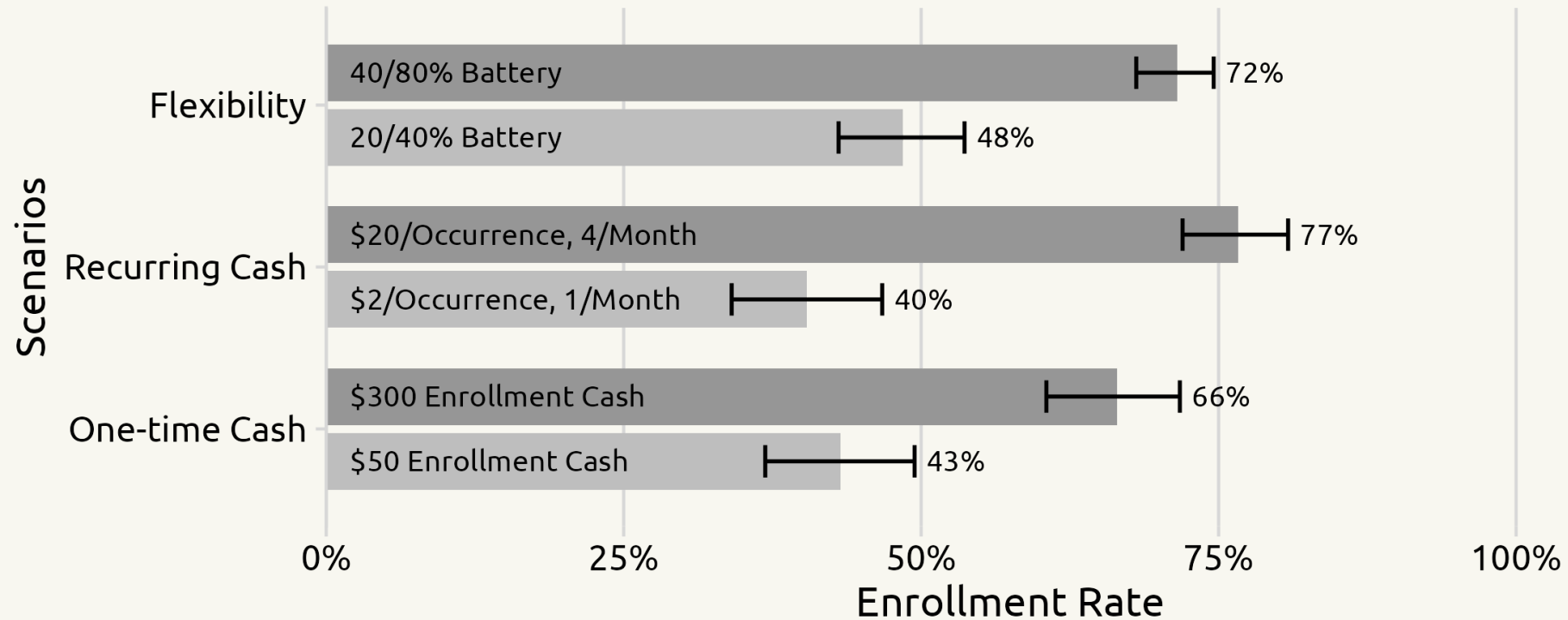
SMC Scenario Analysis



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 (%)

10

Guaranteed Threshold (%)

30

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.



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	-	-



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?",  
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

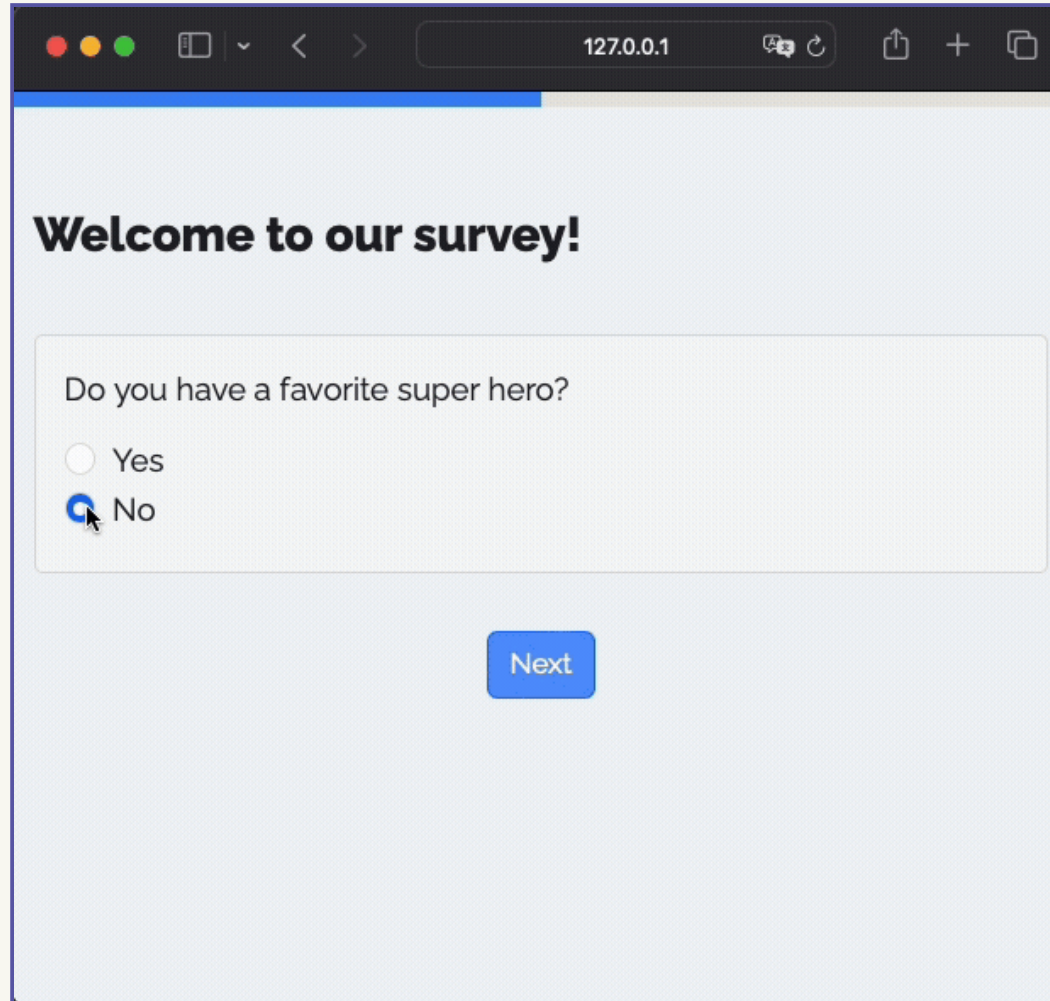
Conditional showing

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

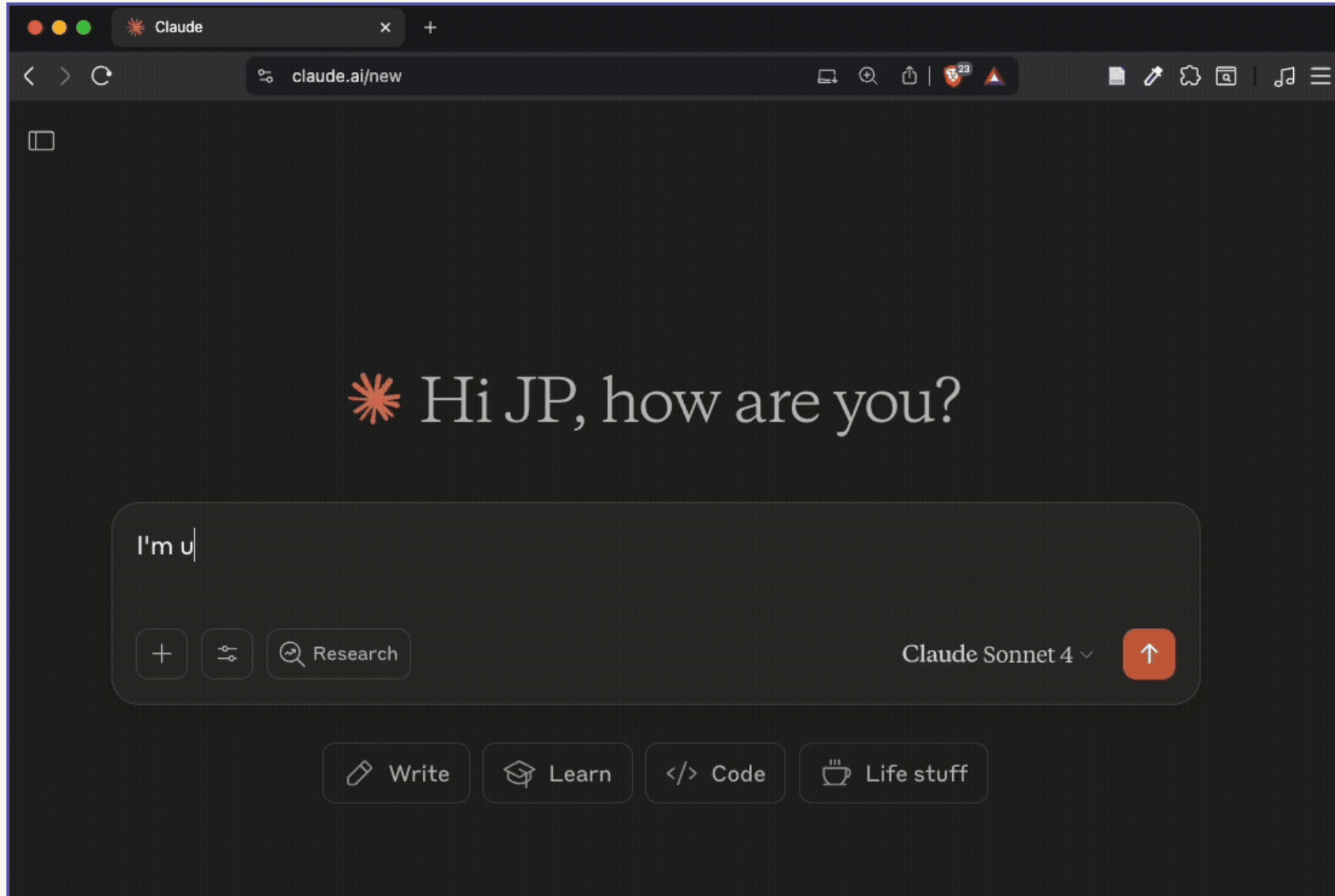
```
1 # Inside server
2 sd_show_if(
3   input$has_fav_hero == "yes" ~ "fav_hero"
4 )
```

Condition ~ Target

“If {condition}, then show {target}”



Generate surveys with LLMs!



The companion `sdstudio` package

The screenshot displays the `surveydown Studio` interface. The top navigation bar includes "surveydown Studio", "Build", "Preview", and "Responses". The main interface is split into two panels: "Structure" on the left and "Code" on the right.

Structure Panel:

- Page: welcome**
 - # 🦹 Welcome to the...
 - has_fav_hero** | mc: Do you have a favorite super hero?
 - fav_hero_name** | text: Who is your favorite super hero?
- Page: hero_details**
 - # Tell us about your...
 - hero_universe** | mc: Which superhero universe do you prefer?
 - hero_qualities** | mc_multiple: What qualities do you find most appealing in superheroes? (Select all that apply)
- Page: powers**
 - # If you could have...

Code Panel:

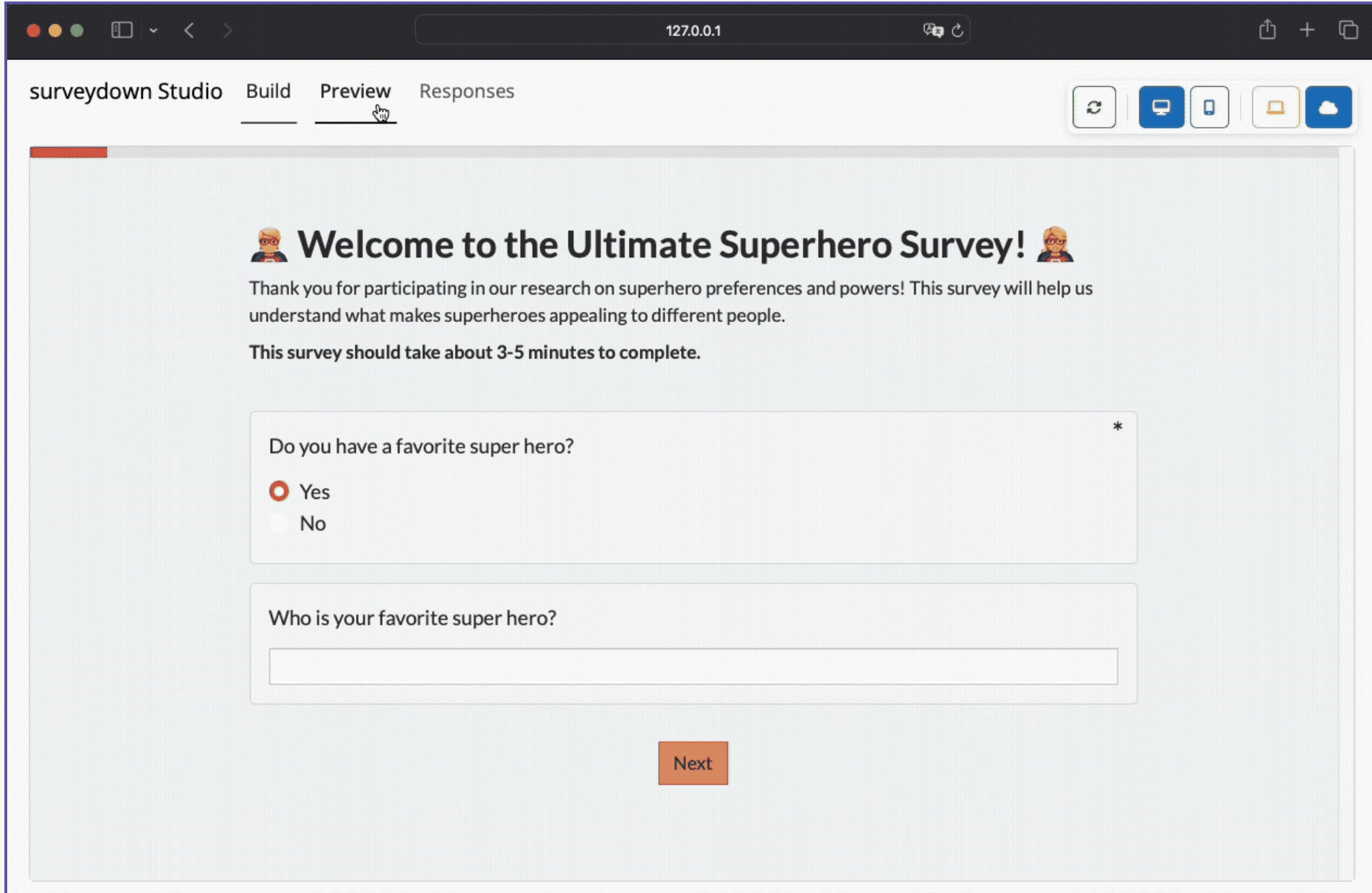
```

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 a web browser window displaying the 'surveydown Studio' interface. The browser's address bar shows '127.0.0.1'. The interface has a dark header with the text 'surveydown Studio' and navigation tabs: 'Build', 'Preview' (which is active and underlined), and 'Responses'. To the right of the tabs are several icons: a refresh icon, a desktop monitor icon, a mobile phone icon, a laptop icon, and a cloud icon.

The main content area is a light blue background with a white border. It features a welcome message with two superhero icons: **Welcome to the Ultimate Superhero Survey!**. Below this, there is a paragraph: '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.' followed by another paragraph: 'This survey should take about 3-5 minutes to complete.'

The first question is a radio button question: 'Do you have a favorite super hero?'. It has two options: 'Yes' (with a selected radio button) and 'No' (with an unselected radio button). A red asterisk is visible in the top right corner of the question box.

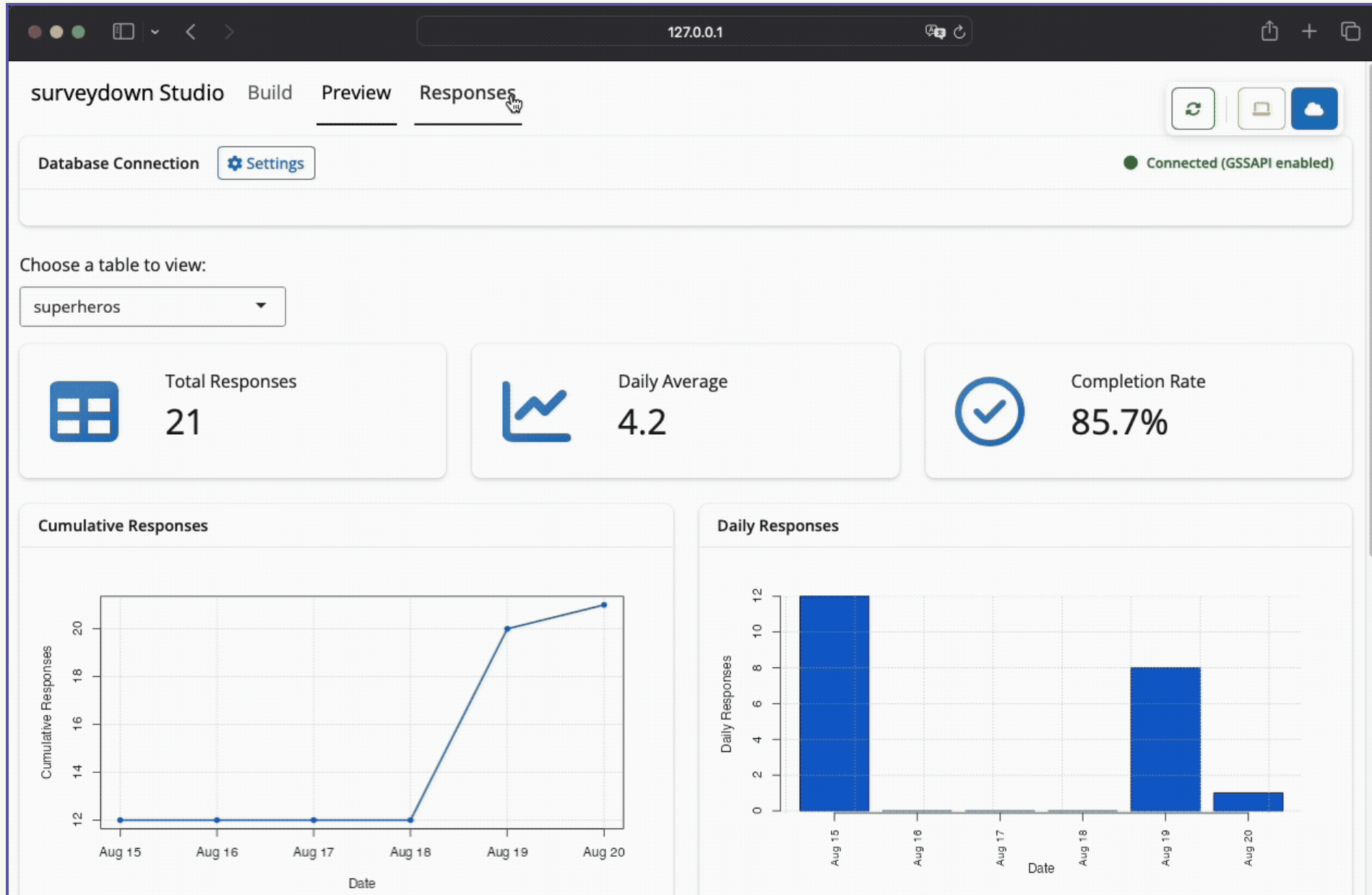
The second question is a text input field: 'Who is your favorite super hero?'. Below the question is a single-line text input box.

At the bottom center of the survey area is an orange button labeled 'Next'.





The companion **sdstudio** package





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>.

