National Grid EV and PHEV Demand Response Evaluation

Prepared for
National Grid
Study No.: MA21-DR04-E-Res EV

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Offering Overview

Offering Summary

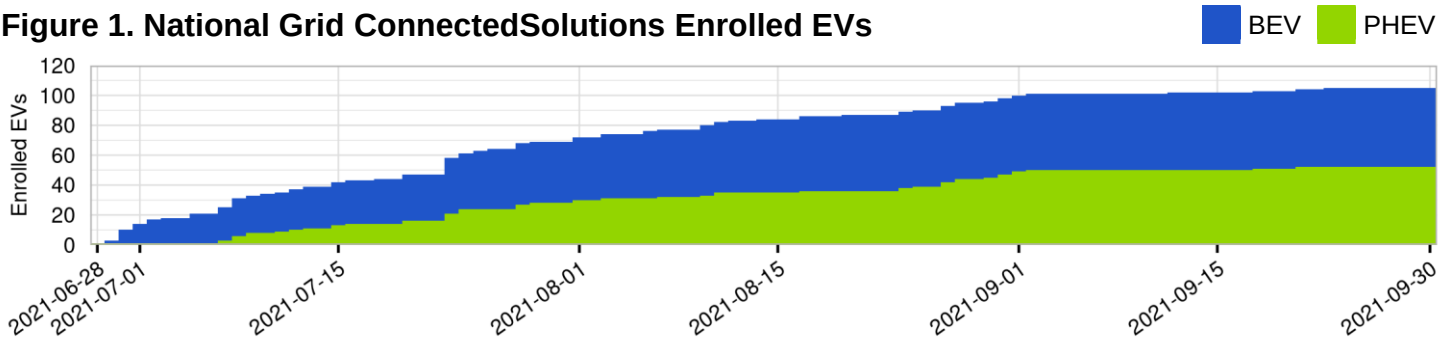
National Grid's ConnectedSolutions EV and PHEV Demand Response Offering aimed to test the potential of reducing peak demand of EV charging load by way of the vehicles' onboard telematics. In addition to testing the peak demand savings potential of the program, National Grid sought to understand customer tolerance of events and satisfaction with the program overall. Participating customers received an incentive upon program enrollment, a per-event incentive based on level of charging, and an annual incentive if they did not participate in any peak events.[1,2] These demand response events occurred for two to three hours during the hours of 2 p.m. to 7 p.m. on non-holiday weekdays and weekends. The primary objectives of this evaluation were to understand demand reductions resulting from incentives for peak events, to understand customer charging patterns, and to assess the customer experience in the program.

Table 1. EV Demand Response Offering Summary Highlights

Program Participant	**State**	Massachusetts	Key Vendors	**Demand Response Management System (DRMS)**	EnergyHub
	Customer Segment	Residential customers		**BEV and PHEV Original Equipment Manufacturers (OEM)**	BMW, Chevrolet, Ford, and Honda
Event Characteristics	**Number of Events**	26	**Event Timing**	2 p.m.–7 p.m. on non-holiday weekdays and weekends from June – September 2021.	
	Event Duration	2-3 hours	**Event Eligibility**	EV charging with Direct Current Fast Chargers were not signaled for events	
	Event Notification	Varies by OEM[3]	**Demand Reduction**	Full curtailment of charging during events	
	Opting Out	Depending on the EV OEM, customers can unplug and re-plug in the EV during the event, push a button in the EV, use the app, and/or respond to a text to opt out of an event.			
Incentives	**Sign-up and Annual**	• $25 enrollment incentive and $20 annual incentive, if customer participates in no events			
	Per-Event[4]	• $20 per event for Level 2 charging events[5] • $10 per event for Level 1 events[5] (incl. for charging outside of National Grid's territory)			

Source: Guidehouse

Figure 1. National Grid ConnectedSolutions Enrolled EVs



Note: The figure excludes 6 enrolled vehicles for which no charging data was provided
Source for Figure: Guidehouse analysis of EV vendor data

[1] This direct load control (DLC) offering is one of three EV managed charging offerings being implemented in Massachusetts in 2021. Along with National Grid's program, Eversource currently implements an EVSE DLC demonstration, as well as a pricing-based demonstration to encourage off-peak charging.

[2] After the June-September 2021 offering, the incentive structure was changed to include only an initial enrollment incentive and a flat annual incentive.

[3] One OEM sent notifications upon plug-in to customers if plug session time intersects with a DR event. Another OEM sent event notifications 24+ hours in advance, again at the start of the event, and at the end of the event to indicate charging will resume. Another OEM sent notifications to all customers at the start of events, whether or not the EV is plugged-in. The last OEM did not send event notifications; however, DR events were shown on the main app screen, in the customer's charging schedule.

[4] Customers need to participate for at least 50% of an event to earn the per-event incentive

[5] Level 1 Charging is defined by National Grid as any session below 1.8 kW. Level 2 charging is defined as any session above 1.8 kW.

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Evaluation Tasks and Methods

EV and PHEV Demand Response Offering Tasks and Evaluation Methods

PARTICIPANT SURVEY

Guidehouse developed, administered, and analyzed an online survey of participants to obtain information on participant driving and charging behavior (and factors that influence these behaviors) from June through September 2021.[6] Additionally, the survey asked about experiences with events and how events, and the program overall, impacted charging behavior. The survey was reviewed by and coordinated with the EV OEMs, in addition to National Grid and the EEAC Evaluation, Measurement, and Verification (EM&V) consultant.

DATA MANAGEMENT

Guidehouse received raw charging session data from each of the OEMs via EnergyHub. Guidehouse performed quality assurance/quality control (QA/QC) of the charging data and other data sources at the outset of the offering. Guidehouse cleaned and formatted the EV session data for the charging behavior, event participation, and impact analyses.

EVENT PERFORMANCE CALCULATION REVIEW

Guidehouse had working sessions with EnergyHub to review and revise their methodology for estimating impacts.[7]

ASSESSMENT OF CHARGING PROFILES

Guidehouse characterized typical charging profiles to understand the broader implications of EV charging and inform future program design changes. Additionally, the assessment of charging profiles explored whether there is evidence of "gaming,"[8] given the program's incentive design.

ASSESSMENT OF EVENT PARTICIPATION

Guidehouse categorized event participation (e.g., Technical Issue, Not Charging, Opt-Out, Partial Participant, Full Participant) for events that occurred in July and August 2021.

IMPACT ANALYSIS

Guidehouse estimated demand impacts during DR events that occurred from June through August 2021 using an engineering approach.[9] The engineering approach, based on total energy consumption during the plug session and the vehicle's state of charge, used an algorithm to estimate when charging would have concluded had no event been called.

REPORTING

Reporting included a draft presentation, a draft report, and a final report. Report contents include survey findings, demand reductions during events for June – August 2021, and findings and recommendations.

[6] The survey was a census attempt, which means it provides the actual numbers and sampling statistical significance is not relevant to its analyses.

[7] Guidehouse had planned to compare EnergyHub's estimates of demand impacts with evaluated impacts. However, the differences between the EV charging datasets that EnergyHub and Guidehouse received prevented EnergyHub from recreating Guidehouse's estimates of impacts.

[8] In other words, is there any evidence that participants are adjusting their charging behavior in anticipation of an event being called in order to receive the per-event incentive (e.g., adjusting their charging time or baseline state of charge)? To assess this, Guidehouse conducted select comparisons of charging patterns, for example, on event days v. non-event days. Guidehouse also investigated whether frequency of participation differed by OEM, due to the difference in event notifications by OEM.

[9] Guidehouse originally planned to estimate demand impacts using both an engineering approach and a within-subject regression approach. However, Guidehouse ultimately deemed the within-subject approach to be untenable given the design of the program (discussed further in section 2.4.2). Therefore, results from the within-subject approach are not included in this report.

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Findings: Customer Experience Research

PARTICIPANT SATISFACTION

- The majority of respondents (80%) reported that they would likely continue to participate in the program in the future.
- If a flat annual incentive of $20 was offered instead of per-event incentives, about half of all respondents would likely continue to participate in the program.
- At the same time, only 49% of respondents were satisfied or very satisfied with current program incentives.
- 31% of survey respondents believed they participated in at least 1 event but did not actually participate. Another 31% (17 out of 54) did not expect to earn per-event incentives.

Figure 2. Likelihood of Continued Program Participation

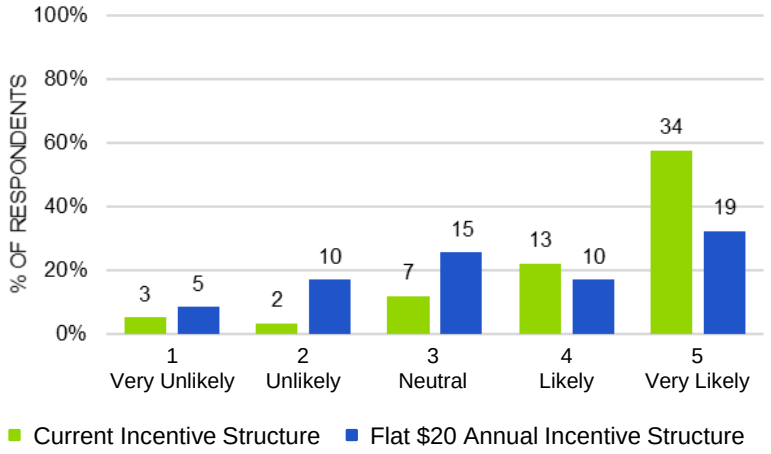
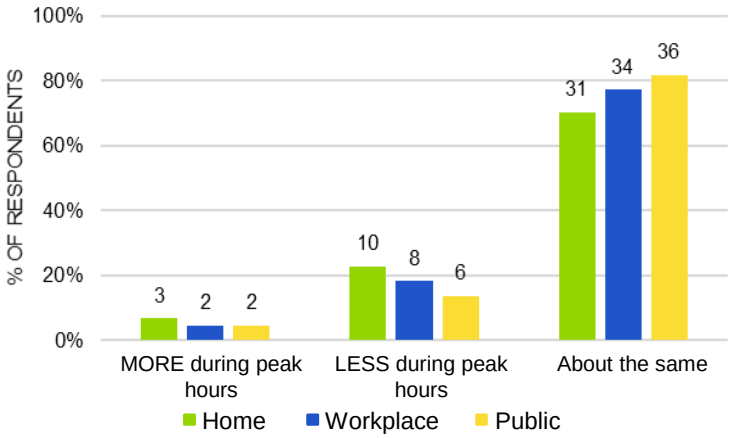


Figure 3. Typical Weekday Peak Charging, Compared to Summer 2020



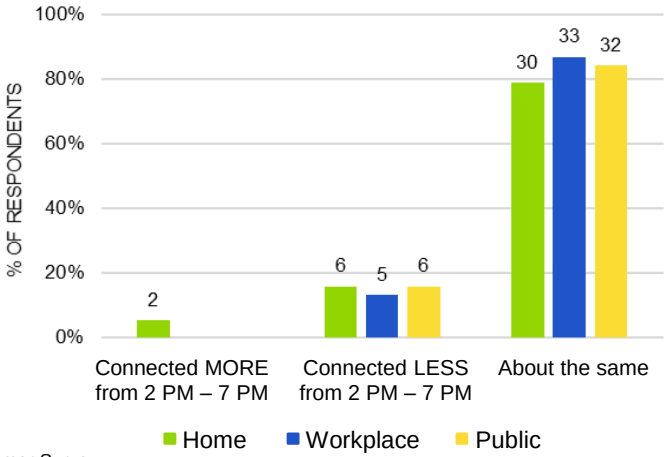
BEHAVIOR DURING EVENTS

- Sixty-four percent of respondents (38 out of 59) recalled at least one peak event in summer 2021.
  - Of the 38 of respondents who recalled at least one peak event, 28 (74%) said the events had no impact on their charging behavior during summer 2021.
  - Of the 36% respondents who did not recall any peak events, about half had EVs for which event notification was not provided.
- Only six respondents recalled opting-out or overriding at least one peak event.

EVSE CHARACTERISTICS & CHARGING BEHAVIOR

- About 56% of all respondents own a Level 2 charger, and the remaining 44% own a Level 1 charger at home.
- Over half of respondents charged their EV until full whenever it was connected to their homer charging device while one-third of respondents used a set charging schedule from their EV or EVSE App.
- Only 16 out of 59 respondents had access to workplace charging during summer 2021 and of these 16 respondents, 12 (75%) reported using workplace charging.
- Over half (53%) of all respondents reported using public chargers; location and availability of chargers were the most common barriers.

Figure 4. Plug-in Behavior Event Days v. Non-Event Days



Source for Figures: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

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Findings: Assessment of Charging Profiles

KEY FINDINGS

- **PHEVs plugged in more frequently than BEVs**. The median number of plug sessions per week was 5 for PHEVs and 2 for BEVs. Eighty-nine percent (89%) of BEVs and 48% of PHEVs plugged in an average of 4 times per week or less.
- **EV plug sessions started most frequently in the evening hours**. The single hour with the most plug-ins was 5 to 6 p.m. for both BEVs and PHEVs, with 11% and 10%, respectively, of plug-ins occurring during that hour.
- **Periods of peak energy consumption differ between BEVs and PHEVs**. Forty-five percent (45%) of all energy consumed on non-event weekdays by BEVs took place between 9 a.m. and 5 p.m., while only 21% of PHEV energy consumption occurred in the same period. This is reflective of BEV peak consumption occurring in the midday hours, while PHEV peak consumption was delayed to the late evening and overnight hours. One OEM's charging optimization system shifted charging for a portion of PHEVs to occur overnight, rather than charging immediately upon plug-in.
- **Hourly average power draw varied more by EV type than by weekday or weekend, and the two EV types' evening peaks occurred at different times of day**. The evening peak occurred at 5 p.m. to 7 p.m. for BEVs and at 7 p.m. to 9 p.m. for PHEVs. The PHEV evening peak was outside of the typical event hours of 4 p.m. to 7 p.m.
- **PHEVs charged a higher percent of their battery capacity per session compared to BEVs**. PHEVs plugged in at an average 47% SOC and unplugged at 88%, while the average BEV plugged in at 54% and unplugged at 78%.

Figure 5. Percent of Energy Consumed by Hour and EV Type – Non-Event Weekdays

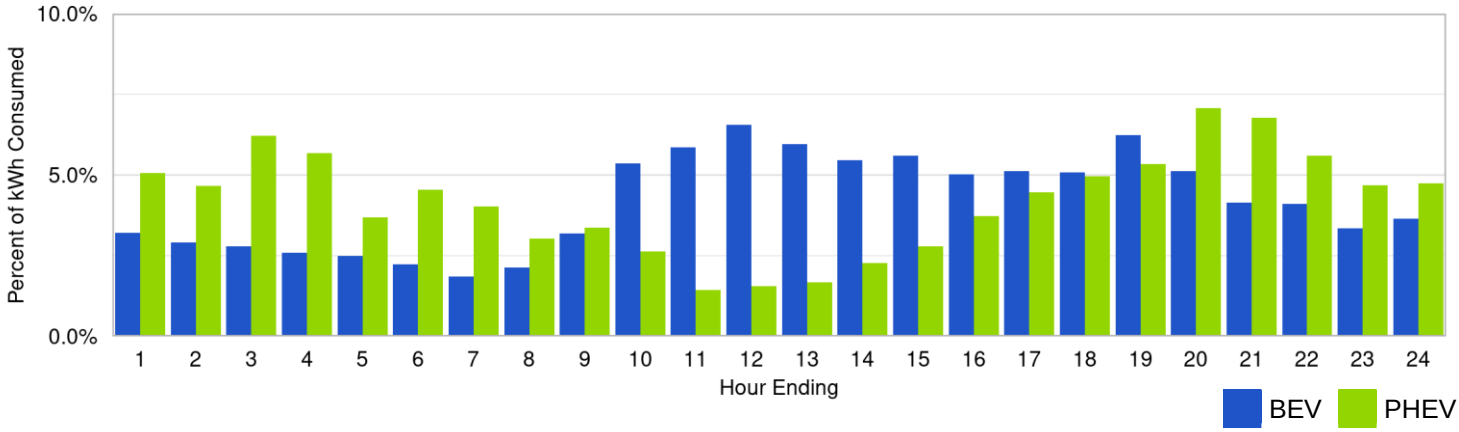
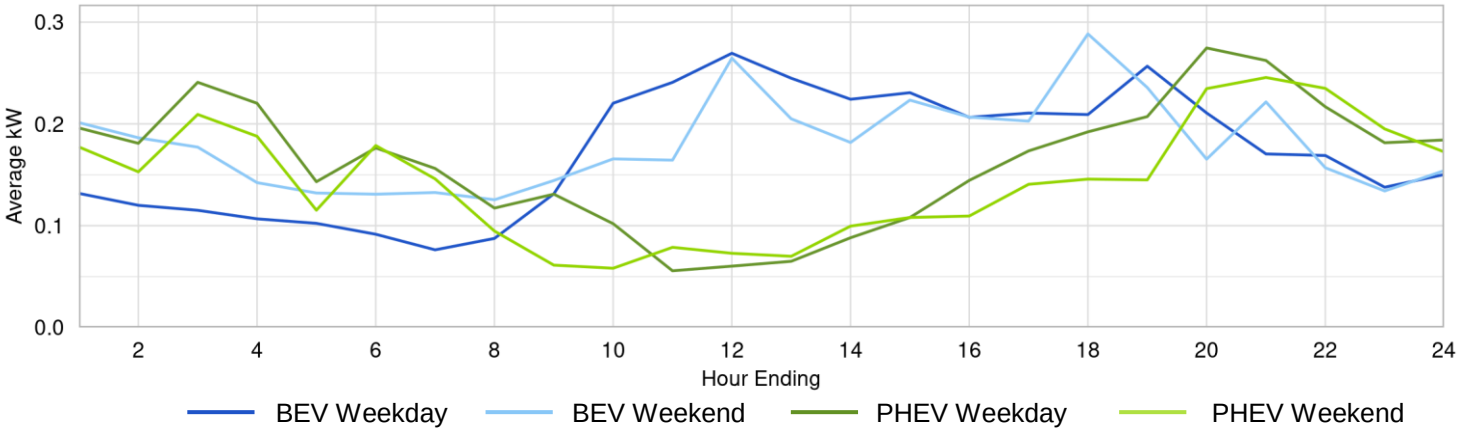


Figure 6. Hourly Average kW by EV Type and Day Type – Non-Event Days



Source for Figures: Guidehouse analysis of EV vendor data

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Findings: Event Participation and Impacts

KEY FINDINGS – EVENT PARTICIPATION

- **Most EVs were unplugged during the event and did not participate, making up 74% of all participation statuses across events**. Of the 86 EVs that were enrolled for at least 5 events, 43% participated in 0 events and 90% participated in fewer than 20% of the events they were enrolled for.
- **Technical issues or opt-outs accounted for 29% of all plugged-in participation statuses**. Of the 18 events that had 10 or more EVs plugged-in, technical issues or opt-outs ranged from 13% to 41% of plugged-in participation statuses.

Figure 7. Participation Status by EV Type

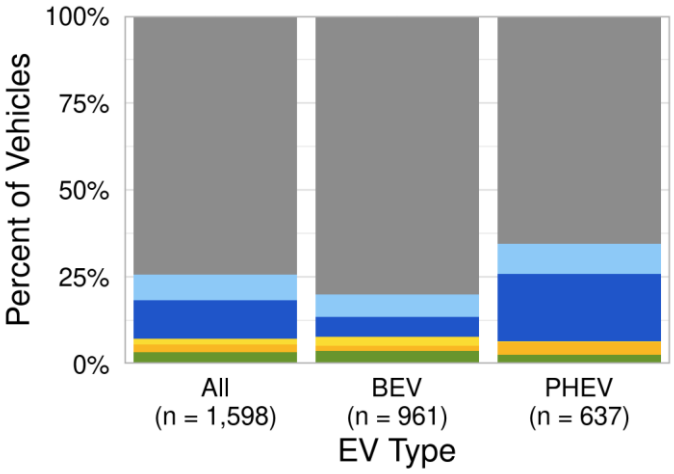

Figure 7 represents the average participation by EV type across all 23 evaluated events. Low participation is primarily driven by customers being unplugged for 74% of event periods. Full and partial participation accounted for 7.3% of event statuses and was slightly higher for BEVs compared to PHEVs (7.8% v. 6.4%, respectively).

Note: "n= " represents the number of participation statuses across all events.

KEY FINDINGS – IMPACT ANALYSIS

- **Demand impacts for all EVs averaged 0.09 kW across all events**. BEV and PHEV average impacts for the analysis period were 0.11 kW and 0.07 kW, respectively.
- **Average demand impacts of *event participants:* All EVs = 1.26 kW; BEVs = 1.36 kW; PHEVs = 1.07 kW**.
- **August events had higher average demand impacts than July events (0.11 kW v. 0.04 kW)**. Contributing factors include an increase in average event participation from 4.5% to 7.8% and an increase in average available line power from 1.53 kW to 2.58 kW.

Figure 8. Weighted Event Average kW Impact per EV by Month and EV Type

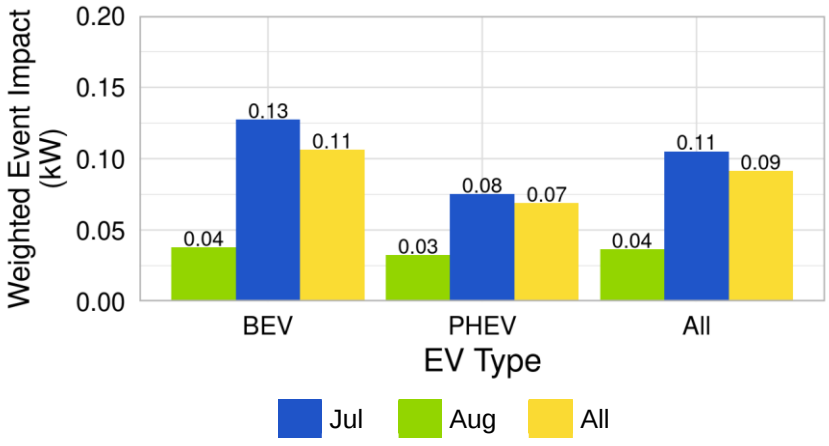

Figure 8 shows the average event kW impact per enrolled EV by month and EV type. In order to control for rolling enrollment, Guidehouse weighted event impacts by the number of enrolled EVs when calculating the monthly and season averages. Average event impacts of enrolled BEVs exceeded those observed for enrolled PHEVs in both July and August (0.04 and 0.13 kW v. 0.02 and 0.08 kW, respectively).

Source for Figures: Guidehouse analysis of EV vendor data

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Final Recommendations and Considerations

Table 4. Key Recommendations from the Evaluation

Research Category	Considerations
Data Collection	**RECOMMENDATION 1:** While the DRMS provider and OEMs have already worked to standardize fields, availability and quality of key fields should be confirmed with each OEM prior to the next evaluation.
	RECOMMENDATION 2: For future evaluations working with session data, clearer guidance should be provided to OEMs on how to summarize charging sessions that overlap event periods.
Impacts	**RECOMMENDATION 3:** Provide event opt-out data for future evaluations, to differentiate between opt-outs and technical issues.
	RECOMMENDATION 4: Claim 6.9 kW as the average total savings observed during ISO-NE peak hours that overlapped event periods.

Table 5. Key Considerations from the Evaluation

Research Category	Considerations
Program Information / Communication	**CONSIDERATION 1:** Consider improving and increasing the level of communication regarding how incentives are earned and when they will be rewarded. If a new annual incentive design is employed, this change should be clearly and directly communicated to existing participants.
Incentive Design	**CONSIDERATION 2:** Consider providing a minimum flat annual incentive to those who do not have the opportunity to earn per-event incentives as a result of never plugging in and/or charging during peak events. This may help minimize confusion/frustration and avoid incentivizing charging behavior that is contradictory to program goals.[10]
	CONSIDERATION 3: If a flat annual incentive for participation in the program is employed, National Grid should monitor program enrollment, satisfaction, and attrition rates to determine whether any adjustments to the level of sign-up and/or annual incentives are needed.
Data Collection	**CONSIDERATION 4:** If available, a more granular dataset such as 15-minute interval data or smaller charging blocks should be provided for future evaluations.
Impacts	**CONSIDERATION 5:** Due to the high proportion of technical issues or opt outs (relative to participating EVs), test that enrolled EVs can get called for events prior to season start.
	CONSIDERATION 6: Continue to monitor the effects of the program on participants' charging behavior on all days (not just event days) through surveys and other methods, as possible. Evaluate this type of behavioral effect to enable National Grid to claim the savings associated with participants choosing to charge during off-peak hours as a result of their participation in the program.

[10] Note that for the 2022 offering, National Grid replaced the per-event incentive with a flat annual incentive of $20, while also increasing the sign-up incentive from $25 to $50.

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1. Introduction

National Grid's ConnectedSolutions EV and PHEV Demand Response Offering (hereinafter referred to as the offering) aimed to test the potential of reducing peak demand of EV charging load by way of the vehicles' onboard telematics. In addition to testing the peak demand savings potential of the program, National Grid sought to understand customer tolerance of events and satisfaction with the program overall. Participating customers were provided incentives for the right to curtail their EV charging during demand reduction events that occurred for two to three hours during the hours of 2 p.m. to 7 p.m. on non-holiday weekdays and weekends from June through September 2021.[1]

This evaluation report describes Guidehouse's customer research, assessment of charging profiles, assessment of event participation, and analysis of impacts. Guidehouse's methodology, data sources used, and key findings are detailed in subsequent sections of this report.

1.1 Offering Summary

National Grid's offering aimed to test the potential of reducing peak demand of EV charging load by way of the vehicles' onboard telematics. Participating customers received an incentive upon program enrollment, a per-event rebate based on level of charging, and an annual incentive that is distributed if customers did not participate in any peak events.[2] Table 1-1 summarizes additional characteristics of the program in 2021.

Table 1-1. EV Demand Response Offering Summary

	Program Attributes	2021
Program Participants	**State**	Massachusetts
	Customer Segment	Residential
	Customer Subsegments	Owners of BMW, Chevrolet, Ford, and Honda Battery Electric Vehicles (BEVs) and Plug-In Hybrid Electric Vehicles (PHEVs)
Key Vendors	**Demand Response Management System (DRMS)**	EnergyHub
	BEV and PHEV Manufacturers	BMW, Chevrolet, Ford, and Honda
Event Characteristics	**Number of Events**	26
	Event Duration	2-3 hours
	Event Timing	Between 2 p.m. and 7 p.m. on non-holiday weekdays and weekends from June through September 2021
	Event Eligibility	EV charging with Direct Current Fast Chargers was not signaled for events
	Demand Reduction Approach	Full curtailment of charging during events

[1] This direct load control (DLC) offering is one of three EV managed charging offerings being implemented in Massachusetts in 2021. Along with National Grid's offering, Eversource currently implements an EVSE DLC demonstration, as well as a pricing-based demonstration to encourage off-peak charging.
[2] After the June-September 2021 offering, the incentive structure was changed to include only an initial enrollment incentive and a flat annual incentive.

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	Program Attributes	2021
	Opting Out	Customers can opt out of events in one of the following ways depending on the EV original equipment manufacturer (OEM): pushing a button in the car, opting out in the app, responding to a text message, and/or unplugging and re-plugging in the EV during the event
Event Notification	**Event Notification**	Varies by OEM[3]
Incentives	**Sign-up Incentive**	$25
	Annual Incentive	$20 per event for Level 2 charging events[4] $10 per event for Level 1 events (incl. for charging that takes place outside of National Grid's territory)[4] $20 annual incentive, if customer participates in no events Customers need to participate for at least 50% of an event to earn the per-event incentive

Source: Guidehouse

Figure 1-1 shows the number of EVs enrolled in the offering from June 2021 through September 2021.[5] On June 29, 2021, the first event day, there were three enrolled EVs. As the figure exhibits, enrollment totals increased throughout the event season for both EV types. On August 31, 2021, the last event day, there were 98 enrolled vehicles. Seven vehicles enrolled after this date, bringing the total to 105 vehicles (53 BEVs and 52 PHEVs).

[3] One OEM sent notifications upon plug-in to customers if plug session time intersects with a DR event. Another OEM sent event notifications 24+ hours in advance, again at the start of the event, and at the end of the event to indicate charging will resume. Another OEM sent notifications to all customers at the start of events, whether or not the EV is plugged-in. The last OEM did not send event notifications; however, DR events were shown on the main app screen, in the customer's charging schedule.

[4] Level 1 charging is defined by National Grid as any session below 1.8 kW. Level 2 charging is defined as any session above 1.8 kW.

[5] The figure and all analysis presented in this report exclude 6 enrolled vehicles for which Guidehouse was not provided charging data.

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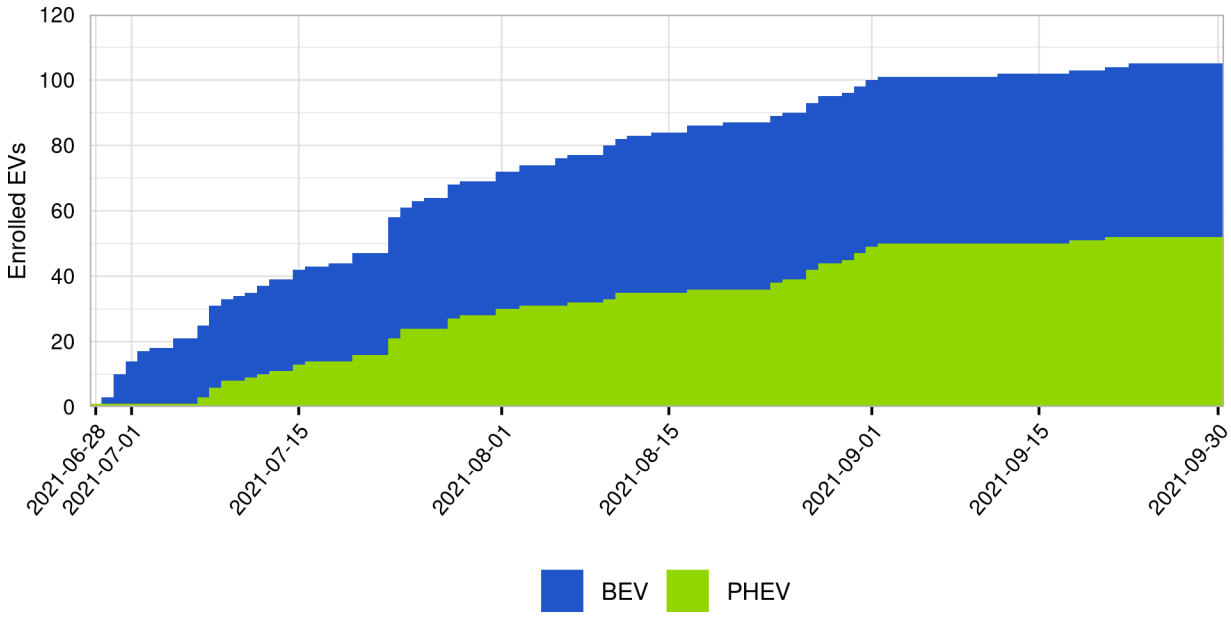
Figure 1-1. National Grid ConnectedSolutions Enrolled EVs



Note: The figure excludes 6 enrolled vehicles for which no charging data was provided.

Source: Guidehouse analysis of EV vendor data

Figure 1-2. summarizes the 26 events called from June through August 2021, including 11 consecutive days from August 10-20. A majority of the events took place in one of two time periods, with 11 occurring from 4 p.m. to 6 p.m. and another 10 from 5 p.m. to 7 p.m. At least one event occurred each day of the week.

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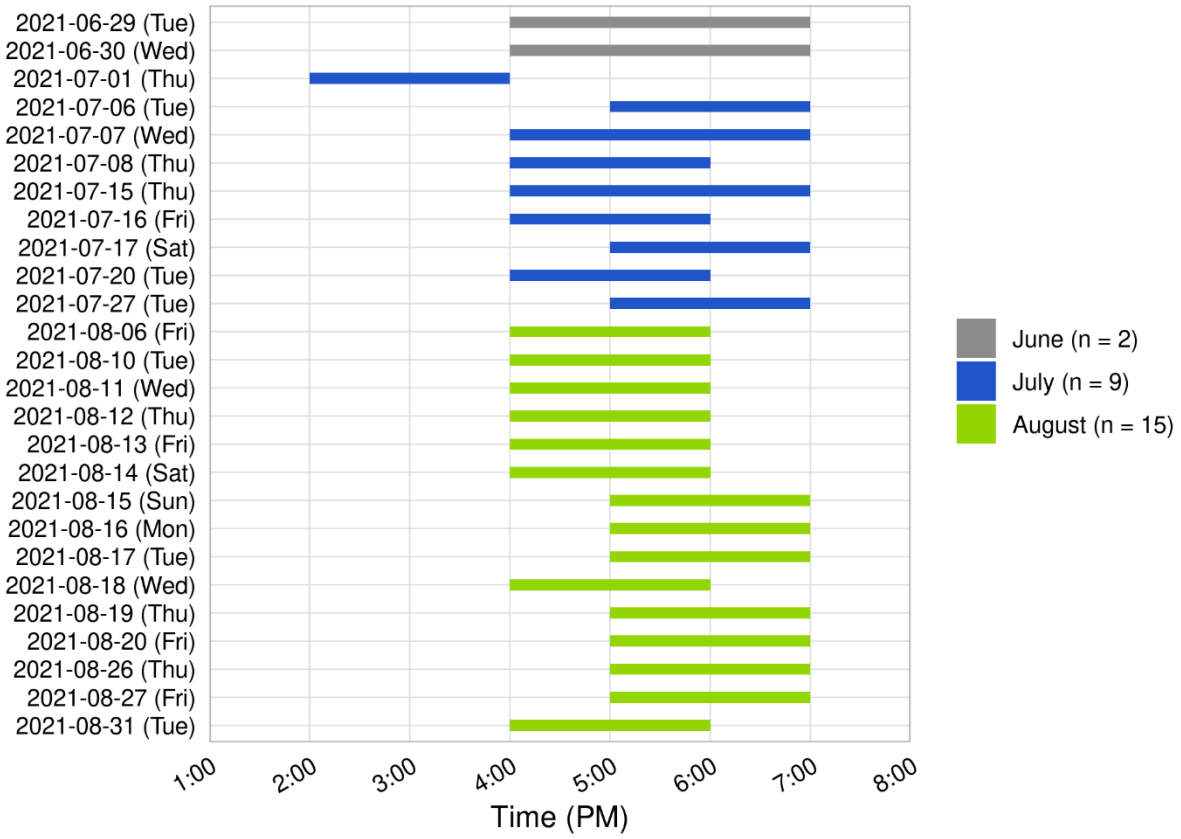
Figure 1-2. Schedule of National Grid Demand Response Events



Note: “n = “ represents the number of events that occurred during a month.

Source: Guidehouse and DRMS provider

1.2 Evaluation Objectives

The primary objectives of this evaluation are to verify that the solution being tested successfully enables demand reductions, and, if so, by how much, as well as to assess customer acceptance of the solution. Additionally, the evaluation seeks to understand customer charging behavior on event and non-event days during the summer.

These objectives will be achieved through the investigation of several research questions relating to 1) Demand Response (DR) Impacts, 2) Customer Segments, and 3) Program Design and Scalability. This evaluation will include the design of the evaluation, implementation, and analyses for the first and second research questions. National Grid will use the data obtained during the evaluation as part of the assessment of the third research question: program design and scalability. These research questions are listed in the table below.

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Table 1-2. BEV and PHEV Program Evaluation Research Questions

Category	Research Question
DR Impacts	• What are typical charging patterns of participants both during DR event periods and outside of DR event periods? For example, percent of charging occurring during certain hours, percent of charging occurring at home or workplace/public electric vehicle supply equipment (EVSE) • What are demand impacts during the DR event? What are demand impacts for all enrolled EVs v. impacts for participating[6] EVs only? • What are opt out rates during DR events? Why are customers opting out?
Customer Segments	• What participant characteristics impact charging patterns? For example, whether the enrolled vehicle is a BEV or PHEV.
Program Design and Scalability (Conducted by National Grid, but the data is obtained through this evaluation.)	• Are customers satisfied with the amount and type of information they are provided about the program? • What is the customer satisfaction with program design features? For example, event notification (including method(s) and timing relative to the event, i.e., how much notice is given), event frequency, event duration, rebate structure • Is there any evidence that participants are adjusting their charging behavior in anticipation of an event being called in order to receive the per-event incentive? • How likely are customers to continue to participate and how should program parameters be modified to achieve greater savings and/or increase customer acceptance of and satisfaction with the solution?[7]

Source: Guidehouse

[6] i.e., actively contributing to load reduction.

[7] Customer acceptance of and satisfaction with the program offerings may be assessed by looking at enrollment and unenrollment rates, unenrollment reasons, rate of opt-out, and self-reported feedback on the degree to which events are viewed as an inconvenience to participants or require participants to adjust their driving or charging behavior, as well as on how satisfied participants are with program design features (e.g., event notification, event frequency, event duration, rebate structure).

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2. Evaluation Tasks and Methods

The evaluation assessed the extent to which the technology solution achieves demand savings, as well as on customer acceptance of the DR offering. Table 2-1 summarizes the evaluation approach.

Table 2-1. EV DLC Offering Evaluation Tasks

Task	Description
Participant Survey	Guidehouse developed, administered, and analyzed an online survey of participants[8] to obtain information on participant driving and charging behavior (and factors that influence these behaviors) from June through September 2021. Additionally, the survey asked about experiences with events and how events, and the program overall, impacted charging behavior. The survey was reviewed by and coordinated with the EV OEMs, in addition to National Grid and the EEAC EM&V consultant. • **Primary Data Collection:** Post-Summer Survey • **Data:** EV Participation, Event Information
Data Management	Guidehouse received raw charging session data from each of the OEMs via EnergyHub. Guidehouse performed quality assurance/quality control (QA/QC) of the charging data and other data sources at the outset of the offering. Guidehouse cleaned and formatted the EV session data for the charging behavior, event participation, and impact analyses. • **Primary Data Collection:** N/A • **Data:** EV Participation, Event Information, EV Charging Session Data, EV Model Specifications
Event Performance Calculation Review	Guidehouse had working sessions with EnergyHub to review and revise their methodology for estimating impacts.[9] • **Primary Data Collection:** N/A • **Data:** EV Charging Session Data
Assessment of Charging Profiles	Guidehouse characterized typical charging profiles to understand the broader implications of EV charging and inform future program design changes. Additionally, the assessment of charging profiles explored whether there is evidence of "gaming,"[10] given the program's incentive design. • **Primary Data Collection**: N/A • **Data:** EV Participation, Event Information, EV Charging Session Data, EV Model Specifications

[8] The survey was a census attempt, which means sampling statistical significance is not relevant to its analyses.

[9] Guidehouse had planned to compare EnergyHub's estimates of demand impacts with evaluated impacts. However, the differences between the EV charging datasets that EnergyHub and Guidehouse received prevented EnergyHub from recreating Guidehouse's estimates of impacts.

[10] In other words, is there any evidence that participants are adjusting their charging behavior in anticipation of an event being called in order to receive the per-event incentive (e.g., adjusting their charging time or baseline state of charge)? To assess this, Guidehouse conducted select comparisons of charging patterns, for example, on event days v. non-event days. Guidehouse also investigated whether frequency of participation differed by OEM, due to the difference in event notifications by OEM.

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Task	Description
Assessment of Event Participation	Guidehouse categorized event participation (e.g., Technical Issue, Not Charging, Opt-Out, Partial Participant, Full Participant) for events that occurred in July and August 2021. • **Primary Data Collection:** N/A • **Data:** EV Participation, Event Information, EV Charging Session Data, EV Model Specifications
Impact Analysis	Guidehouse estimated demand impacts during DR events that occurred from June through August 2021 using an engineering approach.[11] The **engineering approach**, based on total energy consumption during the plug session and the vehicle's state of charge, used an algorithm to estimate when charging would have concluded had no event been called. • **Primary Data Collection:** N/A • **Data:** EV Participation, Event Information, EV Charging Session Data, EV Model Specifications
Reporting	Reporting includes a draft presentation, and draft and final report. The contents of reporting are as follow: • Demand reductions during events for June 2021 – August 2021 • 2021 post-summer survey findings • Findings and recommendations

Source: Guidehouse

The remainder of this section provides additional detail regarding the evaluation approach for each of the items listed in Table 2-1.

2.1 Customer Experience Research

Guidehouse administered one online participant survey in November 2021. Survey invitations were sent by email and reminders were sent to participants between 3 and 5 days after the initial invite was sent. Table 2-2 summarizes the time period covered by the survey, the sampling approach, and completion rate. The response rate of the survey was 56%.

The survey was administered to all Massachusetts program participants who enrolled prior to August 31, 2021. Respondents were provided $10 for completing the survey.

[11] Guidehouse originally planned to estimate demand impacts using both an engineering approach and a within-subject regression approach. However, Guidehouse ultimately deemed the within-subject approach to be untenable given the design of the program (discussed further in section 2.4.2). Therefore, results from the within-subject approach are not included in this report.

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Table 2-2. Participant Survey Summary

Survey Topics	2021 Post-Summer Survey
Time Period Covered	2021 summer (June – August)
Survey Fielded	November 19 – December 5, 2021
Sampling Approach	Attempted census of all customers enrolled prior to August 31, 2021
Invites Sent*	106
Surveys Started	63
Completes	59
Response Rate**	56%

*Based on Enrollment and Incentives filed prior to 08/31/2021; counts include "Accepted" status only.

**Response rate is calculated as the ratio of completes relative to invites sent.

Source: Guidehouse

Table 2-3 summarizes the topics covered in the post-summer 2021 survey. Certain topics were only presented to subsets of respondents as indicated in the table.

Table 2-3. Participant Survey Topics

Survey Topics	Respondents Asked
Motivations and enrollment process	All respondents
EV Information	All respondents
Charging Behavior Summer 2021	All respondents
Change in Driving & Charging Behavior Relative to Summer 2020	All respondents except for those that bought their EV after summer 2020
Additional EVs in Household	Respondents who selected that they own any additional EV(s) that are not enrolled in the program
Charging Behavior During Peak Events	All respondents
Satisfactions and suggestions for Program Improvement	All respondents
Participant Demographics	All respondents

Source: Guidehouse

Table 2-4 includes Guidehouse's activities for the participant survey. The survey instrument for the survey effort is contained in Appendix A.

Table 2-4. Participant Survey Activities

Category	Activities
Survey Design and Programming	• Developed draft survey instrument • Finalized survey instrument based on feedback from National Grid and EEAC Evaluation, Measurement, and Verification consultants. • Programmed survey • QA/QC of programmed survey

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Category	Activities
Sample Preparation	• Received latest enrolled participant information (including contact information) • Prepared samples (e.g., remove those enrolled after August 31, 2021)
Survey Implementation	• Provided National Grid call center with information about the survey effort • Contacted program participants with a link to the online survey • Monitored survey completions • Sent reminder emails • Administered $10 e-gift cards for respondents who completed the survey
Data Cleaning and Analysis	• Cleaned/recoded data in preparation for analysis (including cleaning and coding of verbatim/open-ended responses) • Analyzed data using R

Source: Guidehouse

2.2 Assessment of Charging Profiles

Understanding how customers charge their EVs throughout the analysis period helps inform the appropriate baseline approach for use in the impact analysis, provides insight into the observed per-event savings (e.g., opt-out rates, utilization rates), and informs program scalability.

For this analysis, Guidehouse assessed metrics including average session frequency, session start times, plug-in and plug-out state of charge (SOC), hourly power draw and energy consumption, charging session location, and enrolled vehicle characteristics.

Additionally, the assessment of charging profiles explored whether there was evidence of "gaming". In other words, Guidehouse investigated whether there was any evidence that participants adjusted their charging behavior in anticipation of an event being called in order to receive the per-event incentive.

2.3 Assessment of Event Participation

Guidehouse categorized enrolled EVs into event participation status categories (e.g., full participants, partial participants, non-participants) and analyzed participation status by event[12]. The participation status categories are as follows:

- **Full Participant:** EV was plugged-in and charging at the start of the event and not used during the event
- **Partial Participant**: EV was plugged-in for only part of an event, and was curtailed during that period

[12] The demand reduction approach for this program was to fully curtail charging during event periods. However, Guidehouse observed instances of reduced, but not fully shut-off, charging occurring during the event window. These instances were sometimes categorized as partial or full participants, as detailed in Section 4.3.

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  - **Partial, Plug-in Late**: EV plugged-in after the event started and then was curtailed while plugged-in
  - **Partial, Plug-out Early**: EV was plugged-in and curtailed from the start of the event, and then unplugged during the event
- **Unplugged**: EV was not plugged-in at that start of and throughout the event
- **Plugged-in, Not Charging**: EV was plugged-in but not charging before, during, and after the event[13]
- **Plugged-in, Technical Issue or Opt Out**: EV did not participate due to connectivity, failure to receive DR signal, or decision to opt out[14]

2.4 Impact Analysis

Guidehouse estimated demand impacts during the demand response event for events that occurred in July and August 2021 using an engineering approach. Guidehouse did not include the first three events of the summer 2021 season (June 29th, June 30th, and July 1st) in the impact and participation analyses due to fewer than 15 EVs being enrolled on each of the three event days.

2.4.1 Engineering Approach

The Guidehouse engineering approach is an algorithm used to estimate when charging would have occurred (i.e., counterfactual charging) had no event been called. The counterfactual charging for each EV participating in the event was estimated using total energy consumption that occurred during and after the event, the vehicle's state of charge during the event, power draw observed during the plug session, EV onboard charging rate[15], and the available line power of the plug session. The engineering approach did not capture any behavioral effects on charging resulting from the event.

Guidehouse's approach to estimating counterfactual power draw differed based on the following two scenarios:

- Scenario 1: The plug session started prior to the event start or started during the event and ended after the event concluded
- Scenario 2: The plug session started during the event and ended prior to the event conclusion

For scenario 1, Guidehouse considered the maximum observed non-event power draw as the counterfactual charging rate. Guidehouse then considered potential session energy consumption to be the maximum of available battery capacity (based on SOC) and total energy

[13] An EV may have been plugged-in but not charging due to having a high state of charge or because the EV may have had a set schedule that delayed charging until a certain time after the event period.

[14] Guidehouse was unable to differentiate between charging that occurred but was not recorded due to a technical issue and charging that occurred due to an opt-out, because no opt-out information was made available to Guidehouse.

[15] EV onboard charging rate, or acceptance rate, is the maximum power the EV can receive while charging. The available line power is the power that can be supplied by the EVSE connected to the vehicle, and varies by EVSE model and installation.

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consumed during and after (if any) the event. The counterfactual charging rate and session energy consumption were then used to calculate a counterfactual charging session duration.

For scenario 2, Guidehouse considered the minimum of the available line power and EV onboard charging rate as the counterfactual charging rate. Guidehouse then considered potential session energy consumption to be the maximum of available battery capacity (based on SOC) and total energy consumed during the event. The counterfactual charging rate and session energy consumption were then used to calculate a counterfactual charging session duration.

2.4.2 Decision Not to Use Within-Subject Approach

In addition to estimating demand impacts using an engineering approach, Guidehouse planned to estimate impacts using a within-subject regression approach (individual customer regression approach) to determine the baseline. For each individual customer, this regression approach predicts what charging would have occurred (i.e., counterfactual charging) using enrolled customers' charge session data for non-event days.

This within-subject approach functions well when non-event days and event days cover comparable time periods (e.g., similar days of the week, weeks of the year, months of the year). This is important given that the underlying assumption of this approach is that non-event day charging is a reasonable proxy for what would have occurred during an event. If non-event and event data begin to diverge, there is a risk that assessed impacts would be biased either upwards or downwards. This is because assessed impacts would include the effects of inherent differences in charging across time periods not attributed to EV DLC (such as differences in weekday v. weekend charging behavior, summer v. fall charging behavior).

Due to the rolling enrollment of the program and the number of events called in July and August, 60% of non-event vehicle-days occurred in September, whereas no events occurred in September. To determine whether this would pose a threat to a within-subject approach, Guidehouse assessed differences in average power draw observed during typical event windows on non-event weekdays in July/August compared to September. Guidehouse found substantial differences in average power draw between the two time periods, with 71% of EVs having an average power draw that was either more than 25% higher or more than 25% lower during July and August relative to September.

Due to the assessed differences between the months' average power draw and the concentration of non-event days in September, Guidehouse deemed the within-subject approach would have a predictor of event baselines in July and August with a significant degree of bias. This makes an unbiased and accurate impact estimate unattainable. Therefore, results from the within-subject approach are not included in this report.

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3. Data Sources and Data Review

This section describes the data sources used for this evaluation and the steps taken to prepare the data for analysis. The data sources used included survey data (described in Section 2.1), various data streams from the DRMS provider, zip code information from National Grid, and charging data from four EV OEMs.

3.1 Data from DRMS Provider

- **EV enrollment data:** This data identified each EV enrolled in the EV DLC offering and provided key information about the EV's enrollment, including the date the device was accepted to the program and the EV OEM.
- **Event summary data:** General event information such as date, start time, and stop time.

3.2 Data from National Grid

- **Service territory zip codes:** List of zip codes in National Grid's MA service territory, for the purpose of determing which charging sessions occurred within their territory.

3.3 Data from EV OEMs

- **EV session data:** One row per charging session with high-level summary information including (but not limited to) plug-in and plug-out times[16], charge start and end times, start and end state of charge[17], total energy consumption, available line power, and location of charging session.
- **Vehicle info:** This data included high-level characterization information on each enrolled EV, including make, model name, model year, battery capacity, and maximum on-board charge rate.

Guidehouse used the vendor session data for the assessment of charging behavior and impact analyses. Prior to those analyses, the charging data was cleaned using the following steps:

- **Removed sessions:** Guidehouse removed any charging sessions that had the same start and stop times, outlier sessions that were in the 99th percentile of average power draw by OEM, duplicated charging sessions, and sessions that began after September 2021.
- **Convert into 15-minute intervals:** Session data was converted into 15-minute intervals, which always started and ended on a quarter-hour mark. Total session energy consumption was equally spread across the duration of each charging session.
- **Filled gaps between charging sessions:** 15-minute intervals with no charging were added between the sessions to indicate unplugged periods. This interpolation was

[16] Plug-out time was not provided by all OEMs, but Guidehouse confirmed with OEMs that the final charge end time could be used as a proxy for plug-out time.

[17] End state of charge was not provided by all OEMs, but dividing the energy consumption by EV battery capacity sufficed as an estimated change in SOC.

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necessary to calculate EV utilization and to construct event participation statuses. Missing intervals were filled for the EV's first day with data through September 2021.

3.4 Data Challenges, Recommendations, and Considerations

- **Data availability and quality:** Multiple fields in the charging session data were either not present for some OEMs or had data quality issues that made them unusable for some OEMs. Examples include plug-out time, end state of charge, and location of charging sessions. The lack of plug-out times and end state of charge fields necessitated Guidehouse to estimate replacement values based on other fields and prevented portions of the assessment of charging behavior from being completed.
    - **Recommendation:** While the DRMS provider and OEMs have already worked to standardize fields, availability and quality of key fields should be confirmed with each OEM prior to the next evaluation.
- **Standardization of summarizations:** Charging data was originally summarized by the EV OEMs for the DRMS provider, and only included event periods. In order for Guidehouse to complete the evaluation, the EV OEMs later summarized non-event charging data in addition to the event charging data previously supplied to the DRMS provider. However, the two sets of charging sessions overlapped for three of the four OEMs. Guidehouse, with OEM guidance, coalesced the two datasets to ensure energy consumption was not double counted. This took a considerable amount of time and may have reduced the overall accuracy of the data.
    - **Recommendation:** For future evaluations working with session data, clearer guidance should be provided to OEMs on how to summarize charging sessions that overlap event periods.
- **Granularity of charging sessions:** Due to charging data being summarized to the charging session level, Guidehouse equally distributed session energy consumption across the duration of each charging session. While this method is viable, it does not account for smaller changes in charging that may have occurred over the course of a charging session or event period (e.g., an EV may reduce its power draw as it approaches full state of charge).
    - **Consideration:** If available, a more granular dataset such as 15-minute interval data or smaller charging blocks should be provided for future evaluations.

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4. Analysis and Results

This section summarizes findings from the customer experience research, assessment of charging profiles, event participation analysis, and impact analysis.

4.1 Customer Experience Research

The following section summarizes key findings related to the 2021 post-summer survey of program participants. In the figures within this section, the percent of respondents is located on the y-axis and the respondent counts are located above each bar.

4.1.1 Key Findings

The following subsections detail the key findings from the 2021 post-summer survey. More details on these findings are provided in section 4.1.2. These key findings are also summarized in Table 5-1 within the Findings and Considerations section of this evaluation report.

4.1.1.1 EVSE Characteristics

- Approximately 56% of the respondents (33 out of 59) own a Level 2 charger at home, and the remaining 44% of respondents (26 out of 59) own a Level 1 charger at home.
- Most respondents (39 out of 59, 66%) store their home charging device in an unheated garage, and almost one-third of respondents (17 out of 59, 29%) store their home charging device outside.

4.1.1.2 Participant Satisfaction

- Satisfaction with the program is likely high as indicated by the fact that 80% of respondents (47 out of 59) reporting that they would likely continue to participate in the future.
- If a flat annual incentive of $20 was offered instead of per-event incentives, about half of all respondents (29 out of 59, 49%) stated they would likely continue to participate in the program. This is 31% less than the general likelihood of respondents (80%) that would participate again in the future with the current program structure.
- At the same time, when asked about their satisfaction with current program incentives, only 49% of respondents (29 out of 59) were satisfied or very satisfied with program incentives. The primary suggestions for improvement of program incentives were to better communicate with participants on how incentives are earned and when they should expect to receive incentives as well as to offer more opportunity to earn incentives.
- Guidehouse combined survey self-reported information about how many events respondents believed they participated in with the results of the event participation analysis. More than one-third (37%, 21 out of 54) believed they participated in at least 1 event and actually did participate[18] while 31% of survey respondents (17 out of 54) believed they participated in at least 1 event but did not actually participate. The latter

[18] At the time of the survey, the latter group had not yet received any per-event incentives from the program due to a delay in administration of incentives.

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result suggests that some participants may be confused about what constitutes participation in an event. Average satisfaction with incentives for these two respondent categories is 3.6 and 4.1 (out of 5), respectively. Finally, another 31% (17 out of 54) did not expect to earn per-event incentives. The average satisfaction of this group is lower at 3.1.

4.1.1.3 Motivations and Enrollment

- More than half of respondents (33 out of 59, 56%) stated their top motivation for purchasing an EV was to help the environment. A little under half of respondents (26 out of 59, 44%) stated their primary motivation for enrolling in the program was to receive incentives, followed by desire to reduce environmental impacts (17 out of 59, 29%).
- 85% of respondents (50 out of 59) were satisfied with the enrollment process, and nearly all respondents (55 out of 59, 93%) did not encounter difficulties while enrolling. Suggestions for improving the enrollment process centered around improving information provided about the program, namely what is expected of participants and clarification of program rules with regards to incentives.

4.1.1.4 Charging Behavior

- Over half of respondents (55%, 31 out of 56) charged their EV until full whenever it was connected to their home charging device while 34% (19 out of 56) used a set charging schedule from their EV or EVSE App.
- Four survey respondents indicated that they actively adjusted their charging behavior/schedule as a result of being enrolled in the program (e.g., choosing to delay their charging until night time to align with program goals).
- Only 16 out of 59 respondents (27%) had access to workplace charging during the summer of 2021. Of these 16 respondents, 12 (75%) reported actually using workplace charging and performed about 40% of their overall charging at their workplace, on average. The primary barrier to workplace charging was the availability of charging stations.
- About 53% of respondents (31 out of 59) reported using public chargers and the most commonly cited barriers to public charging were location and availability of chargers.

4.1.1.5 Behavior During Events

- Respondents believed they successfully participated in, on average, approximately 3.5 times the number of events they actually participated in.[19] This was similar for BEVs and PHEVs. Again, this indicates that there was confusion among respondents as to what behavior constituted participation in events.
- Sixty-four percent of respondents (38 out of 59) recalled at least one peak event in summer 2021. Of the 21 respondents (36%) who did not recall any peak events, about half had EVs for which event notification was not provided.

[19] According to the event participation assessment (section 4.3).

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- The majority of respondents who recalled at least one event (34 out of 38, 89%) recalled receiving notifications about peak events. The majority of respondents who recalled receiving peak event notifications were satisfied with them.
- Of the 64% of respondents (38 out of 59) that recalled at least one peak event in summer 2021, 74% (28 out of 38) said that the events had no impact on their charging behavior during summer 2021. Only six respondents recalled opting-out or overriding at least one event. Of these six respondents, three opted out of "some events" and three "rarely" opted out.

4.1.2 Participant Survey Results

The remainder of this section contains more detailed findings from the 2021 post-summer survey. Appendix B includes the output for every survey question.

4.1.2.1 Participant EVSE Characteristics

Over half of the respondents (33, 56%) own a Level 2 charger at home, and the remainder of respondents (26, 44%) own a Level 1 charger at home.

Per Figure 4-1, 66% of respondents (39) store their home charging device (Level 1 or Level 2) in an unheated garage, and 29% of respondents (17) store their home charging device outside.[20]

[20] Although not a major factor in the summer, cold winter temperatures can affect charging in unheated garages and outdoors. Prolonged exposure to extremely low or high temperatures can influence how effectively the Lithium-ion (Li) battery charges and reduces its longevity. The optimal charging temperature range for Li-batteries is between 15°C to 35°C (59°F to 95°F) even though Li-battery manufacturers usually list the charging temperature range as 0°C to 45°C (32°F to 113°F). Sources: Aqwu, Daberechi, F. K. Opara, Nkwachukwu Chuwuchekwa, D. O. Dike, and L. Uzoechi. 2017. "Review of comparative battery energy storage systems (Bess) for energy storage applications in tropical environments." *IEE NIGERCON* 1000-1005. Motoaki, Yutaka, Wenqi Yi, and Shawn Salisbury. 2018. "Empirical analysis of electric vehicle fast charging under cold temperatures." *Energy Policy* 162-168.

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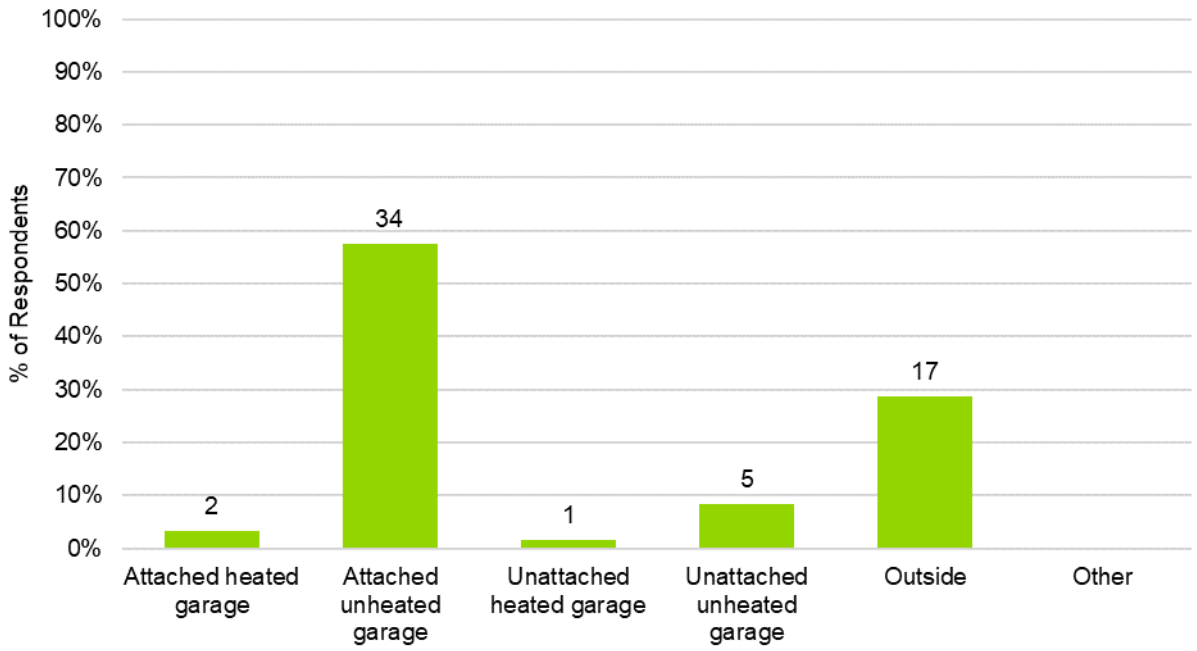
Figure 4-1. Location of Home Charging Device (n=59)



D2. Which of the following best describes the location of your home charging station?

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

4.1.2.2 Participant Satisfaction

Satisfaction with the program is likely high as indicated by the fact that with 80% of respondents (47) reporting that they would likely continue to participate in the future (Figure 4-3).

When asked about their satisfaction with program incentives, only 49% of respondents were satisfied or very satisfied with program incentives.[21] The most commonly cited frustration from respondents included that they believed their EV charging was curtailed during peak events, yet they never received the per-event incentives. Another related source of frustration and confusion was the perceived lack of opportunity to earn the per-event incentive (as one respondent noted: *The threshold for high peak events is too high; we received none during the summer.)*

Additionally, one respondent questioned the logic of the incentive structure noting: *We were already charging outside of peak events deliberately. To take advantage of this program we would have to go out of our way to charge during the peak event's so the charging could be restricted.*[22]

For some additional context around satisfaction particularly related to incentives, Figure 4-2 shows how respondent satisfaction with incentives varies by respondent category. The green

[21] Determined as the percentage that selected 4 or 5 to the following question: S7. On a scale of 1 through 5, where 1 is “Very dissatisfied” and 5 is “Very satisfied”, how would you rate your satisfaction with the program incentives for summer 2021?

[22] This is a common policy problem for incentive programs. People already doing “the right thing” are left out of receiving any reward for doing so while those that don’t do “the right thing” are given incentives to get them to make the desired change.

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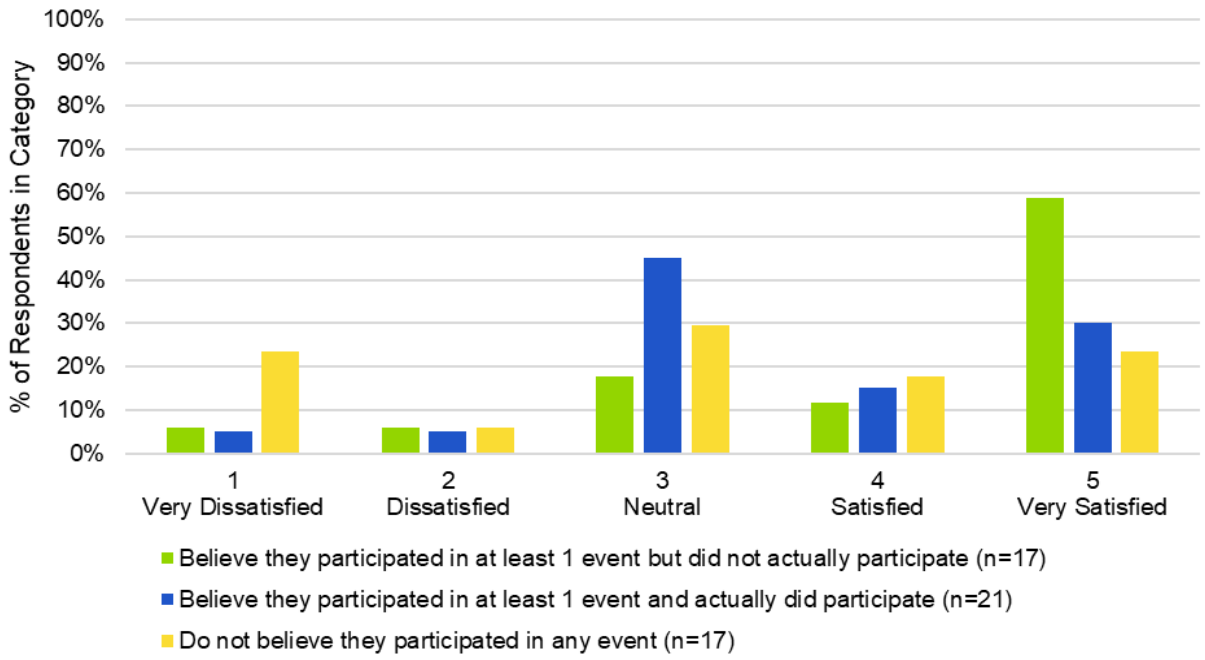
and blue categories are similar - in both cases, respondents believed they participated in at least 1 event, whether they did or not, but had not yet received any incentives beyond the sign-up incentive due to a delay in the program's administration of incentives. These categories represent 31% and 37% of respondents, respectively. Average satisfaction with incentives for the green and yellow categories is 4.1 and 3.6 (out of 5), respectively.

In the case of the green category, those who believed they earned an incentive for participation in at least one event but did not actually participate, this result suggests that some participants may be confused about what constitutes participation in an event (e.g., perhaps these respondents received notification about certain events but were not plugged in during the event in question or were plugged in but not charging).

The yellow category represents the 31% of respondents that did not expect to earn any per-event incentives. The average satisfaction of this respondent category is lower at 3.1. Thirteen of these 17 respondents did not recall any events throughout summer 2021. The remaining 4 recalled two or more events, but were likely unplugged and/or not charging.

Figure 4-2. Satisfaction with Per-Event Incentives by Respondent Category (1="Very dissatisfied, 5="Very Satisfied")



S6. Approximately how many events do you expect you earned an incentive for in summer 2021?

S7. On a scale of 1 through 5, where 1 is "Very dissatisfied" and 5 is "Very satisfied", how would you rate your satisfaction with the program incentives for summer 2021?

Note: Data for actual event participation comes from the event participation assessment (analysis of telemetry data). The total respondents reflected in this chart (54) is lower than the 59 total survey respondents - 3 respondents were removed due to not having any charging data during events and 2 respondents answered "Don't Know" when asked about their level of satisfaction with incentives.

Three respondent EVs did not have charging data on any event days, and, therefore were removed from the results of S6 and S7 shown above.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey and Guidehouse analysis of EV vendor data

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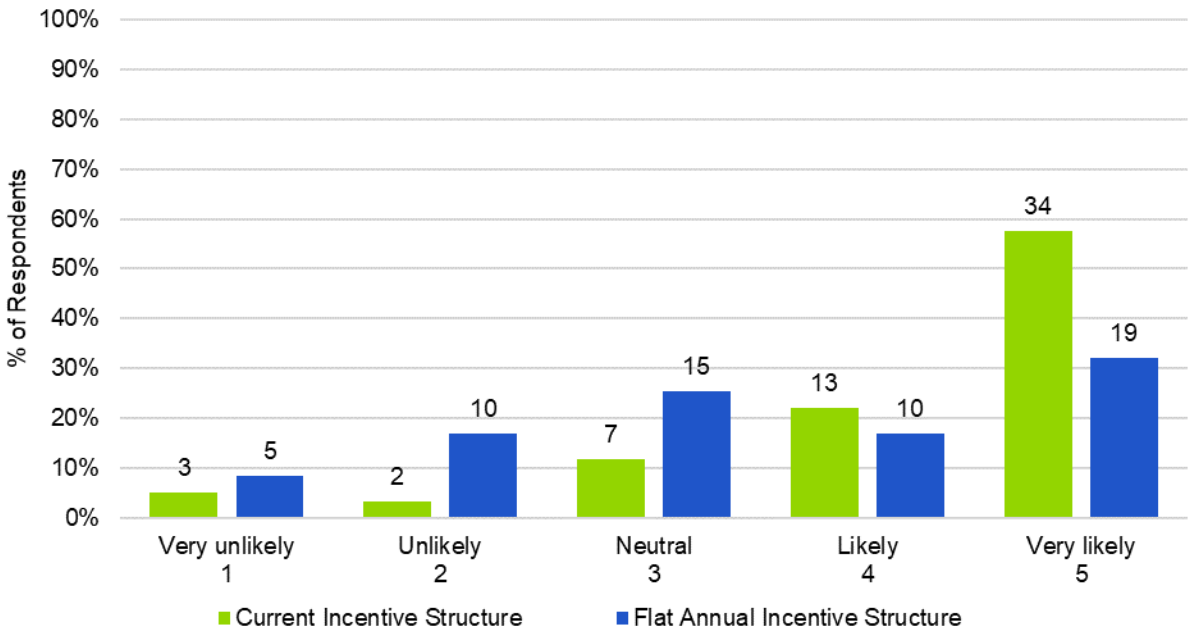
Twenty-one respondents (36%, 21 out of 59) provided open-ended feedback on ways to improve program incentives. The primary suggestions for improvement were as follows:

- Communicate about how incentives are earned, what the status is of incentives earned over the course of the summer, and when participants should expect to receive incentives (8)
- Offer more events or raise incentives (6)
- Send payments to customers faster (5)

At the time of the design of this survey, National Grid was already considering a change to the offering's incentive structure for periods beyond summer 2021. The survey was leveraged to test participants' reactions to an alternative incentive design – a flat annual incentive of $20 in lieu of the current per-event incentive of $10-20. Almost half, 49%, of the respondents (29) stated they were likely to continue to participate in the program if a flat annual incentive of $20 was instituted. This is 31% less than the general likelihood of respondents (80%) that would participate again in the future with the current program structure (Figure 4-3).[23]

Figure 4-3. Likelihood of Continued Program Participation with the Current Per-Event Incentive Structure and with a Flat $20 Annual Incentive Structure (n=59)



S9. On a scale of 1-5, where 1 is "Very unlikely" and 5 is "Very likely", how likely are you to continue to participate in National Grid's ConnectedSolutions EV and PHEV Demand Response program?

S12. On a scale of 1 to 5, where 1 is "Very unlikely" and 5 is "Very likely", if the program replaced per-event incentives with one flat annual incentive of $20, how likely are you to continue to participate in National Grid's ConnectedSolutions EV and PHEV Demand Response program?

Note: This figure reflects two separate questions from the post-summer survey. The results from question S9. are shown with the 'green' bars and question S12. are shown with the 'blue' bars. In 5.B, the figures are separated by each individual post-summer survey question.

[23] National Grid has since instituted a flat annual incentive of $20, while also increasing the sign-up incentive from $25 to $50.

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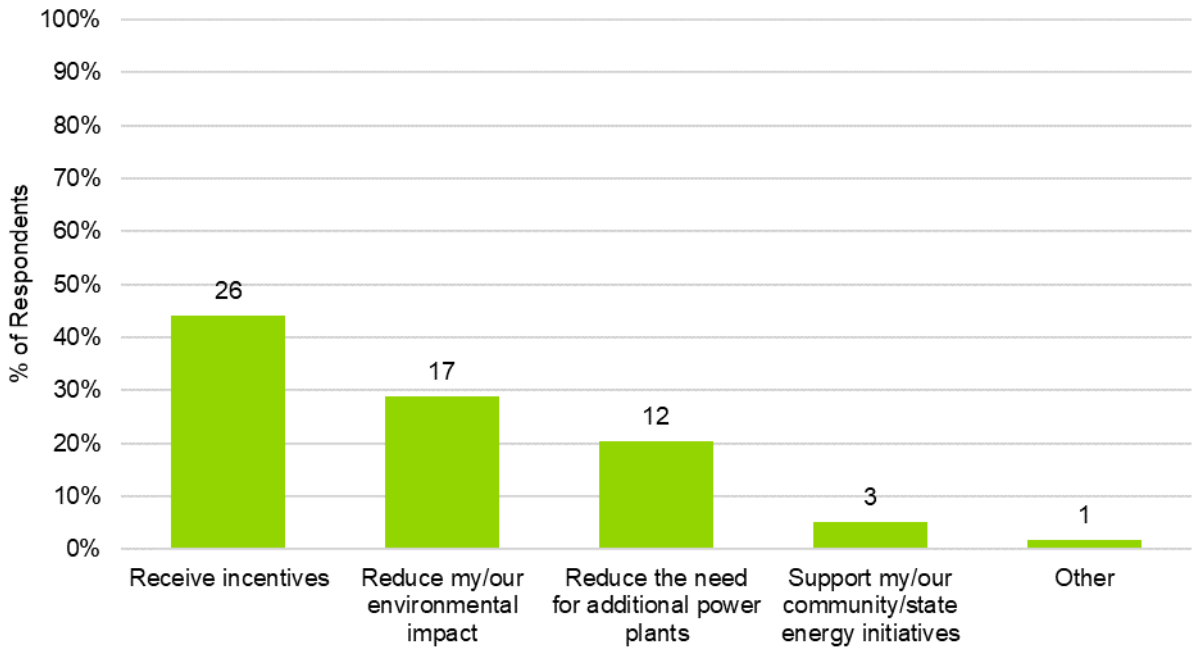
Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

4.1.2.3 Motivations and Enrollment

More than half of respondents (33, 56%) stated their top motivation for purchasing an EV was to help the environment. A little under half of respondents (26, 44%) stated their primary motivation for enrolling in the program was to receive incentives, followed by desire to reduce environmental impacts (17, 29%), as shown in Figure 4-4.

Figure 4-4. Top Motivation for Enrolling (n=59)



E1. What was your top motivation for enrolling in National Grid's ConnectedSolutions EV and PHEV Demand Response Program?

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

The vast majority of respondents (50, 85%) were satisfied with the enrollment process (Figure 4-5), and nearly all respondents (55, 93%) did not encounter difficulties while enrolling. A few respondents offered suggestions for improving the enrollment process that centered around improving information provided about the program, namely an explanation of what is expected of participants, and clarification of program rules with regards to incentives. One respondent noted: *[The program] is not explained very well. It is misleading in it's rewards as well. It said something like you would get $20 every time you charged which sounded really too good to be true.*

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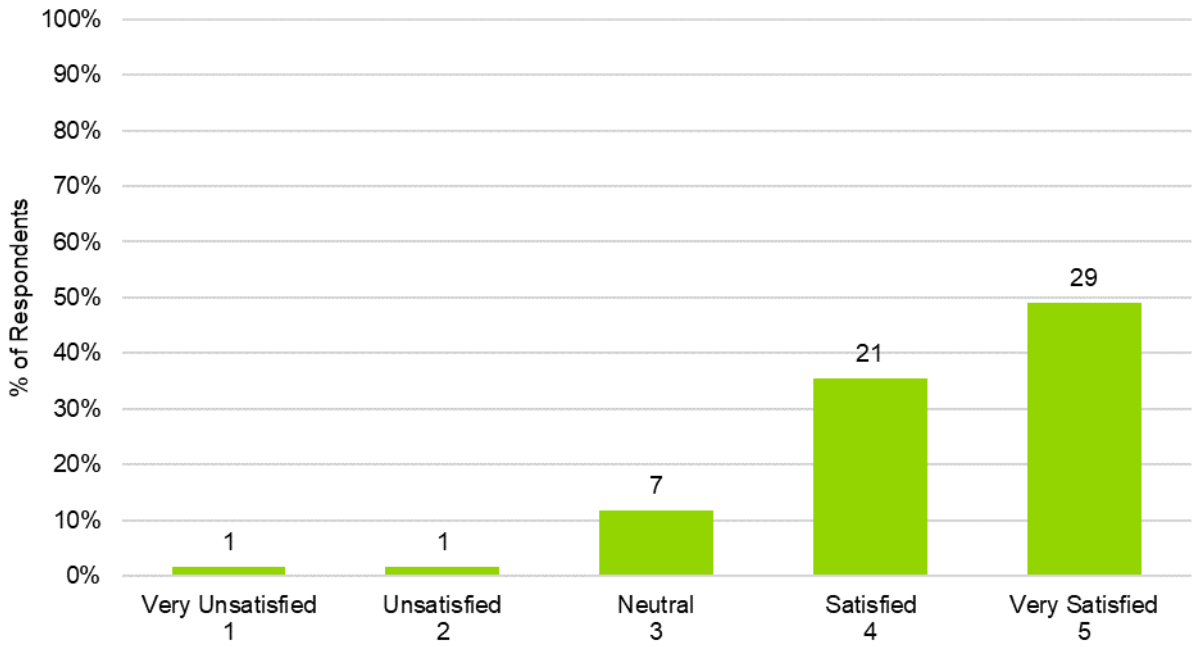
Figure 4-5. Satisfaction with the Enrollment Process (n=59)



E3. Using a scale of 1 to 5 where 1 indicates "Very unsatisfied" and 5 indicates "Very satisfied", how satisfied were you with the process of enrolling in the program?

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

4.1.2.4 Charging Behavior

Respondents indicated that the majority of their summer 2021 charging was done **at home** (81% of a participant's total charging, on average) with minimal charging at workplace (8%) and public stations (11%).

Table 4-1. Self-Reported Percentage of Charging by Location (Summer 2021)

Charging Station Location	Average % of Charging per Respondent	% of Respondents That Charged at Least Some Amount at Location
Home	81%	95% (56)
Workplace	8%	20% (12)
Public	11%	53% (31)

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

Figure 4-6 below shows that the most common weekday time for respondents' EVs to be plugged in to their Level 1 or Level 2 at home was between 6 p.m. and 6 a.m.

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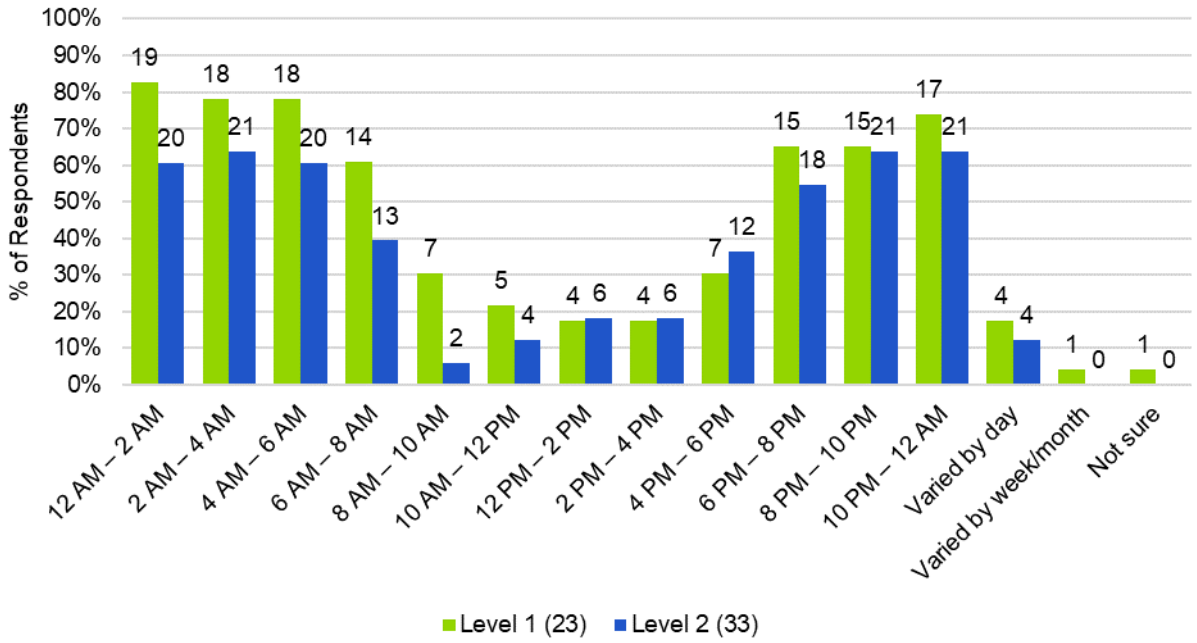
Figure 4-6. Typical Weekday Connection Times for Home Charging Device (n=56)



CB6. Indicate the time ranges during which the electric vehicle was *typically* connected (regardless of charging or not) to your *home charging device* on weekdays (Monday – Friday) during summer 2021 (June – August). Select all the time ranges that apply.

Note: 3 out of the 59 total survey respondents reported never charging at home during summer 2021.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

More than half of respondents (55%, 31 of 56) reported charging their EV until full whenever it was connected to the home charging device while roughly one-third of respondents (19, 34%) used a set charging schedule from an EV or device app (see Figure 4-7).

Of the respondents who use a charging schedule during the weekdays, 15 (27%) set their charging schedule themselves and 4 (7%) used a default schedule, likely set by their respective EV manufacturer. Respondents with charging schedules had the following weekday start and end times:

- Charge start: Late afternoon | Charge end: Night (4)
- Charge start: Early evening | Charge end: Morning (9)
- Charge start: Late evening | Charge end: Morning (6)

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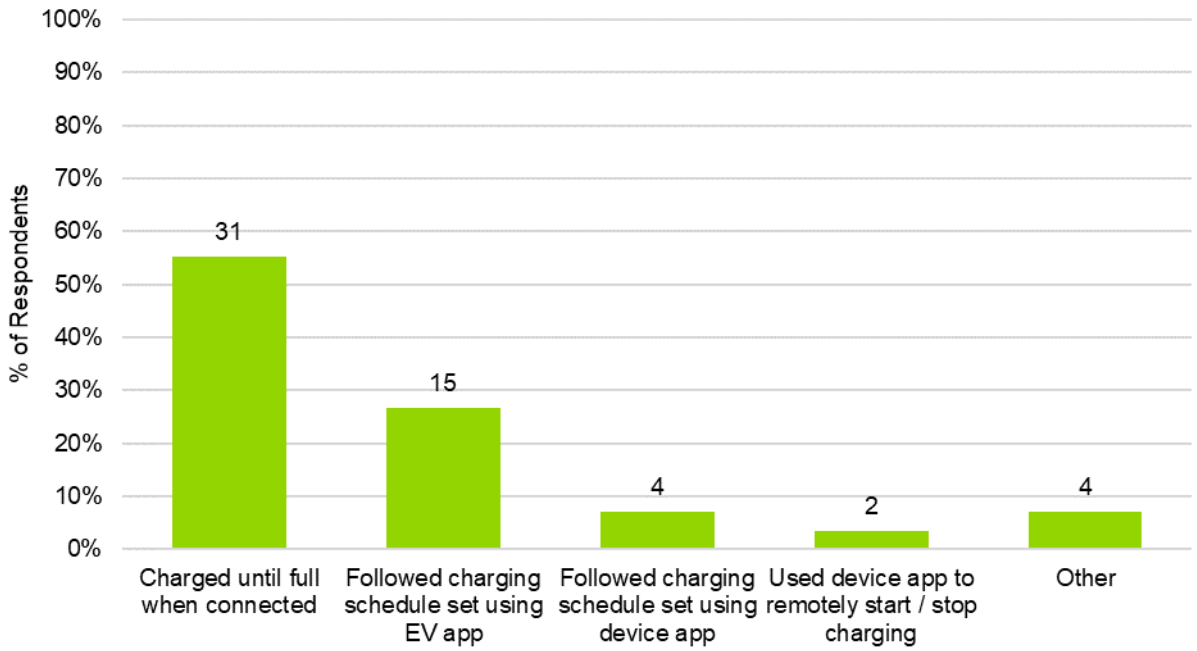
Figure 4-7. Household Charging Device Usage (n=56)



CB5. During summer 2021, which of the following best describes your household's use of your home charging device for your electric vehicle?

Note: 3 out of the 59 total survey respondents reported never charging at home during summer 2021.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

Few respondents reported having access to workplace charging during the summer of 2021 (only 16 respondents). Of these respondents, 12 (75%) reported actually using workplace charging, performing, on average, roughly 40% of their overall charging at their workplace. Of these 12 respondent EVs, 5 are BEVs (17% of respondent BEVs) and 7 are PHEVs (24% of respondent PHEVs). The majority of respondents that have access to workplace charging reported that the greatest barrier to workplace charging was the availability of charging stations.

A little over half of the respondents (31, 53%) reported using public chargers and performed, on average, 21% of their overall charging at public charging stations. Of these 31 respondent EVs, 18 are BEVs (60% of respondent BEVs) and 13 are PHEVs (45% of respondent PHEVs). Most respondents indicated that they are limited by the availability and location of public charging stations but are motivated to use them because they are convenient, cheap, and/or fast.

In terms of changes in charging behavior since the previous summer (2020), the majority of respondents reported charging the same amounts at home, work, and at public charging stations during summer 2021 relative to summer 2020 (Figure 4-8). Only four survey respondents indicated that they actively adjusted their charging behavior/schedule generally as a result of the program (e.g., choosing to delay their charging until night time to align with program goals).

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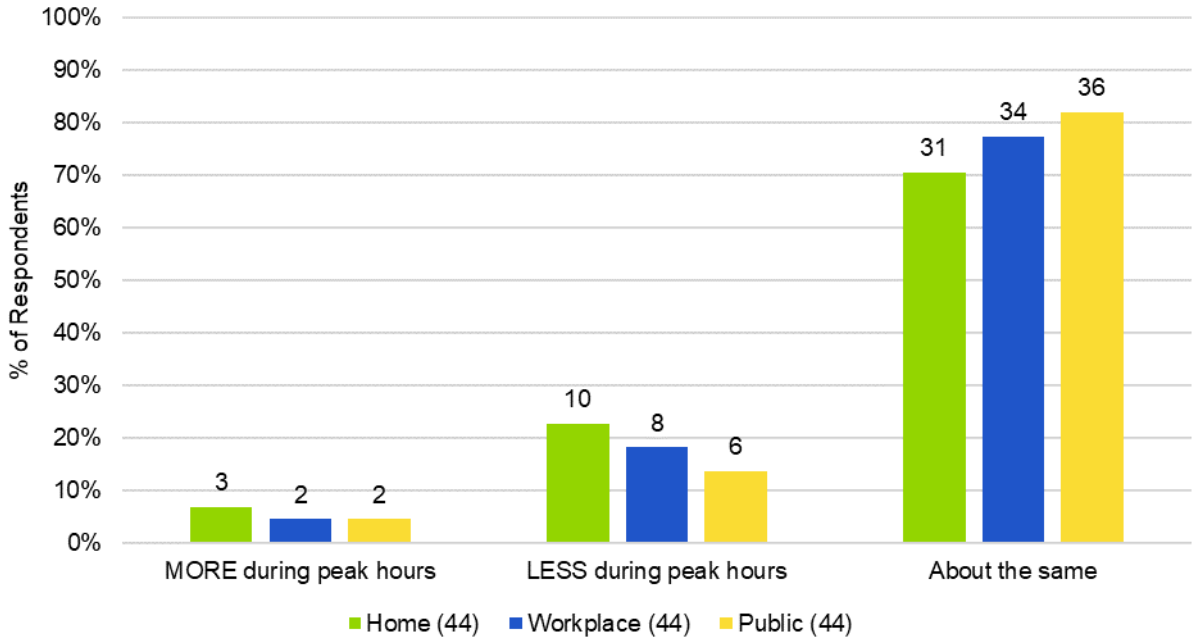
Figure 4-8. Change in Peak Charging for Weekdays in Summer 2021 Compared to Summer 2020 (n=44)



CS5. Compared to the summer of 2020, was this EV typically charging more, less, or the same amount in summer *2021 during the weekday hours of 2 PM to 7 PM*? Please indicate how this varied by charging location.

Note: 13 out of the 59 total survey respondents purchased their EV after summer 2020, and two respondents respondend "about the same" to a previous question (CS3. Compared to the summer of 2020, was this EV typically charging more, less, or the same amount on *weekdays in summer 2021*?) for all charging locations (home, workplace, and public). Subsequently, these two respondents were not presented with question CS5.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

4.1.2.5 Behavior During Events

Overall, respondents reported being aware of an average of 4.6 events in summer 2021. Respondents with BEVs were aware of 7.5 events on average, while those with PHEVs were aware of 1.7 events on average. This is not surprising given that enrollment for one PHEV manufactuer began mid-way through the summer season and this OEM also did not provide event notifications. Additionally, Table 4-2 illustrates that respondents believed they successfully participated in, on average, approximately 3.5 times the number of events they actually participated in.[24] This was similar for BEVs and PHEVs. Again, this indicates that there was confusion among respondents as to what behavior constituted participation in events.

[24] According to the event participation assessment (section 4.3).

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Table 4-2. Event Awareness and Actual Participation

Metric	Overall (n=56)
Average number of events of which respondents were aware	4.6
Average number of events for which an incentive was expected	4.1
Average actual number of events in which respondents participated	1.2

ET1. How many peak events do you recall in summer 2021 (June through August)?

S6. Approximately how many events do you expect you earned an incentive for in summer 2021?

Note: Data for "Actual Events Participated In" comes from the event participation analysis (analysis of telemetry data). Three respondent EVs did not have charging data on any event days, and, therefore were removed from the results of ET1 and S6 shown above.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey and Guidehouse analysis of EV vendor data.

Approximately 64% of respondents (38) recalled at least one peak event in summer 2021 and 74% of these respondents (28) said that the peak events had no impact on their charging or driving behavior during summer 2021. Furthermore, only 16% (6) of the respondents that recalled peak events also recalled choosing to opt-out or override at least one event. Of the six that recalled opting out of at least one event, three did so for "some events" and three did so "rarely."

Over one-third of respondents (35%, 21 of 59) respondents did not recall any peak events in summer 2021. Of those who did not recall any peak events, about half had EVs (11 of 21) for which event notification was not provided (see Table 4-5 within section 4.3.2). The remaining may never have been plugged in during event hours (and therefore may not have received event notification, depending on the EV OEM).

The majority of respondents who recalled at least one event (34, 89%) recalled receiving notifications about peak events (consistent with the fact that all but one EV OEM provided event notifications). Of these respondents, 65% of them (22) recalled receiving notifications before the event was in progress. The timing of when respondents recalled receiving notifications about peak events somewhat varied depending on the EV OEM of their enrolled EV (Figure 4-9). This is not surprising given that each participating EV OEMs provided event notifications at different times (see Table 4-5 within section 4.3.2).

Overall, most of the respondents who recalled peak event notifications (25 of 34, 74%) were satisfied with these notifications. About 62% of respondents (21) did not have suggestions for improving peak event notifications, but a few example suggestions from respondents related to wanting more advance notice of events.

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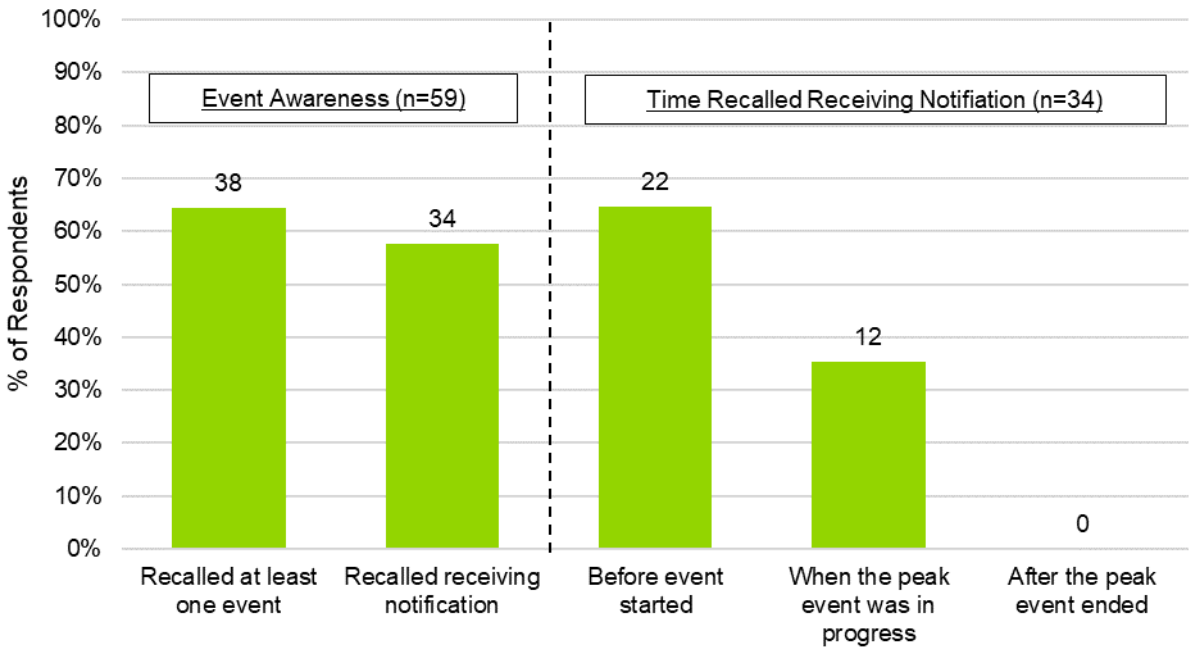
Figure 4-9. Peak Event Awareness and Notification



ET1. How many peak events do you recall in summer 2021 (June through August)?

ET2. Do you recall ever receiving notifications (i.e., in-app, emails, text messages) about peak events?

ET4. At what time do you recall receiving notifications about peak events?

Note: 21 out of the total 59 survey respondents recalled zero peak events.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

Given the per-event incentive structure that was in place during summer 2021, one research question of interest was whether the incentive structure would lead to "gaming" – customers charging more during hours they know or anticipate will be event hours. As shown Figure 4-11, only two respondents indicated that they connected more during the hours of 2-7 p.m. on event days compared to non-event days. Additionally, the event participation analysis confirmed there was no evidence of customers "gaming" the program by changing their charging behavior to plug in during typical event windows to receive the per-event incentive (see section 4.3).

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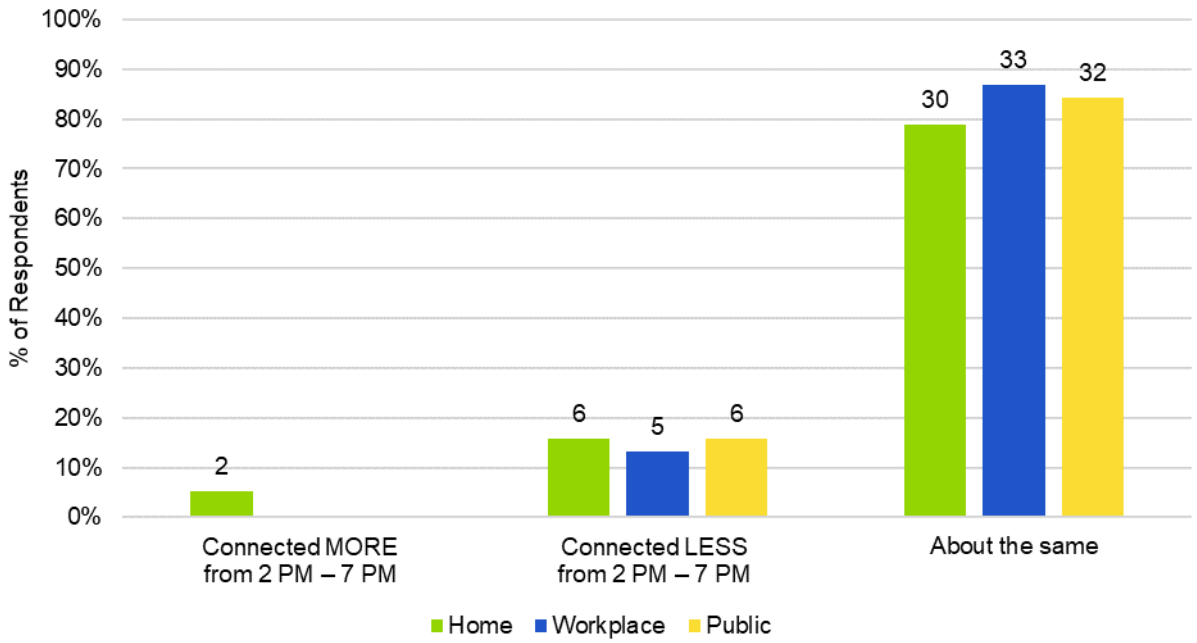
Figure 4-10. Plug-in Behavior Event Days v. Non-Event days (n=38)



ET11. Compared to days in summer 2021 when *no* peak event was called, was this EV typically connected to a charging device more, less, or the same amount *from 2 PM – 7 PM* relative to other hours? Indicate how the connected timing changed by charging location.

Note: 38 out of the total 59 survey respondents recalled at least one peak event and 21 out of the total 59 survey respondents recalled zero peak events.

Source: Guidehouse analysis of 2021 EV and PHEV Demand Response Post-Summer Survey

4.2 Assessment of Charging Profiles

The section contains findings from the assessment of participant charging behaviors during summer 2021.

4.2.1 Key Findings

- **PHEVs plugged in more frequently than BEVs.** The median number of plug sessions per week was 5 for PHEVs and 2 for BEVs. Eighty-nine percent (89%) of BEVs and 48% of PHEVs plugged in an average of 4 times per week or less.
- **EV plug sessions started most frequently in the evening hours.** The single hour with the most plug-ins was 5 to 6 p.m. for both BEVs and PHEVs, with 11% and 10%, respectively, of plug-ins occurring during that hour.
- **Periods of peak energy consumption occurred at different times for BEVs and PHEVs.** Forty-five percent (45%) of all energy consumed on non-event weekdays by BEVs took place between 9 a.m. and 5 p.m., while only 21% of PHEV energy consumption occurred in the same period. This is reflective of BEV peak consumption occurring in the midday hours, while PHEV peak consumption was delayed to the late evening and overnight hours. One OEM's charging optimization system shifted charging for a portion of PHEVs to occur overnight, rather than charging immediately upon plug-in.

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- **Hourly average power draw varied more by EV type than by weekday or weekend, and the two EV types' evening peaks occurred at different times of day.** The evening peak occurred at 5 p.m. to 7 p.m. for BEVs and at 7 p.m. to 9 p.m. for PHEVs. The PHEV evening peak was outside of the typical event hours of 4 p.m. to 7 p.m.
- **PHEVs charged a higher percent of their battery capacity per session compared to BEVs.** PHEVs plugged in at an average 47% SOC and unplugged at 88%, while the average BEV plugged in at 54% and unplugged at 78%.

4.2.2 Charging Profile Analysis Results

Guidehouse's experience with EV data has shown that a breadth of metrics can be helpful in characterizing charging behavior. For instance, understanding when plug sessions occur is relevant to National Grid in understanding potential DR impacts. Guidehouse investigated the charging behavior of enrolled devices across multiple segmentations of the data, including battery electric vehicles (BEV) versus plug-in hybrid electric vehicles (PHEV), and weekday versus weekend. Table 4-3 contains some summary data related to the enrolled EVs. Enrolled BEVs have larger battery capacities and higher maximum onboard charging rates than enrolled PHEVs, which allows BEVs to charge for longer at higher power draws.

Table 4-3. Enrolled Vehicle Information Summary

Category	Enrolled BEVs	Enrolled PHEVs
Number of EVs with Data	53	52
Average Battery Capacity (kWh)	56.3 kWh	14.9 kWh
Average Maximum Onboard Charge Rate (kW)	7.8 kW	4.9 kW
% Model Year:	-	-
2021	15%	17%
2020	38%	13%
2019	15%	6%
2018	4%	50%
2017	17%	10%
≤ 2016	11%	4%

Source: Guidehouse analysis of EV vendor data and program enrollment data

Figure 4-11 shows the percentage of EVs by average number of plug sessions per week, ranging from 1 to 13 plug sessions per week. BEVs tended to plug in less frequently than PHEVs, with 89% of BEVs and 48% of PHEVs plugging in an average of 4 times per week or less. There were 11 vehicles – all PHEVs – that averaged more than 7 plug sessions per week. Due to the lower battery capacities of PHEVs, it is not unexpected that PHEVs would be plugged in more frequently.

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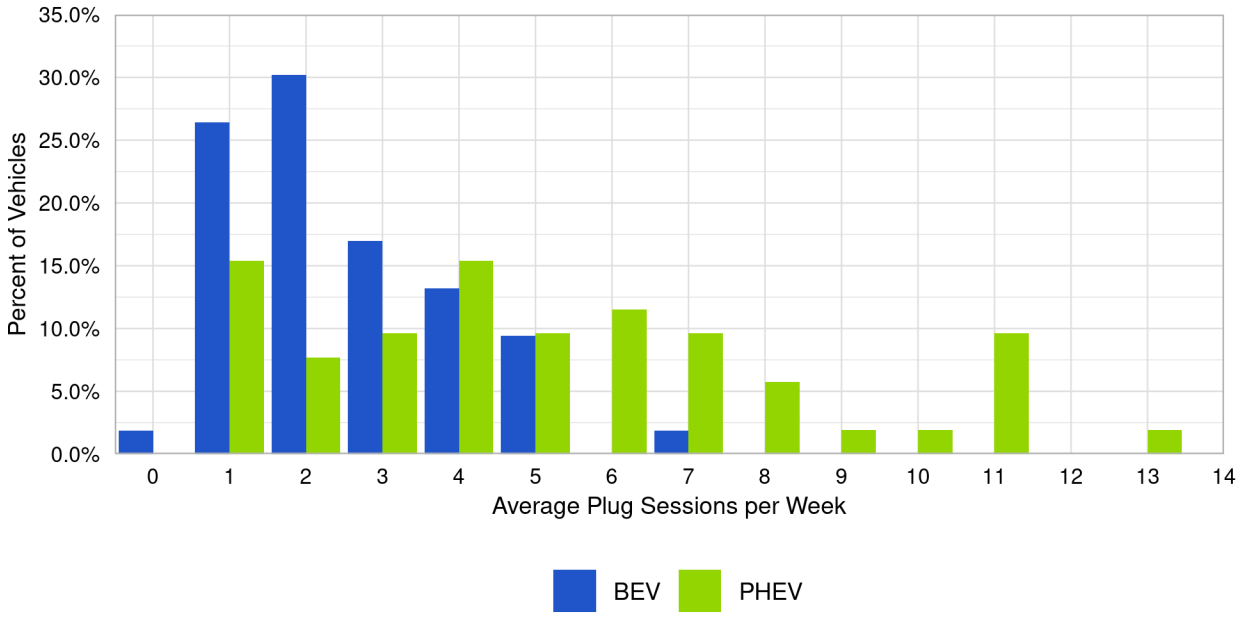
Figure 4-11. Average Number of Plug Sessions per Week



Note: Plot contains data for both event and non-event days.

Source: Guidehouse analysis of EV vendor data

Figure 4-12 shows the percent of plug sessions started by hour of day. The single hour with the most plug-ins was 5 to 6 p.m. for both BEVs and PHEVs, with 11% and 10%, respectively, of plug-ins occurring during that hour. While the peak of plug sessions begin in the evening hours, potentially after enrolled customers commute home, there is also a steady number of plug sessions occurring through the middle of the day. Over 5% of BEV plug sessions begin in 5 separate hours from 8 a.m. to 4 p.m. on weekdays, which may indicate customers utilizing public or workplace charging stations.[25]

[25] Location data was not available for all EVs (as highlighted in Section 3.4). As a result, a comparison of home v. away charging sessions was not included in this report.

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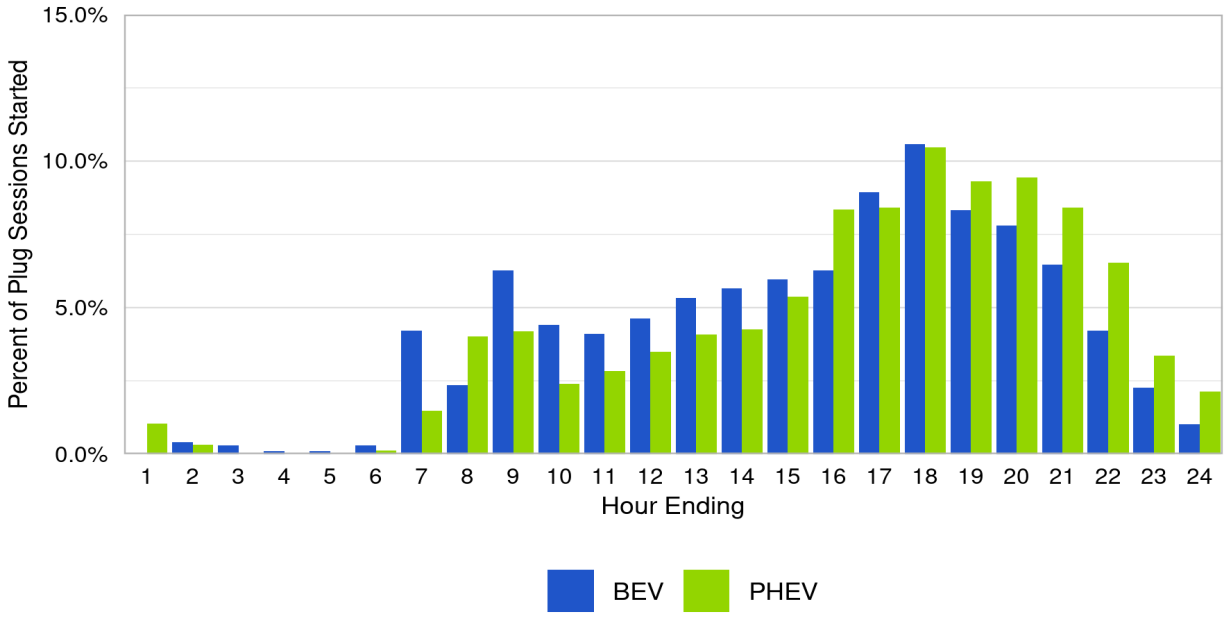
Figure 4-12. Percent of Plug Session Starts by Hour and EV Type – Weekdays



Note: Plot contains data for both event and non-event weekdays.

Source: Guidehouse analysis of EV vendor data

Figure 4-13 shows the percent of energy consumed by hour on non-event weekdays. The two EV types experienced vastly different consumption patterns – BEV energy consumption peaked in the middle of the day, while PHEV energy consumption peaked during evening and overnight hours. Forty-five percent (45%) of all energy consumed on non-event weekdays by BEVs took place between 9 a.m. and 5 p.m., while only 21% of PHEV energy consumption occurred in the same period. Guidehouse believes the deviation of energy consumption between the two EV types from the plug-in times seen in Figure 4-13 may be driven by two potential factors. First, BEV plug sessions starting between 7 a.m. and 12 p.m. charged at an average rate of 4.6 kW compared to 3.4 kW for BEV plug sessions starting between 4 p.m. and 8 p.m. The higher average power draws of the sessions starting in late morning allowed more concentrated midday energy consumption, while energy consumption of evening plug sessions was distributed more across late night and early morning hours. Second, Guidehouse confirmed with the DRMS provider that a portion of PHEVs had their charging shifted by an OEM's optimization system to occur overnight. Therefore, the energy consumption shown here differs in part because BEV charging was more likely to start immediately after plug-in whereas PHEV charging was often delayed.

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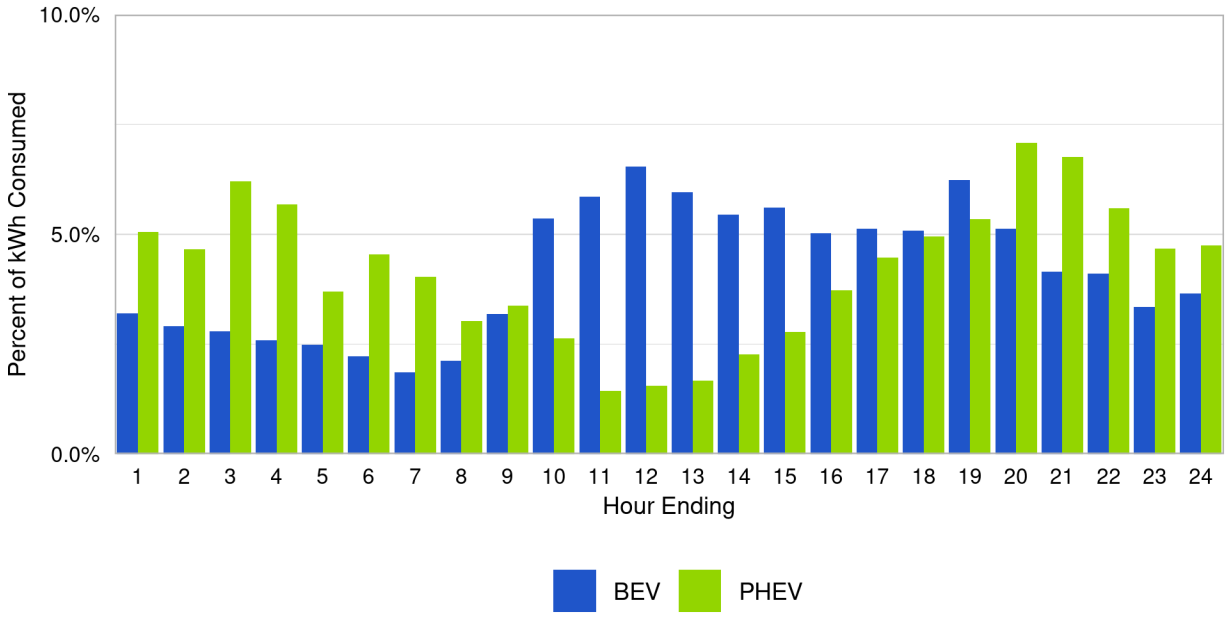
Figure 4-13. Percent of Energy Consumed by Hour and EV Type – Non-Event Weekdays



Note: Plot contains data for non-event weekdays only.

Source: Guidehouse analysis of EV vendor data

Guidehouse analyzed the hourly average power draw of enrolled EVs by vehicle and day type, and plotted the non-event day averages in Figure 4-15. Both BEVs and PHEVs experienced multiple peaks in average power draw, aligning with the energy consumption distribution plotted in Figure 4-14. The two peaks occurred at 11 a.m. to 12 p.m. and 5 p.m. to 7 p.m. for BEVs, and occurred at 3 a.m. to 4 a.m. and 7 p.m. to 9 p.m. for PHEVs. PHEVs had less of an opportunity for event curtailment, due to the evening PHEV peak occurring outside of typical event hours of 4 p.m. to 7 p.m. The average power draw was similar for weekdays and weekends within each EV type, although BEVs did have higher midday charging rates on weekdays and lower power draws from 12 a.m. to 9 a.m.

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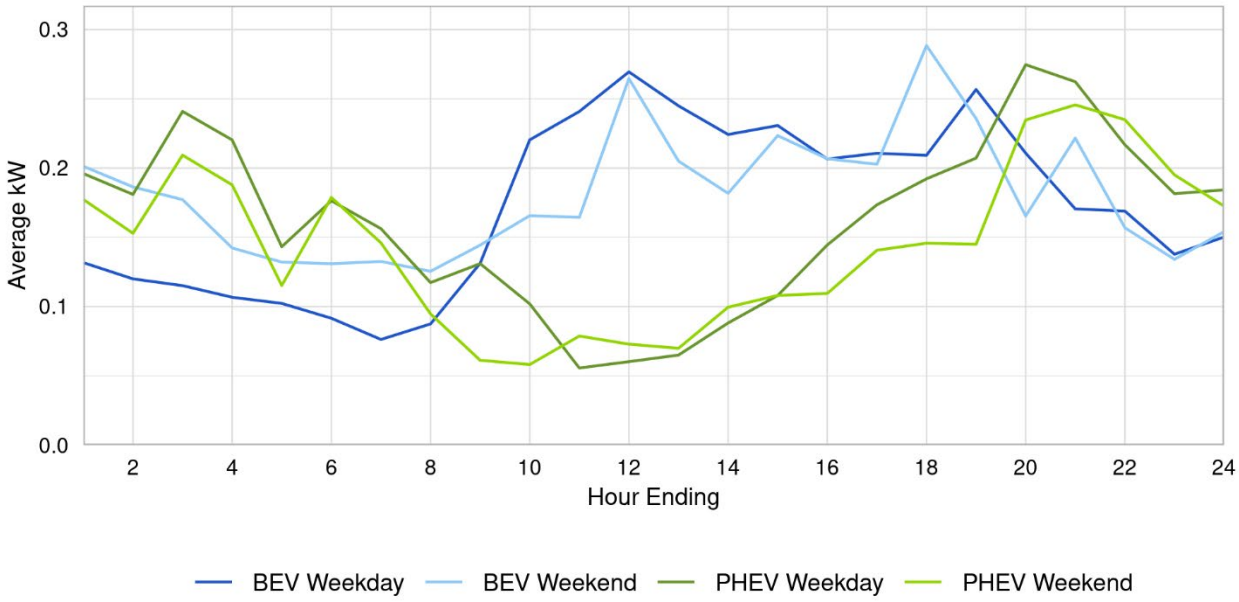
Figure 4-14. Hourly Average kW by EV Type and Day Type – Non-Event Days



Note: Plot contains data for non-event days only.

Source: Guidehouse analysis of EV vendor data

Figure 4-15 shows the average start state of charge and end state of charge per session by EV type. The average PHEV plugged in at 47% SOC and unplugged at 88%, while the average BEV plugged in at 54% and unplugged at 78%. As shown earlier in Table 4-3, enrolled PHEVs and BEVs had average battery capacities of 14.9 kWh and 56.3 kWh, respectively. The smaller battery capacities of enrolled PHEVs make it possible to both expend and recharge larger portions of SOC in shorter amounts of time than BEVs, explaining why PHEVs may typically have lower start SOCs and higher end SOCs.

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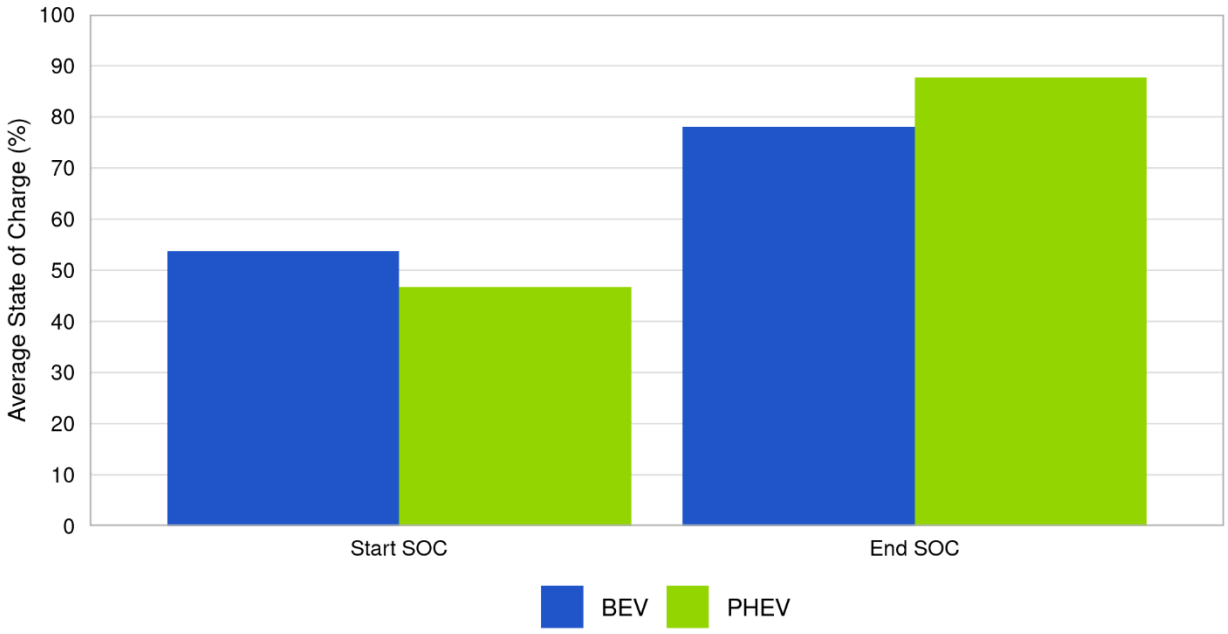
Figure 4-15. Average Session Start and End State of Charge by EV Type



Note: Plot contains data for both event and non-event days.

Source: Guidehouse analysis of EV vendor data

Table 4-4 displays several key metrics related to the charging behavior of enrolled vehicles. PHEVs plug in more than twice as frequently as BEVs, but BEVs consumed more energy per plug session (13.3 kWh v. 5.7 kWh). This higher average consumption is likely due to BEVs having larger battery capacities and not needing to be charged as frequently. BEV plug sessions also had a higher average available line power than PHEVs (5.2 vs 3.2 kW)[26], as shown below.

[26] The available line power is the power that can be supplied by the EVSE connected to the vehicle, and varies by EVSE model and installation.

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Table 4-4. Vehicle Session Summary Statistics by EV Type

Metric	BEV	PHEV	All
Enrolled EVs with Data	53	52	105
Total Enrolled Vehicle-days with Data	3,967	3,055	7,022
Plug Sessions	1,326	2,055	3,381
Weekly Average Plug Sessions per EV	2.0	4.5	3.1
Total Energy Consumption (kWh)	17,696	11,645	29,341
Avg. Session Plug Duration (hours)*	10.0	12.0	11.2
Avg. Session Consumed Energy (kWh)	13.3	5.7	8.7
Avg. Available Line Power (kW)	5.2	3.2	4.0
Percent of Charging Sessions in NG Service Territory	99%	98%	98%

Note: Plug-out time was not provided for all OEMs, and in those cases Guidehouse used the final charging session end time as a proxy for plug-out time. EVs may remain plugged-in after the final charging session and, therefore, this number may underestimate total plugged-in duration.

Source: Guidehouse analysis of EV vendor data

4.3 Assessment of Event Participation

The section contains findings from the assessment of event participation during summer 2021.

4.3.1 Key Findings

- **Most EVs were unplugged during the event and did not participate, making up 74% of all participation statuses across events.** Of the 86 EVs that were enrolled for at least 5 events, 43% participated in 0 events and 90% participated in fewer than 20% of the events they were enrolled for.
- **Full and partial participation accounted for 7.3% of participation statuses and 7.4% of statuses were flagged as technical issues or opt-outs.** Technical issues could not be differentiated from opt-outs because no opt-out data was made available to Guidehouse.
- **Technical issues or opt-outs accounted for 29% of all plugged-in participation statuses.** Of the 18 events that had 10 or more EVs plugged-in, technical issues or opt-outs ranged from 13% to 41% of plugged-in participation statuses.
- **Enrolled customers received event notifications at different times and under varying criteria, depending on the OEM.** Guidehouse cannot definitively isolate the impact of these differences on event participation from other differences across OEMs, but there were no obvious indications that event notification timing had an impact on participation.
- **There was no evidence of customers "gaming" the program** by changing their charging behavior to plug in during typical event windows and receive the per-event incentive. Such "gaming" behavior was not observed even for the OEM that provided day-ahead notifications.

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4.3.2 Event Participation Results

Figure 4-16 represents the average participation by EV type across all 23 evaluated events. Low participation is primarily driven by customers being unplugged for 74% of event periods. Full and partial participation accounted for 7.3% of event statuses, and was slightly higher for BEVs compared to PHEVs (7.8% vs 6.4%, respectively). The difference in EV type is likely driven by the amount of PHEV charging that occurs overnight due to shifted charging patterns, as detailed in the Assessment of Charging Profiles section of this report.

Less than 8% (7.4%) of event statuses were flagged as technical issues or opt-outs due to non-curtailed charging occurring during the event period. Half (49) of EVs with event data had a technical issue or opt-out status for at least one event in the analysis period. Out of those 49 EVs, only 4 either had technical issues or opted-out of all the events for which they were plugged-in for.

The demand reduction approach for this program was to fully curtail charging during event periods. However, Guidehouse observed instances of reduced, but not fully shut-off, charging occurring during the event window. These instances were categorized as partial or full participants if the observed power draw during the event period was less than 50% of the observed power draw occurring immediately before or after the event. Participants with greater than 0.1 kWh consumption during the event window make up 63 (53%) of the analysis period's total partial or full participant statuses.

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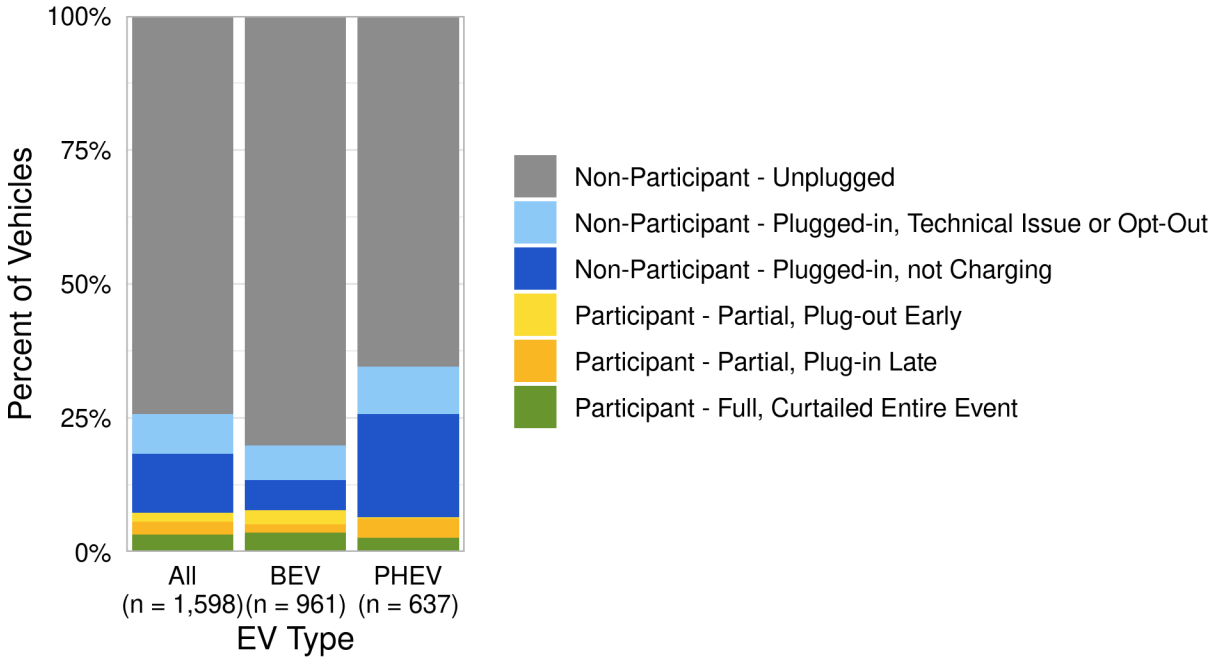
Figure 4-16. Participation Status by EV Type[27]



Note: "n = " represents the number of participation statuses across all events. *Source: Guidehouse analysis of EV vendor data*

Figure 4-17 shows the frequency of participation (full or partial) for the 86 EVs that were enrolled during at least 5 events. 43% of all EVs participated in 0 events they were enrolled for, and 90% of EVs participated in fewer than 20% of the events they were enrolled for. Technical issues or opt-outs accounted for 29% of all plugged-in event statuses. Of the 18 events that had 10 or more EVs plugged-in, technical issues or opt-outs ranged from 13% to 41% of plugged-in event statuses.

[27] A "Non-Participant - Plugged-in, not Charging" status is applied when an EV may have been plugged-in but not charging due to having a high state of charge or because the EV may have had a set schedule that delayed charging until a certain time after the event period. Plug-out time was not provided for all OEMs, and in those cases Guidehouse used the final charging session end time as a proxy for plug-out time. EVs may remain plugged-in after the final charging session and, therefore, this plot may underestimate the number of EVs plugged-in but not charging and overestimate those unplugged.

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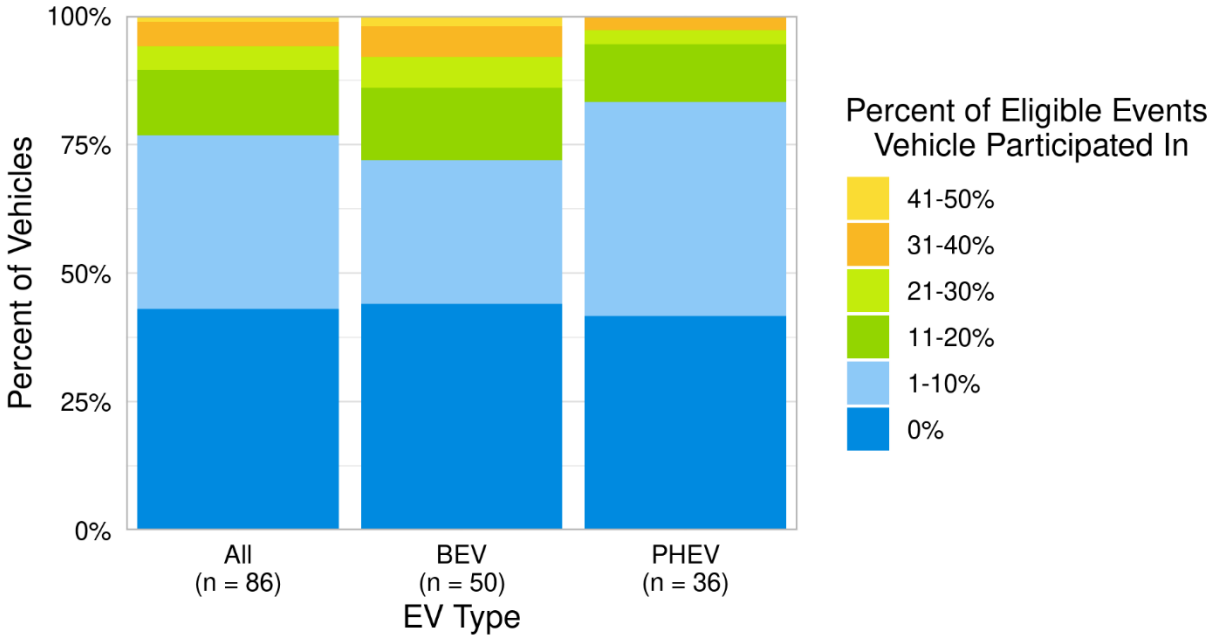
Figure 4-17. Frequency of Participation by EV Type



Note: "n = " represents the number of EVs enrolled for at least five events.

Source: Guidehouse analysis of EV vendor data

The program was intended to notify customers only when they plugged-in during an event window or if an event began while their EV was already plugged-in. However, notifications for each of the four OEMs differed in timing and criteria. One OEM contacted customers if their plug session overlapped with a DR event, one notified all enrolled EVs at the event start, one provided day-ahead notifications and also notified all enrolled EVs at the event start, and the fourth provided no notification but showed the event in the app's charging schedule page. These different methods and criteria are shown in Table 4-5.

Although event notifications differed by OEM, Guidehouse cannot definitively isolate the impact of these differences on event participation from other differences across OEMs (e.g., scheduled charging) and general differences in charging behavior across participants. That said, there were no obvious indications that event notification timing had an impact on participation. Relatedly, there was no evidence of customers changing their charging behavior to plug in during typical event windows to receive the per-event incentive. Such "gaming" behavior was not observed even for the OEM that provided day-ahead notifications.

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Table 4-5. Event Notification Characteristics by OEM

OEM	Timing of Notification	Notification Method	Opt-out Method
OEM1	At plug-in, if plugged-in time intersects with DR event	Push notification	Within app
OEM2	When notification is received from DRMS provider (24+ hours prior to event) At event start, whether EV is plugged-in or not	Text message	Text message
OEM3	At event start, whether EV is plugged-in or not	Text message	Text message
OEM4	No notification. Shown in app's charging schedule	None	Within app

Source: DRMS provider and OEMs

4.4 Impact Analysis

The section contains findings from the analysis of impacts during summer 2021.

4.4.1 Key Findings

- **Demand impacts for all EVs averaged 0.09 kW across all events.** BEV and PHEV average impacts for the analysis period were 0.11 kW and 0.07 kW, respectively.
- **Average demand impacts of *event participants* were 1.26 kW for all EVs, 1.36 kW for BEVs, and 1.07 kW for PHEVs.**
- **August events had higher average demand impacts than July events (0.11 kW v. 0.04 kW).** Contributing factors include an increase in average event participation from 4.5% to 7.8% and an increase in average available line power from 1.53 kW to 2.58 kW.
- **Peak hours identified by ISO New England had average total impacts of 6.9 kW, and ranged from 0.22 kW to 16.02 kW.** Fourteen of 62 ISO-NE peak hours overlapped event periods.

4.4.2 Impact Results

Figure 4-18 shows an example baseline for the August 15, 2021 event. Guidehouse calculated demand impacts by comparing the actual charging during the event to a calculated engineering baseline. In Figure 4-18, hour ending 17 to hour ending 19 are shaded to represent the event period.

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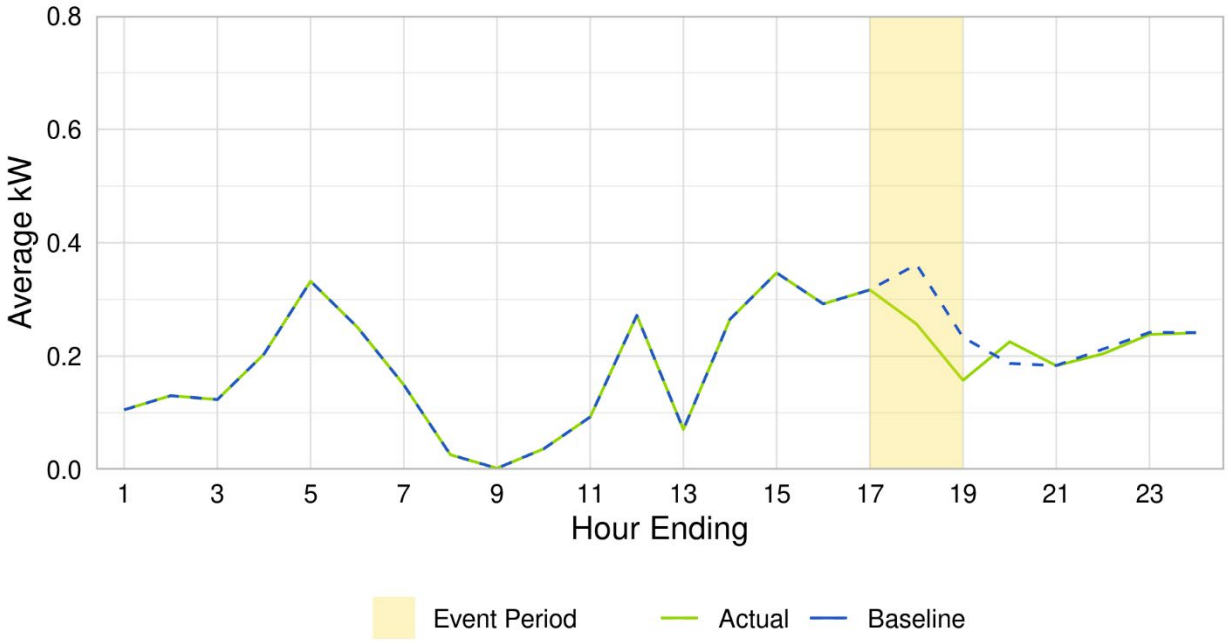
Figure 4-18. Example Baseline for August 15, 2021 Event



Source: Guidehouse analysis of EV vendor data

Figure 4-19 shows the average event kW impact per enrolled EV by month and EV type. In order to control for rolling enrollment, Guidehouse weighted event impacts by the number of enrolled EVs when calculating the monthly and season averages. Average event impacts of enrolled BEVs exceeded those observed for enrolled PHEVs in both July and August (0.04 and 0.13 kW v. 0.02 and 0.08 kW, respectively). The program's average demand impacts were 0.04 kW for July events, 0.11 kW for August events, and 0.09 kW for all events. Hourly and average impacts by event are detailed in Appendix 5.E.

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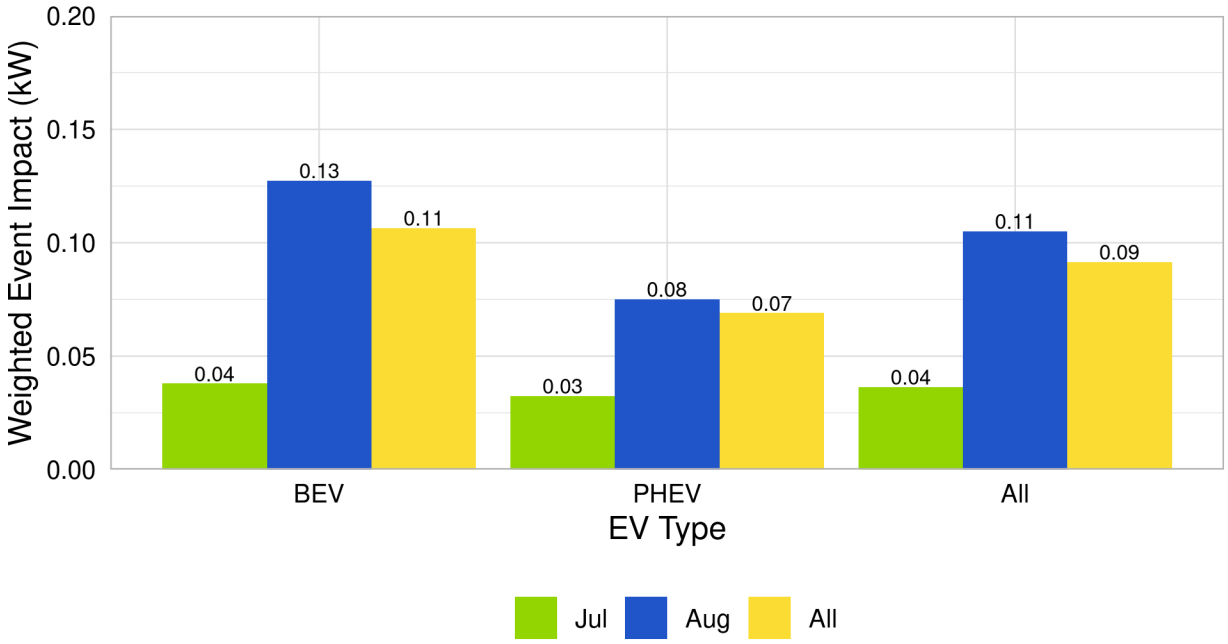
Figure 4-19. Weighted Event Average kW Impact per EV by Month and EV Type



Source: Guidehouse analysis of EV vendor data

Table 4-6 shows a combination of factors that contributed to average impacts being higher in August than in July for both EV types. Average event participation rose from 4.5% to 7.8% and the average available line power of participants increased from 1.53 kW to 2.58 kW. An increase in the average available line power indicates that curtailed Level 2 charging sessions accounted for more of the participating sessions, which in turn increased the potential curtailable load. The average onboard charging rate of participating EVs increased for each EV type as well but decreased in the overall average, due to PHEVs making up a larger portion of the participants in August than in July.

Table 4-6. Characteristics of Event Participants

EV Type	Month	Average Event Participation	Total Instances of Participation	Average Available Line Power (kW)	Average Vehicle Onboard Charging Rate (kW)
All	Jul	4.5%	17	1.53	6.59
All	Aug	7.8%	106	2.58	6.55
BEV	Jul	5.3%	14	1.74	7.24
BEV	Aug	8.5%	64	2.96	8.17
PHEV	Jul	1.8%	3	0.57	3.57
PHEV	Aug	6.9%	42	2.01	4.09

Source: Guidehouse analysis of EV vendor data

Figure 4-20 shows the average event demand impacts for EVs that were fully or partially participating in the events compared to the average event impact for all EVs. As stated above for Figure 4-20, Guidehouse weighted event impacts by the number of enrolled EVs when calculating the monthly and season averages. The average event impact of participating EVs was 1.07 kW for PHEVs, 1.36 kW for BEVs, and 1.26 kW for all EVs.

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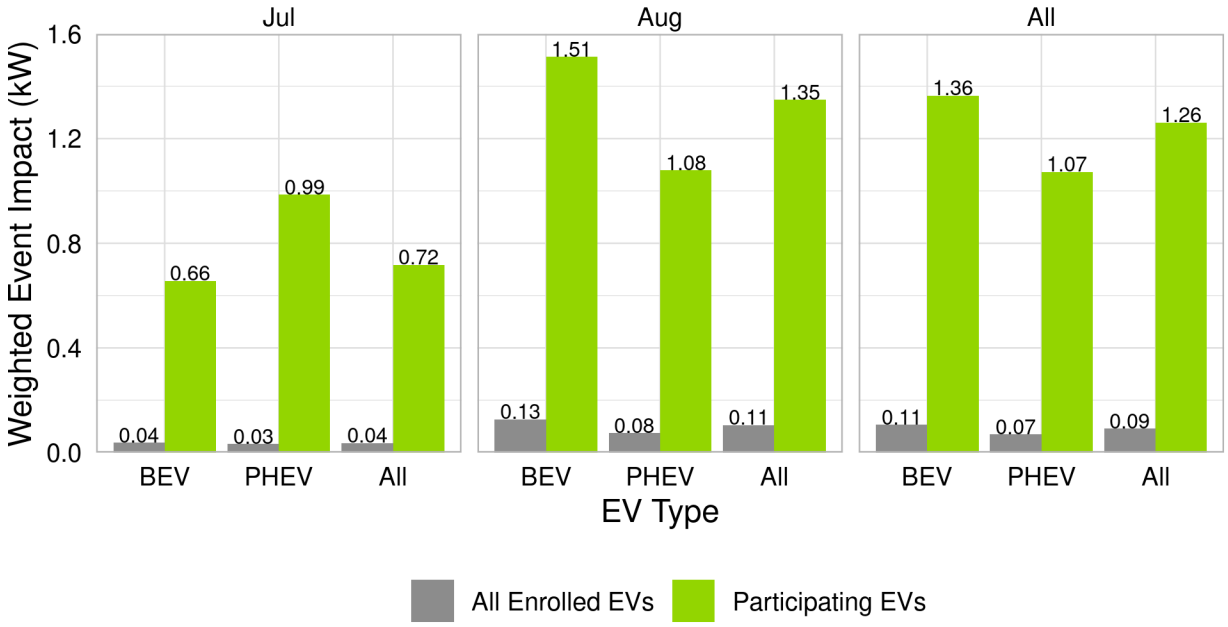
Figure 4-20. Weighted Event Average kW Impact per EV for Participating Devices



Source: Guidehouse analysis of EV vendor data

The Independent System Operator New England (ISO-NE) identified 62 peak hours (maximum of one per day) observed in July-September 2021. As shown in Table 4-7, fourteen of these hours were included in event periods of this offering and ranged in total impacts of 0.22 kW on July 20th to 16.02 kW on August 11th and averaged 6.87 kW. Demand response events were called on nine additional days with ISO-NE peak hours, but the event periods did not include those hours.

Table 4-7. Impacts During ISO-NE Peak Hours

Event Date	Hour Ending	Enrolled EVs	Total Impact (kW)
7/7/2021	17	25	0.62
7/15/2021	17	42	1.59
7/20/2021	18	47	0.22
8/6/2021	17	76	14.39
8/10/2021	17	80	7.31
8/11/2021	17	82	16.02
8/12/2021	17	83	13.42
8/13/2021	17	83	8.77
8/14/2021	17	84	0.51
8/15/2021	18	84	8.83
8/16/2021	18	84	8.83
8/18/2021	17	86	2.02
8/20/2021	18	87	11.49
8/31/2021	17	98	2.09

Source: Guidehouse analysis of EV vendor data

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5. Findings and Considerations

Key findings from each research activity, along with key considerations for the program, are summarized in the tables below.

Table 5-1. Key Findings – Customer Experience Research

Research Category	Findings
Participant and EVSE Characteristics	Approximately 56% of the respondents (33 out of 59) own a Level 2 charger at home, and the remaining 44% of respondents (26 out of 59) own a Level 1 charger at home.
	Most respondents (39 out of 59, 66%) store their home charging device in an unheated garage, and almost one-third of respondents (17 out of 59, 29%) store their home charging device outside.
Participant Satisfaction	Satisfaction with the program is likely high as indicated by the fact that 80% of respondents (47 out of 59) reported that they would likely continue to participate in the future.
	If a flat annual incentive of $20 was offered instead of per-event incentives, about half of all respondents (29 out of 59, 49%) stated they would likely continue to participate in the program. This is 31% less than the general likelihood of respondents (80%) that would participate again in the future with the current program structure.
	At the same time, when asked about their satisfaction with current program incentives, only 49% of respondents (29 out of 59) were satisfied or very satisfied with program incentives. The primary suggestions for improvement of program incentives were to better communicate with participants on how incentives are earned and when they should expect to receive incentives as well as to offer more opportunity to earn incentives.
	Guidehouse combined survey self-reported information about how many events respondents believed they participated in with the results of the event participation analysis. 37% (21 out of 54) believed they participated in at least 1 event and actually did participate while 31% of survey respondents (17 out of 54) believed they participated in at least 1 event but did not actually participate. The latter result suggests that some participants may be confused about what constitutes participation in an event. Average satisfaction with incentives for these two respondent categories is 3.6 and 4.1 (out of 5), respectively. Finally, another 31% (17 out of 54) did not expect to earn per-event incentives. The average satisfaction of this group is lower at 3.1.
Motivations and Enrollment	More than half of respondents (33 out of 59, 56%) stated their top motivation for purchasing an EV was to help the environment. A little under half of respondents (26 out of 59, 44%) stated their primary motivation for enrolling in the program was to receive incentives, followed by desire to reduce environmental impacts (17 out of 59, 29%).
	85% of respondents (50 out of 59) were satisfied with the enrollment process, and nearly all respondents (55 out of 59, 93%) did not encounter difficulties while enrolling. Suggestions for improving the enrollment process centered around improving information provided about the program, namely what is expected of participants and clarification of program rules with regards to incentives.

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Charging Behavior	Half (55%) of respondents (31 out of 56) charged their EV until full whenever it was connected to their home charging device while 34% (19 out of 56) used a set charging schedule from their EV or EVSE app.
	Four survey respondents indicated that they actively adjusted their charging behavior/schedule generally as a result of the program (e.g., choosing to delay their charging until night time to align with program goals).
	Only 16 out of 59 respondents (27%) had access to workplace charging during the summer of 2021. Of these 16 respondents, 12 reported actually using workplace charging and performed about 40% of their overall charging at their workplace, on average. The primary barrier to workplace charging was the availability of charging stations.
	About 53% of respondents (31 out of 59) reported using public chargers and the most commonly cited barriers to public charging were location and availability of chargers.
Behavior During Events	Respondents believed they successfully participated in, on average, approximately 3.5 times the number of events they actually participated in.[28] This was similar for BEVs and PHEVs. Again, this indicates that there was confusion among respondents as to what behavior constituted participation in events.
	Sixty-four percent of respondents (38 out of 59) recalled at least one peak event in summer 2021. Of the 21 respondents (36%) who did not recall any peak events, about half had EVs for which event notification was not provided.
	The majority of respondents who recalled at least one event (34 out of 38, 89%) recalled receiving notifications about peak events. The majority of respondents who recalled receiving peak event notifications were satisfied with them.
	Of the 64% of respondents (38 out of 59) that recalled at least one peak event in summer 2021, 74% (28 out of 38) said that the events had no impact on their charging behavior during summer 2021. Only six respondents recalled opting-out or overriding at least one event. Of these six respondents, three opted out of “some events” and three “rarely” opted out.

Source: Guidehouse

Table 5-2. Key Findings – Assessment of Charging Profiles

Research Category	Findings
Charging Profile Analysis	**PHEVs plugged in more frequently than BEVs.** The median number of plug sessions per week was 5 for PHEVs and 2 for BEVs. Eighty-nine percent (89%) of BEVs and 48% of PHEVs plugged in an average of 4 times per week or less.
	EV plug sessions started most frequently in the evening hours. The single hour with the most plug-ins was 5 to 6 p.m. for both BEVs and PHEVs, with 11% and 10%, respectively, of plug-ins occurring during that hour.

[28] According to the event participation assessment (section 4.3).

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Research Category	Findings
	Periods of peak energy consumption occurred at different times for BEVs and PHEVs. Forty-five percent (45%) of all energy consumed on non-event weekdays by BEVs took place between 9 a.m. and 5 p.m., while only 21% of PHEV energy consumption occurred in the same period. This is reflective of BEV peak consumption occurring in the midday hours, while PHEV peak consumption was delayed to the late evening and overnight hours. One OEM's charging optimization system shifted charging for a portion of PHEVs to occur overnight, rather than charging immediately upon plug-in.
	Hourly average power draw varied more by EV type than by weekday or weekend, and the two EV types' evening peaks occurred at different times of day. The evening peak occurred at 5 p.m. to 7 p.m. for BEVs and at 7 p.m. to 9 p.m. for PHEVs. The PHEV evening peak was outside of the typical event hours of 4 p.m. to 7 p.m.
	PHEVs charged a higher percent of their battery capacity per session compared to BEVs. PHEVs plugged in at an average 47% SOC and unplugged at 88%, while the average BEV plugged in at 54% and unplugged at 78%.

Source: Guidehouse

Table 5-3. Key Findings – Assessment of Event Participation

Research Category	Findings
Event Participation	**Most EVs were unplugged during the event and did not participate, making up 74% of all participation statuses across events.** Of the 86 EVs that were enrolled for at least 5 events, 43% participated in 0 events and 90% participated in fewer than 20% of the events they were enrolled for.
	Full and partial participation accounted for 7.3% of participation statuses and 7.4% of statuses were flagged as technical issues or opt-outs. Technical issues could not be differentiated from opt-outs because no opt-out data was made available to Guidehouse.
	Technical issues or opt-outs accounted for 29% of all plugged-in participation statuses. Of the 18 events that had 10 or more EVs plugged-in, technical issues or opt-outs ranged from 13% to 41% of plugged-in participation statuses.
	Enrolled customers received event notifications at different times and under varying criteria, depending on the OEM. Guidehouse cannot definitively isolate the impact of these differences on event participation from other differences across OEMs, but there were no obvious indications that event notification timing had an impact on participation.
	There was no evidence of customers "gaming" the program by changing their charging behavior to plug in during typical event windows and receive the per-event incentive. Such "gaming" behavior was not observed even for the OEM that provided day-ahead notifications.

Source: Guidehouse

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Table 5-4. Key Findings – Impacts

Research Category	Findings
Impacts	**Demand impacts for all EVs averaged 0.09 kW across all events.** BEV and PHEV average impacts for the analysis period were 0.11 kW and 0.07 kW, respectively.
	Average demand impacts of *event participants* were 1.26 kW for all EVs, 1.36 kW for BEVs, and 1.07 kW for PHEVs.
	August events had higher average demand impacts than July events (0.11 kW v. 0.04 kW). Contributing factors include an increase in average event participation from 4.5% to 7.8% and an increase in average available line power from 1.53 kW to 2.58 kW.
	Peak hours identified by ISO New England had average total impacts of 6.9 kW, and ranged from 0.22 kW to 16.02 kW. Fourteen of 62 ISO-NE peak hours overlapped event periods.

Source: Guidehouse

Table 5-5. Key Recommendations from the Evaluation

Research Category	Recommendations
Data Collection	**Recommendation 1:** While the DRMS provider and OEMs have already worked to standardize fields, availability and quality of key fields should be confirmed with each OEM prior to the next evaluation.
Data Collection	**Recommendation 2:** For future evaluations working with session data, clearer guidance should be provided to OEMs on how to summarize charging sessions that overlap event periods.
Impacts	**Recommendation 3:** Provide event opt-out data for future evaluations, to differentiate between opt-outs and technical issues.
Impacts	**Recommendation 4:** Claim 6.9 kW as the average total savings observed during ISO-NE peak hours that overlapped event periods.

Source: Guidehouse

Table 5-6. Key Findings Considerations from the Evaluation

Research Category	Considerations
Program Information / Communication	**Consideration 1:** Consider improving and increasing the level of communication regarding how incentives are earned and when they will be rewarded. If a new annual incentive design is employed, this change should be clearly and directly communicated to existing participants.
Incentive Design	**Consideration 2:** Consider providing a minimum flat annual incentive to those who do not have the opportunity to earn per-event incentives as a result of never plugging in and/or charging during peak events. This may help minimize confusion/frustration and avoid incentivizing charging behavior that is contradictory to program goals.[29]

[29] Note that for the 2022 offering, National Grid replaced the per-event incentive with a flat annual incentive of $20, while also increasing the sign-up incentive from $25 to $50.

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Research Category	Considerations
Incentive Design	**Consideration 3:** If a flat annual incentive for participation in the program is employed, National Grid should monitor program enrollment, satisfaction and attrition rates to determine whether any adjustments to the level of sign-up and/or annual incentives are needed.
Data Collection	**Consideration 4:** If available, a more granular dataset such as 15-minute interval data or smaller charging blocks should be provided for future evaluations.
Impacts	**Consideration 5:** Due to the high proportion of technical issues or opt outs (relative to participating EVs), test that enrolled EVs can get called for events prior to season start.
Impacts	**Consideration 6:** Continue to monitor the effects of the program on participants' charging behavior on all days (not just event days) through surveys and other methods, as possible. Evaluate this type of behavioral effect to enable National Grid to claim the savings associated with participants choosing to charge during off-peak hours as a result of their participation in the program.

Source: Guidehouse

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A. Participant Survey Instrument

A.1 2021 Participant Survey Instrument

[Survey starts] National Grid thanks you for participating in the ConnectedSolutions EV and PHEV Demand Response Program. In an effort to improve the program and its ability to reduce strain on the electricity grid during periods of peak demand, we have some questions related to your experiences in the program and your household's charging and driving behavior in general.

If you cannot complete the survey all at one time or if you accidentally exit the survey mid-course, you can resume the survey where you left off by clicking on the link from the email you received. Once you have completed the survey, you will have the option to provide your email address so we can email you your $10 eGift Card.

A.1.1 Enrollment

E1. What was your top motivation for enrolling in National Grid's ConnectedSolutions EV and PHEV Demand Response Program?

[Response option order for options a-d is randomized for each respondent]

a. Receive incentives
b. Reduce my environmental impact
c. Reduce the need for additional power plants
d. Support my community and/or state's energy initiatives
e. Other (*specify*) **[Open-ended]**

E2. How did you learn about National Grid's ConnectedSolutions EV and PHEV Demand Response Program? Select all that apply.

a. **[EV Manufacturer name]** email
b. **[EV Manufacturer name]** website
c. **[EV Manufacturer name]** app
d. EnergyHub website
e. Friend/family/neighbor
f. National Grid email
g. National Grid website
h. National Grid Other (*specify*) **[Open-ended]**
i. Other, please specify: **[Open-ended]**
j. Not sure **[Mutually exclusive response]**

E3. On a scale of 1 to 5, where 1 indicates "Very unsatisfied" and 5 indicates "Very satisfied", how satisfied were you with the process of enrolling in the program?

a. Very Unsatisfied	**b.**	**c.**	**d.**	**e.** Very Satisfied
1	2	3	4	5

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E4. Did you encounter any challenges or difficulties during the enrollment process?

a. Yes, I encountered challenges during the enrollment process
b. No, I did not encounter any challenges during the enrollment process

[If E4 = a, continue; otherwise, skip to E6]

E5. What challenges or difficulties did you encounter during the enrollment process? **[Open-ended, optional]**

E6. How could the ConnectedSolutions EV and PHEV Demand Response Program enrollment process be improved?

a. **[Open-ended]**
b. No improvements needed
c. Not sure

A.1.2 EV Characteristics and Driving Behavior During Summer 2021

EV1. How many licensed drivers are there in your household? **[Enter numeric]**

EV2. Please provide the make, model, and year of your enrolled EV. **[Make, model, and year of EV #1 to be based on this response]**

	Make and Model	**Year**
Enrolled EV #1	**[Dropdown]**	**[Dropdown]**

EV3. Does your household own any other EVs (that are not enrolled in the program)? This includes other all-battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). It does NOT include pure hybrid vehicles (i.e., those that do not require the battery to be charged via charging equipment). Select all that apply.

a. Yes, our household owns an additional BEV(s) that is not enrolled in the program
b. Yes, our household owns an additional PHEV(s) that is not enrolled in the program
c. No, our household does not own any BEVs or PHEVs beyond what is enrolled **[Mutually exclusive response]**

[If EV3 = a, continue; otherwise, skip to EV5]

EV4. How many additional BEVs does your household own? **[Dropdown w/ values 0-4]**

[If EV3 = b, continue; otherwise, skip to EV6]

EV5. How many additional PHEVs does your household own? **[Dropdown w/ values 0-4]**

[Display text] Please answer the remaining questions thinking about the electric vehicle that is enrolled in the program.

EV6. Did this electric vehicle serve as the primary form of transportation for at least one member of the household on weekdays during summer 2021 (June through August)?

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a. Yes
b. No

EV7. What was your household's top motivation for buying the electric vehicle?

[Response option order for options a-h is randomized for each respondent]

a. We/I wanted to save money
b. We/I wanted to help the environment
c. There were rebates available (*specify*) **[Open-ended]**
d. We/I wanted the latest technology
e. It fits with my/our lifestyle
f. For comfort reasons
g. Fuel independence
h. Convenience (not having to stop at gas station)
i. Other (*specify*) **[Open-ended]**

[Display text] We now have some questions about how your household used the electric vehicle during the summer. Please answer the questions thinking about ***this past summer – i.e., June 2021 through August 2021.***

EV8. Which of the following best describes how your household *typically* used this electric vehicle on weekdays (Monday through Friday) during the summer of 2021 (June through August)?

a. I or another member of my household used it on a regular schedule (e.g., to and from work)
b. I or another member of my household used it as needed (e.g., to complete errands)
c. No one from my household used it on weekdays
d. Other (*Please describe how your vehicle was typically used on weekdays*) **[Open-ended]**

EV9. On a *typical* summer 2021 weekday (Monday, Tuesday, etc.), on average, how many miles was this electric vehicle driven by you and other members of your household? Don't worry about being exact – just provide your best estimate for the total miles driven on a typical summer weekday for 2021.

a. 0-10 miles
b. 11-20 miles
c. 21-30 miles
d. 31-50 miles
e. 51-70 miles
f. 71-100 miles
g. 101-150 miles
h. > 150 miles
i. It varied significantly day-to-day or depending on the day of the week (*Please describe*) **[Open-ended]**
j. It varied significantly depending on the week or month (*Please describe*) **[Open-ended]**
k. Not sure

A.1.3 Charging Behavior During Summer 2021

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[Display text] Still thinking about your enrolled electric vehicle, we now have some questions about how your household *charged* this electric vehicle during this past summer. Please answer the questions thinking about ***this past summer – i.e., June 2021 through August 2021.***

CB1. Approximately what percentage of your EV's charging this past summer took place at your home, work, public, or other charging stations? Don't worry about being precise, just take your best guess.

Charging Location	**% of EV charging**
CB1_1. My home charger	**[Numeric]** %
CB1_2. Workplace charger	**[Numeric]** %
CB1_3. Public charger	**[Numeric]** %
CB1_4. Other (*specify*) **[Open-ended]**	**[Numeric]** %

CB2. Which of the following best describes the electric vehicle charging device that you have at home?

a. Level 1 charger (i.e., a charger that plugs into a standard 120-volt outlet)
b. Level 2 charger (i.e., a charger that plugs into a high-output 220/240-volt outlet)
c. I do not have a charger for use at home

[If CB2 = b, continue; otherwise, skip to CB4]

CB3. Please select the make of your Level 2 charger. **[Dropdown]**

[If CB1_1 > 0%, continue; otherwise, skip to CB11]

CB4. During summer 2021, when your electric vehicle was not being used and at home, was it typically connected to your home charging device?

a. Yes, I/we typically always had the EV connected to our home charging device when not using the EV
b. No, I/we only connected the EV to our home charging device at select times; *please describe* (e.g., when the EV battery had a certain % charge remaining) **[Open-ended]**
c. Other (*specify*) **[Open-ended]**
d. Not sure

CB5. During summer 2021, which of the following best describes your household's use of your home charging device for your electric vehicle?

a. Whenever the EV was connected to our home charging device, it charged until it was fully charged
b. I/We used the home charging device app to remotely start and stop charging of the EV
c. I/We followed a charging schedule that I/we set using the home charging device app
d. I/We followed a charging schedule that I/we set using the EV's app
e. Other, please specify: **[OPEN-ENDED]**

[If CB5 = c OR d, continue; otherwise, skip to CB5_b]

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CB5_a. How was your electric vehicle's home charging schedule determined?

a. I/We selected it
b. It is the default schedule
d. Other (*specify*) **[Open-ended]**
e. Don't know

CB5_b. Did National Grid's ConnectedSolutions EV and PHEV Demand Response Program influence your choice of home charging schedule at all?

a. Yes, *please describe* **[Open-ended]**
b. No
c. Don't know

CB6. Below, please indicate the time ranges during which the electric vehicle was ***typically connected to your home charging device*** on weekdays (Monday through Friday) during summer 2021 (June through August). Select all the time ranges that apply.

As an example, if you typically disconnected the electric vehicle at 7:30 AM to go to work and then you connected this electric vehicle again when you returned home at 5:30 PM (leaving it connected until the following morning), you would select all ranges between 12 AM and 8 AM, and between 4 PM and 12 AM.

a. 12 AM – 2 AM
b. 2 AM – 4 AM
c. 4 AM – 6 AM
d. 6 AM – 8 AM
e. 8 AM – 10 AM
f. 10 AM – 12 PM
g. 12 PM – 2 PM
h. 2 PM – 4 PM
i. 4 PM – 6 PM
j. 6 PM – 8 PM
k. 8 PM – 10 PM
l. 10 PM – 12 AM
m. It varied significantly day-to-day or depending on the day of the week, M–F (*please describe*) **[Open-ended]**
n. It varied significantly depending on the week or month (*please describe*) **[Open-ended]**
o. Not sure **[Mutually exclusive response]**

[If CB5 = b, continue; otherwise, skip to CB8]

CB7. At approximately what time did you typically start and stop charging your electric vehicle with your home charging device on weekdays in summer 2021? **[Open-ended]**

[If CB5 = c OR d, continue; otherwise, skip to CB9]

CB8. At approximately what time was your electric vehicle's charging typically scheduled to start and end on weekdays in summer 2021? **[Open-ended]**

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CB9. Compared to your household's use of your home charging device on weekdays, was the ***amount of time*** this electric vehicle was ***typically connected to your home charging device*** in summer 2021 different on weekends?

a. Yes, the EV was connected more on weekends
b. Yes, the EV was connected less on weekends
c. No / Not significantly

CB10. Compared to your household's use of your home charging device on weekdays, was the ***timing*** of when this electric vehicle was ***typically connected to your home charging device*** in summer 2021 different on weekends (e.g., shifted from being connected early evening through early morning to being connected all day when not in use)?

a. Yes (*please describe*) **[Open-ended]**
b. No / Not significantly

CB11. Is this electric vehicle driven to a workplace that has workplace charging available?

Please answer this question based on whether or not charging is available at a workplace, regardless of whether you or other household members go into work regularly and/or use it.

a. Yes
b. No
c. Not applicable (e.g., full-time remote, retired)

[If CB1_2 > 0% OR CB11 = a, continue; otherwise, skip to CB15]

CB12. Below, please indicate when this electric vehicle was ***typically connected to a workplace charging station on weekdays*** (Monday through Friday) during the summer 2021 (June through August). Select all the time ranges that apply.

As an example, if you typically connected this electric vehicle to a workplace charging station around 3 PM and disconnected when you left to return home at 5:30 PM, you would select ranges 2 PM – 4 PM and 4 PM – 6 PM.

a. 12 AM – 2 AM
b. 2 AM – 4 AM
c. 4 AM – 6 AM
d. 6 AM – 8 AM
e. 8 AM – 10 AM
f. 10 AM – 12 PM
g. 12 PM – 2 PM
h. 2 PM – 4 PM
i. 4 PM – 6 PM
j. 6 PM – 8 PM
k. 8 PM – 10 PM
l. 10 PM – 12 AM
m. It varied significantly day-to-day or depending on the day of the week, M–F (*please describe*) **[Open-ended]**
n. It varied significantly depending on the week or month (please describe) **[Open-ended]**
o. Not sure **[Mutually exclusive response]**

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CB13. What are your main motivations for using ***workplace charging stations***? Select all that apply.

a. My workplace charging is free
b. My workplace charging is cheaper than charging at home
c. My workplace charging is faster than charging at home
d. Workplace charging is convenient
e. Workplace charging allows me to commute fully in electric mode
f. I charge at workplace charging stations to avoid charging during peak hours (2PM - 7PM)
g. Other (*specify*) **[Open-ended]**

[If CB11 = a, continue; otherwise, skip to CB15]

CB14. Are there are any barriers for you or your household members to use ***workplace charging stations*** to charge this electric vehicle? Select all that apply.

a. There is limited availability of workplace chargers
b. Workplace charging station time limits are a barrier
c. Workplace charging stations are not compatible with my EV
d. I have not experienced any barriers to using workplace charging stations **[Mutually exclusive response]**
e. Other (*specify*) **[Open-ended]**

[If CB1_3 > 0%, continue; otherwise, skip to CB16]

CB15. What are your main motivations for using ***public charging stations***? Select all that apply.

a. Public charging is cheaper than charging at home
b. Public charging is faster than charging at home
c. Public charging is convenient
d. Public charging allows me to commute fully in electric mode
e. I charge at public charging stations to avoid charging during peak hours (2PM - 7PM)
f. Other (*specify*) **[Open-ended]**

CB16. Are there are any barriers for you or your household members to use ***public charging stations*** to charge this electric vehicle? Select all that apply.

a. Public charging is more expensive than charging at home
b. There is limited availability of public chargers
c. Public charging stations are not always located near where I am going
d. Public charging station time limits are a barrier
e. Public charging stations are not always compatible with my EV
f. I have not experienced any barriers to using public charging stations **[Mutually exclusive response]**
g. I have not tried to use public charging stations **[Mutually exclusive response]**
h. Other (*specify*) **[Open-ended]**

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A.1.4 Changes Since Summer 2020

[Display text] Now we have some questions about how driving and charging changed, if at all, for the electric vehicle ***since summer of 2020***. In answering these questions, please think about the typical weekday in summer 2021 when ***no peak event was called***.

CS1. Compared to your household's use of your electric vehicle in the summer 2020, did the typical ***miles per day*** that this electric vehicle was driven on weekdays change in summer 2021?

a. Yes, we drove the EV more on weekdays in summer 2021
b. Yes, we drove the EV less on weekdays in summer 2021
c. No / Not significantly
d. We bought the EV after the summer of 2020

[If CS1 ≠ d, continue; otherwise, skip to A1]

CS2. Compared to your household's use of this electric vehicle in the summer of 2020, did the ***timing*** of when this electric vehicle was typically driven on weekdays change in summer 2021?

a. Yes
b. No / Not significantly

[If CS2 = a, continue; otherwise, skip to CS3]

CS2_a. Please describe how the timing of when this electric vehicle was typically driven on weekdays changed in summer 2021 compared to summer 2020. **[Open-ended]**

CS3. Compared to the summer of 2020, was this EV typically ***charging more, less, or the same amount on weekdays*** in summer 2021? Please indicate how this varied by charging location.

	a. The EV was charging ***more on weekdays*** in summer 2021	**b.** The EV was charging ***less on weekdays*** in summer 2021	**c.** About the same
CS3_1. My home charger			
CS3_2. Workplace charger			
CS3_3. Public charger			

[If CS3_1 ≠ c OR CS3_2 ≠ c OR CS3_3 ≠ c, continue; otherwise, skip to CS6]

CS4. What accounts for the change in the amount of ***charging on weekdays*** between summer 2020 and summer 2021? **[Open-ended]**

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CS5. Compared to the summer of 2020, was this EV typically charging more, less, or the same amount in summer 2021 ***during the weekday hours of 2 PM to 7 PM***? Please indicate how this varied by charging location.

	a. The EV was charging ***more*** during the weekday hours of 2 PM – 7 PM than during other hours in summer 2021	**b.** The EV was charging ***less*** during the weekday hours of 2 PM – 7 PM than during other hours in summer 2021	**c.** About the same
CS5_1. My home charger			
CS5_2. Workplace charger			
CS5_3. Public charger			

[I CS5_1 ≠ c OR CS5_2 ≠ c OR CS5_3 ≠ c, continue; otherwise, skip to CS7]

CS6. What accounts for the change in the amount of ***charging on weekdays from 2 PM – 7 PM*** between summer 2020 and summer 2021? **[Open-ended]**

CS7. What, if any, additional observations do you have to share related to how your household's use of this electric vehicle and/or charging stations changed between summer 2020 and summer 2021?

a. **[Open-ended]**
b. No additional observations

A.1.5 Additional EVs in Household

[If EV3 = a OR b, continue; otherwise, skip to QET1]

A1. Thank you for answering the previous questions thinking about the enrolled electric vehicle. You indicated that your household has more than one EV. Please describe how your household used the additional electric vehicle(s) in summer 2021 (e.g., driven approximately 5 miles per weekday, on average, mostly after 4 pm). **[Open-ended, optional]**

A2. Additionally, please describe how your household charges the additional electric vehicle(s). How do you manage home charging between EVs? **[Open-ended, optional]**

A.1.6 Behavior During Events

ET1. The National Grid's ConnectedSolutions EV and PHEV Demand Response Program rewards you for using less energy during peak event periods, when others are using more electricity. During these peak events, National Grid pauses your charger's energy use until the event is over, unless you override the event.

How many peak events do you recall in summer 2021 (June through August)? If you enrolled during this timeframe, provide the number you recall since you enrolled. **[Enter numeric][If ET1 > 0, continue; otherwise, skip to S5]**

ET2. Do you recall ever receiving notifications (i.e., in-app, emails, text messages) about peak events?

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a. Yes
b. No

[If ET2 = a, continue; otherwise, skip to ET6]

ET3. How did you receive notifications about peak events? Select all that apply.

a. EV app
b. Email
c. Text message
d. Other (*specify*) **[Open-ended]**

ET4. At what time do you recall receiving notifications about peak events? Select all that apply.

a. When the peak event was in progress
b. *Before* the peak event started
c. *After* the peak event ended

ET5. On a scale of 1 to 5, where 1 is “Very dissatisfied” and 5 is “Very satisfied”, how would you rate your satisfaction with peak event notification?

a. Very Dissatisfied	**b.**	**c.** Neutral	**d.**	**e.** Very Satisfied	**f.** Don’t know
1	2	3	4	5	

ET5_a. Are there ways that peak event notifications could be improved?

a. Yes (specify) **[Open-ended]**
b. No / No improvements needed
c. Not sure

ET6. For the peak events you can recall during summer 2021, how often was your electric vehicle connected to a charging device during event hours?

a. Connected for all event hours
b. Connected for most event hours
c. Connected for some event hours
d. Never connected during event hours
e. Don’t know

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ET7. Please indicate how the peak events affected your normal charging and/or driving behavior during summer 2021. Select all that apply.
[Response option order for options a-d is randomized for each respondent]

a. No impacts **[Mutually exclusive response]**
b. Had to modify charging schedule to make sure my vehicle was charged for when it was needed (*specify*) **[Open-ended]**
c. Had to defer or reschedule activities so we/I could wait to finish charging the EV since charging was paused during the peak event
d. I had to disconnect my vehicle before it was fully charged
e. Other (*specify*) **[Open-ended]**
f. Don't know **[Mutually exclusive response]**

ET8. Did you take any other actions in response to being notified that a peak event was occurring?

a. Yes (*specify*) **[Open-ended]**
b. No / No other actions taken

ET9. Compared to days in summer 2021 when *no* peak event was called, was this EV ***typically connected to a charging device more, less, or the same amount on peak event days***? Please indicate how the amount of time connected changed by charging location.

	a. The EV was connected ***more*** on peak event days	**b.** The EV was connected ***less*** on peak event days	**c.** About the same
ET9_1. My home charger			
ET9_2. Workplace charger			
ET9_3. Public charger			

[If ET9_1 ≠ c OR ET9_2 ≠ c OR ET9_3 ≠ c, continue; otherwise, skip to ET11]

ET10. What accounts for the change in the amount of time this electric vehicle was ***typically connected to a charging device*** between days with no peak events and days with peak events? **[Open-ended]**

ET11. Compared to days in summer 2021 when *no* peak event was called, was this EV ***typically connected to a charging device more, less, or the same amount during the hours of 2 PM – 7 PM*** relative to other hours? Please indicate how the connected timing changed by charging location.

	a. The EV was connected ***more*** during the hours of 2 PM – 7 PM than during other hours on peak event days	**b.** Yes, the EV was connected ***less*** during the hours of 2 PM – 7 PM than during other hours on peak event days	**c.** About the same
ET11_1. My home charger			
ET11_2. Workplace charger			
ET11_3. Public charger			

[If ET11_1 ≠ c OR ET11_2 ≠ c OR ET11_3 ≠ c, continue; otherwise, skip to ET13]

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ET12. What accounts for the change in the amount of time this electric vehicle was ***typically connected to a charging device during the hours of 2 PM – 7 PM*** between days with no peak events and days with peak events? **[Open-ended]**

ET13. What, if any, additional observations do you have to share related to how your household's use of charging devices changed between days with no peak events and days with peak events in summer 2021?

a. **[Open-ended]**
b. No additional observations

ET14. On peak event days in summer 2021, did you ever "opt-out" or override a peak event to stop the program from pausing your charging during the event?

a. Yes
b. No
c. Don't know

[If ET14 = a, continue; otherwise, skip to S1]

ET14_a. How did you opt-out or override a peak event(s)? Select all that apply.

a. Through the EV itself
b. Through the EV app
c. By unplugging and re-plugging in the EV to a charging device
d. Other (*specify*) **[Open-ended]**
e. Don't know **[Mutually exclusive response]**

ET15. How often would you say you chose to opt-out or override a peak event?

a. Every peak event
b. Most peak events
c. Some peak events
d. Rarely
e. Never
f. Unsure/Don't know

[I ET14 = a AND ET15 ≠ e, continue; otherwise, skip to S1]

ET16. For what reason(s) did you opt-out or override the peak event(s)? **[Open-ended]**

ET17. On a scale of 1 to 5, where 1 means "Very difficult or confusing" and 5 means "Very easy", how easy was it to opt-out of or override peak events?

a. Very Difficult or Confusing	b.	c. Neutral	d.	e. Very Easy	f. Don't know
1	2	3	4	5	

ET18. How could the process of opting out or overriding a peak event be improved?

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a. **[Open-ended]**
b. No improvements needed
c. Not sure

A.1.7 Program Satisfaction

S1. On a scale of 1 to 5, where 1 is "Very dissatisfied" and 5 is "Very satisfied", how would you rate your satisfaction with the following aspects of National Grid's ConnectedSolutions EV and PHEV Demand Response Program to-date?

	a. Very Dissatisfied	b.	c. Neutral	d.	e. Very Satisfied	f. Don't know
	1	2	3	4	5	
S1a. Number of peak events						
S1b. Length of peak events						
S1c. Timing of peak events (i.e., what period during the day events occurred)						

S2. How could the number of peak events be improved?

a. **[Open-ended]**
b. No improvements needed
c. Not sure

S3. How could the length of peak events be improved?

a. **[Open-ended]**
b. No improvements needed
c. Not sure

S4. How could the timing of peak events be improved?

a. **[Open-ended]**
b. No improvements needed
c. Not sure

S5. In terms of program incentives, program rules as of summer 2021 specified the following:

- You are provided $25 for enrolling in the program
- You are provided $10-$20 per event, depending on your charging rate (Level 1 / Level 2)

Does this align with your understanding of what you would receive for enrolling in the program and participating in events in summer 2021?

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a. Yes
b. No (*please describe what your understanding is*) **[Open-ended]**
c. Don't know

S6. Approximately how many events do you expect you earned an incentive for in summer 2021? **[Enter numeric]**

S7. On a scale of 1 through 5, where 1 is "Very dissatisfied" and 5 is "Very satisfied", how would you rate your satisfaction with the program incentives for summer 2021?

a. Very Dissatisfied	**b.**	**c.** Neutral	**d.**	**e.** Very Satisfied	**f.** Don't know
1	2	3	4	5	

S8. How could program incentives be improved?

a. **[Open-ended]**
b. No improvements needed
c. Not sure

S9. On a scale of 1-5, where 1 is "Very unlikely" and 5 is "Very likely", how likely are you to continue to participate in National Grid's ConnectedSolutions EV and PHEV Demand Response program?

a. Very Unlikely	**b.**	**c.**	**d.**	**e.** Very Likely
1	2	3	4	5

[If S9 = a-b, continue; otherwise, skip to S11]

S10. What change(s) to National Grid's ConnectedSolutions EV and PHEV Demand Response Program, if any, would encourage you to continue participating? **[Open-ended, optional]**

[If S9 = c-e, continue; otherwise, skip to S12]

S11. What recommendations would you make, if any, to help improve National Grid's ConnectedSolutions EV and PHEV Demand Response Program going forward? **[Open-ended, optional]**

S12. On a scale of 1 to 5, where 1 is "Very unlikely" and 5 is "Very likely", if the program replaced per-event incentives with one flat annual incentive of $20, how likely are you to continue to participate in National Grid's ConnectedSolutions EV and PHEV Demand Response program?

a. Very Unlikely	**b.**	**c.**	**d.**	**e.** Very Likely
1	2	3	4	5

A.1.8 Demographics

[Display text] You're almost done! We just have a few more questions.

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D1. Which of the following best describes the property type where your home charging station is located?

a. Single family home
b. Multi-family home (2-4 units)
c. Multi-family home (5+ units)
d. Mobile home
e. Not a residence (e.g., business, workshop or other)
f. Other (*specify*) **[Open-ended]**

D2. Which of the following best describes the location of your home charging station?

a. In an attached heated garage
b. In an attached garage with no heat
c. In an unattached heated garage
d. In an unattached garage with no heat
e. Outside
f. Other (*specify*) **[Open-ended]**

D3. Which of the following age categories do you fall into?

a. 18-24
b. 25-34
c. 35-44
d. 45-54
e. 55-64
f. 65 or over
g. Prefer not to provide

D4. What is the last grade of school you completed?

a. Grade school or less (1-8)
b. Some high school (9-11)
c. Graduated high school (12)
d. Vocational/technical school
e. Some college (1-3 years)
f. Graduated college (4 years)
g. Post graduate education
h. Prefer not to provide

D5. Which category best describes your gender?

a. Male
b. Female
c. Other
d. Prefer not to provide

D6. How many people occupied your home this summer 2021? Enter zero where appropriate. **[Responses are restricted to two digits]**

Occupant Type	Number of People

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Children, under 18	**[Enter Numeric]**
Adults, 18 to 65	**[Enter Numeric]**
Adults, 65 and older	**[Enter Numeric]**

D7. **[PIPE IN VALUES FOR D7 BASED ON SUM OF RESPONSES TO D6]** What will be your estimated total annual household income in 2021 before taxes (in other words, your gross household income)? **[Example choices shown below are for if sum of D6 values = 1]**

a. Less than $19,600
b. $19,601 - $39,100
c. $39,101 - $45,600
d. $45,601 - $52,100
e. $52,101 - $58,700
f. $58,701 - $65,200
g. $65,201 - $71,700
h. $71,701 - $78,200
i. $78,201 - $97,800
j. $97,801 - $130,400
k. Greater than $130,400
l. Prefer not to answer

A.1.9 Closing

C1. We have reached the end of the survey. Do you have any additional comments regarding the National Grid's ConnectedSolutions EV and PHEV Demand Response Program?

a. **[Open-ended]**
b. None

C2. Thank you for taking the time to fill out this survey for the National Grid's ConnectedSolutions EV and PHEV Demand Response Program! Please provide your email address so we may email you a $10 eGift Card redeemable at a number of retailers including Amazon.com and Visa (to see your options visit https://www.rewardsgenius.com/reward-catalog).

a. Enter email address **[Open-ended]**
b. I prefer not to provide my email address

[Survey close] We thank you for your time spent taking this survey. Your response has been recorded.

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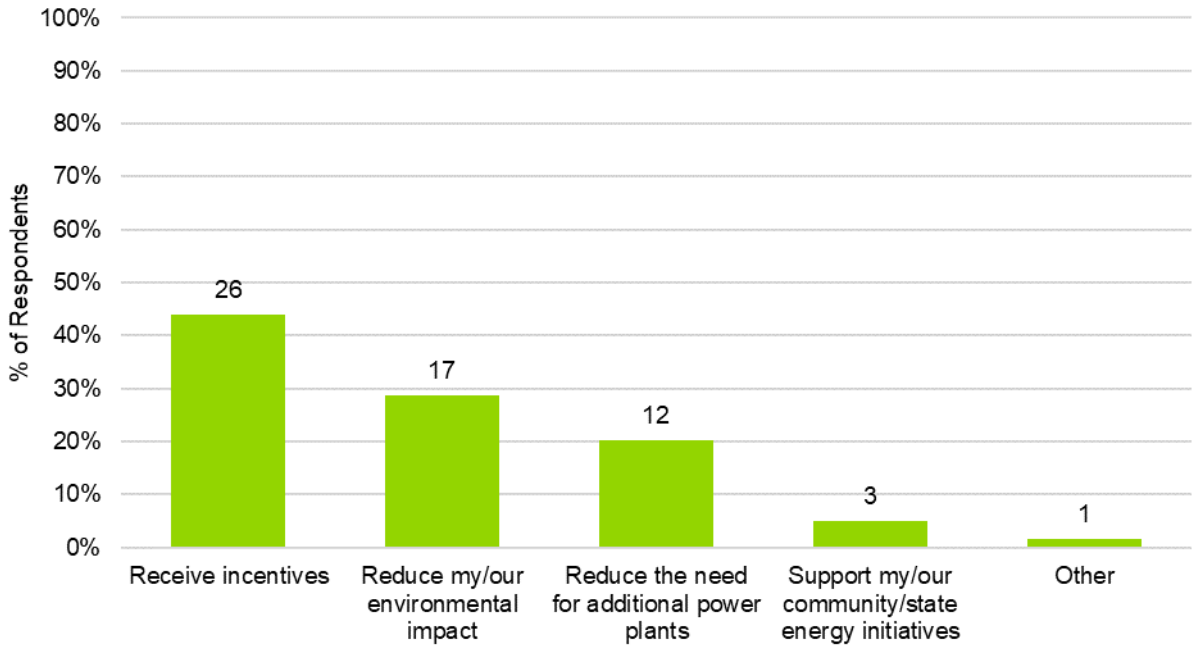
B. Participant Survey Output

B.1 2021 Participant Survey Output

B.1.1 Enrollment

E1. What was your top motivation for enrolling in National Grid's ConnectedSolutions EV and PHEV Demand Response Program? (n=59)



Source: Guidehouse

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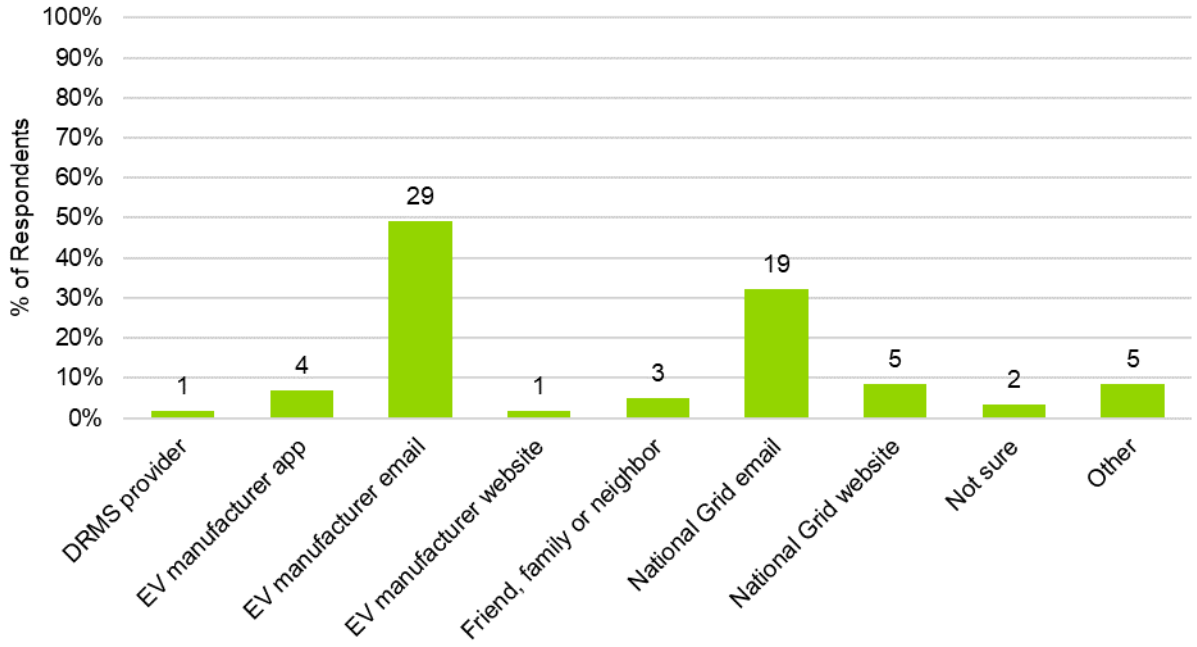
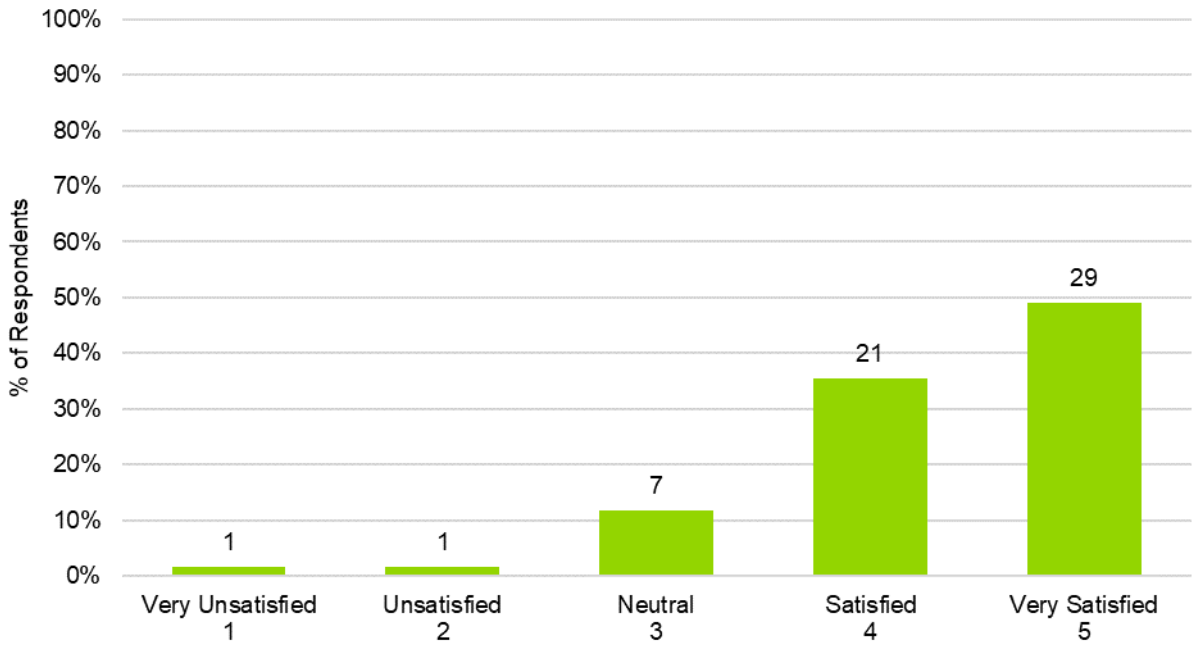
E2. How did you learn about National Grid's ConnectedSolutions EV and PHEV Demand Response Program? Select all that apply. (n=59)



Source: Guidehouse

E3. Using a scale of 1 to 5, how satisfied were you with the process of enrolling in the program? (n=59)



Source: Guidehouse

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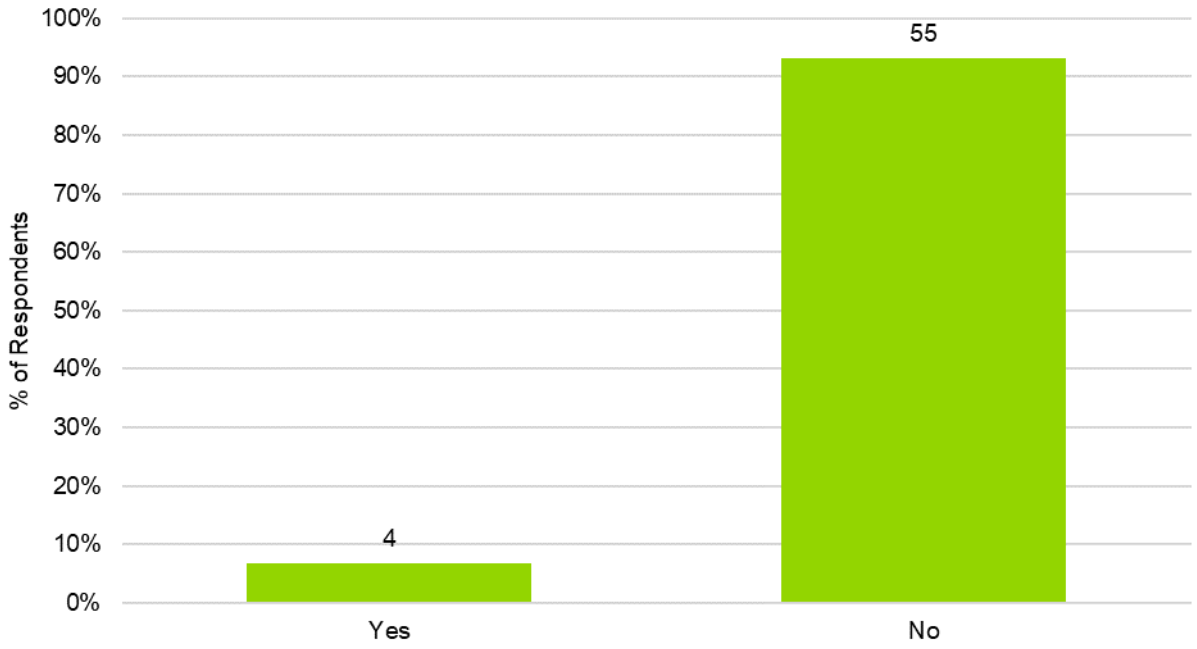
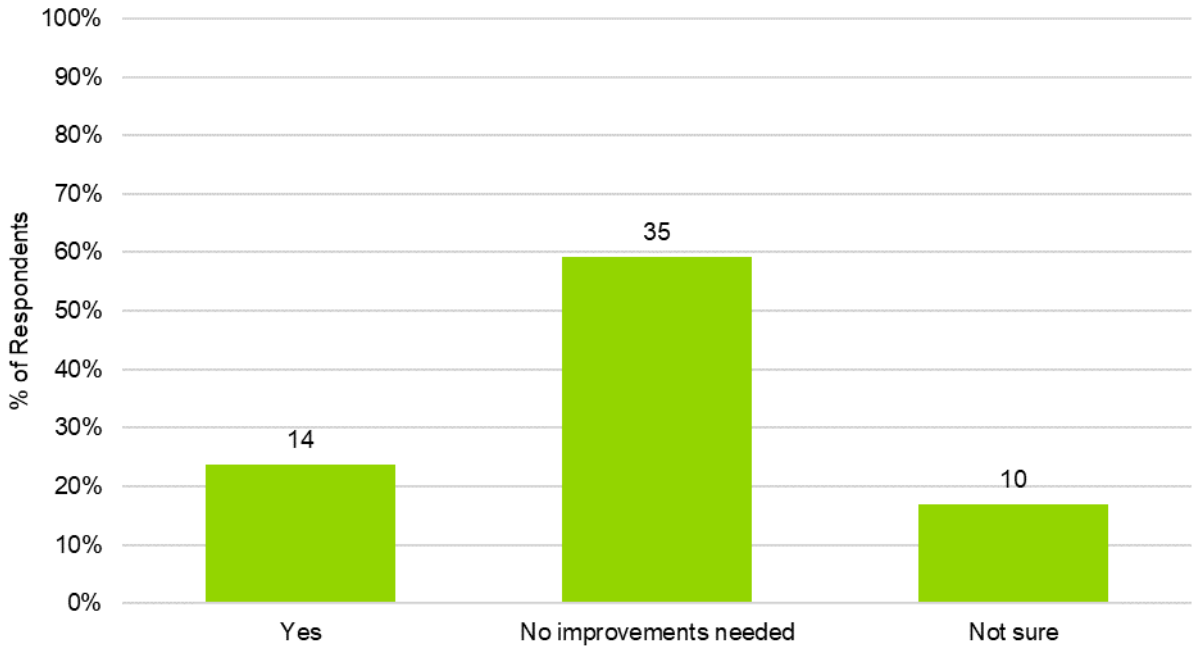
E4. Did you encounter any challenges or difficulties during the enrollment process? (n=59)



Source: Guidehouse

E6. How could the ConnectedSolutions EV and PHEV Demand Response Program enrollment process be improved? (n=59)



Source: Guidehouse

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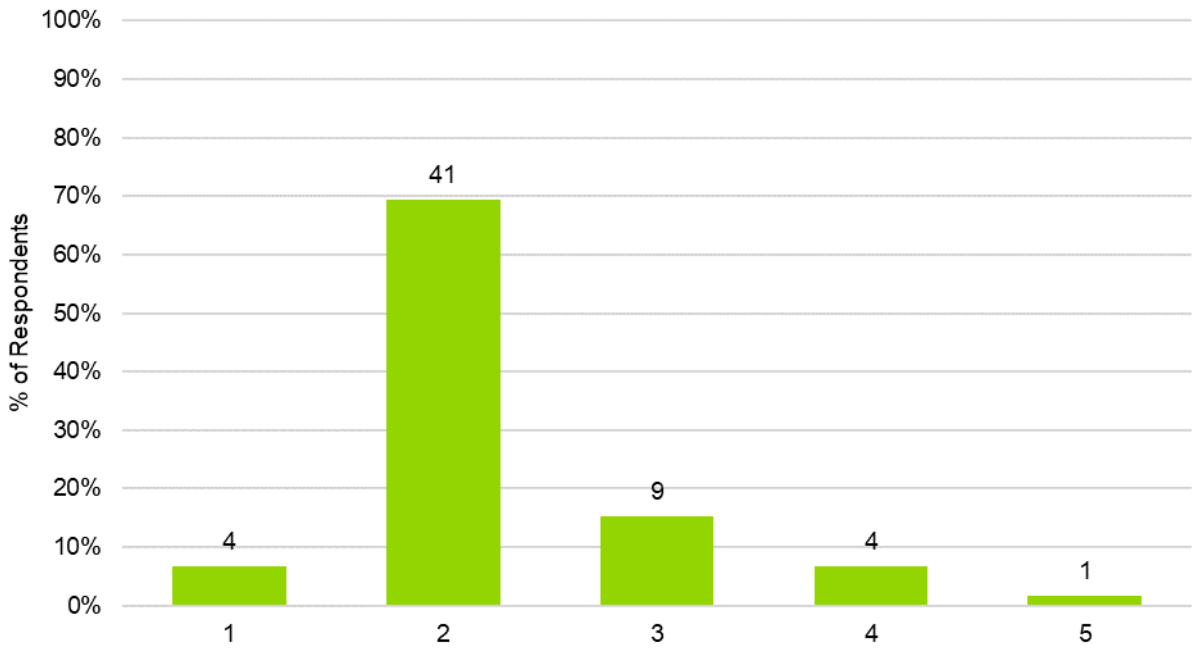
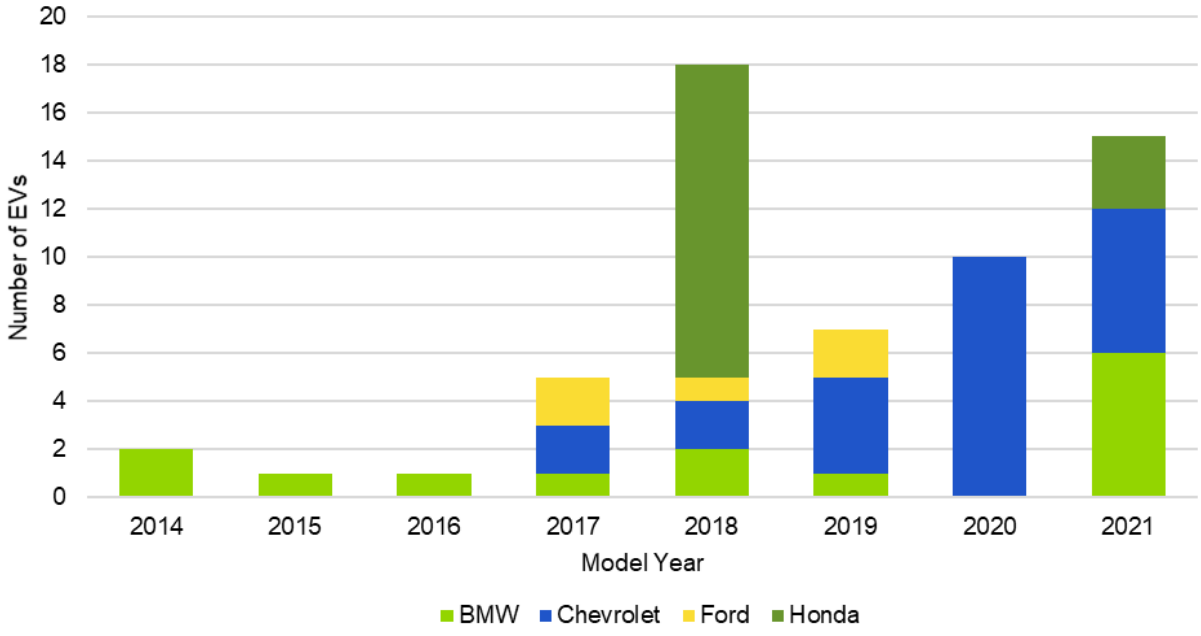
B.1.2 EV Characteristics and Driving Behavior During Summer 2021

EV1. How many licensed drivers are there in your household? (n=59)



Source: Guidehouse

EV2. Please provide the make, model, and year of your enrolled EV. (n=59)



Source: Guidehouse

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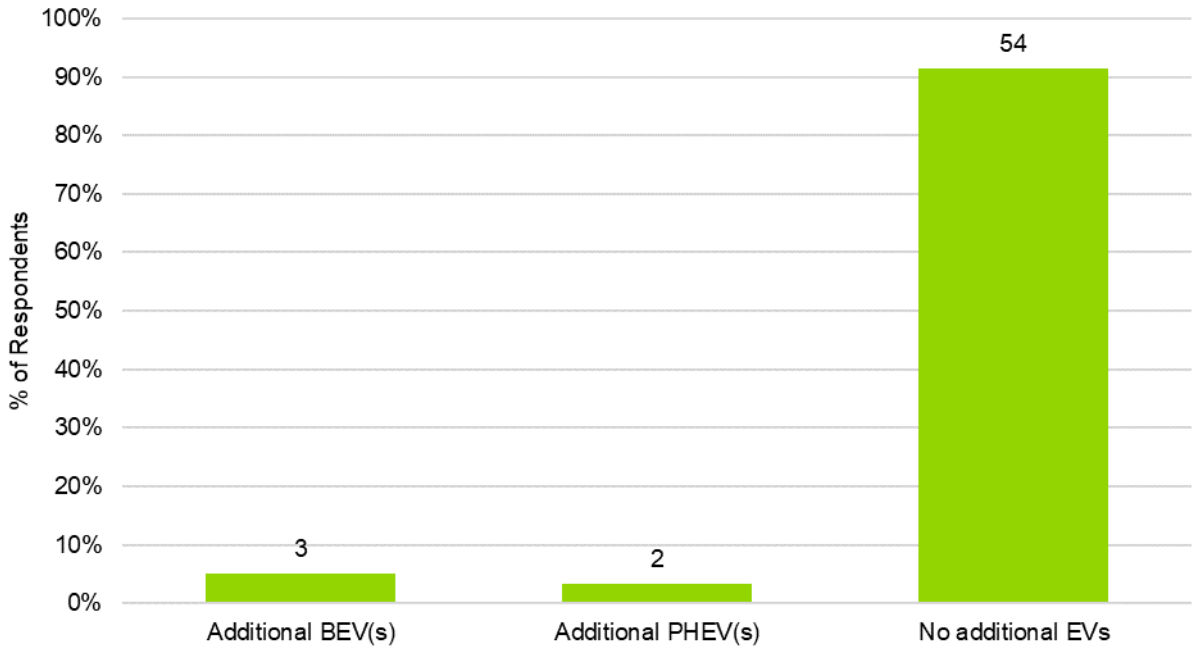
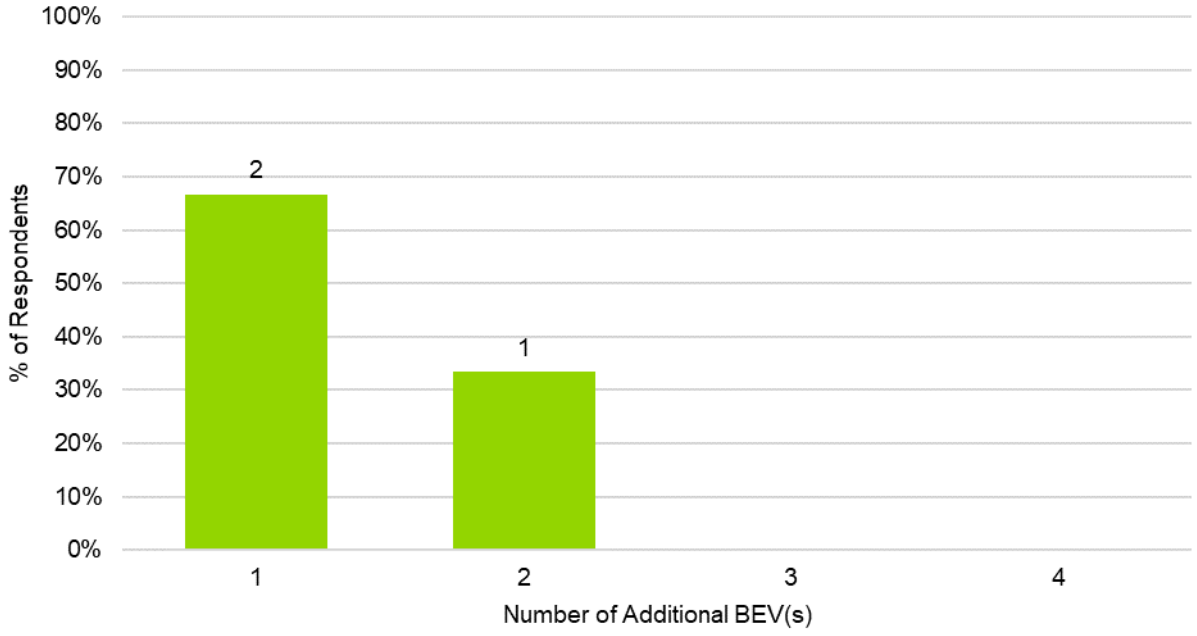
EV3. Does your household own any other EVs (that are not enrolled in the program)? This includes other all-battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). This does NOT include pure hybrid vehicles. Select all that apply. (n=59)



Source: Guidehouse

EV4. How many additional BEVs does your household own? (n=3)



Source: Guidehouse

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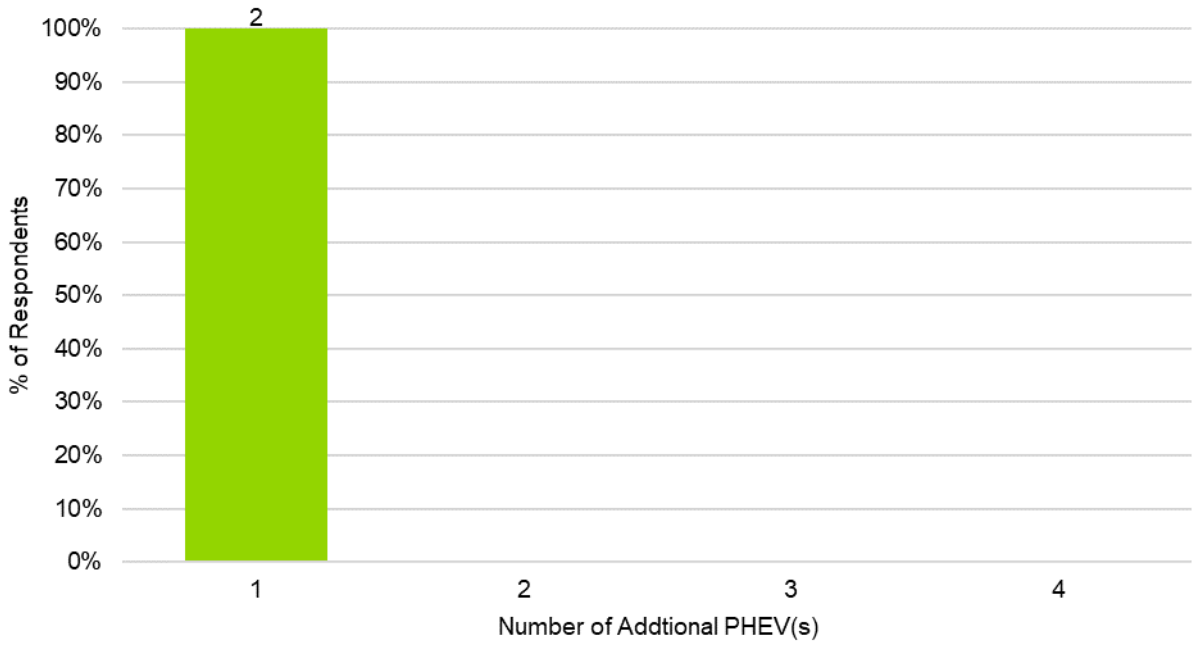
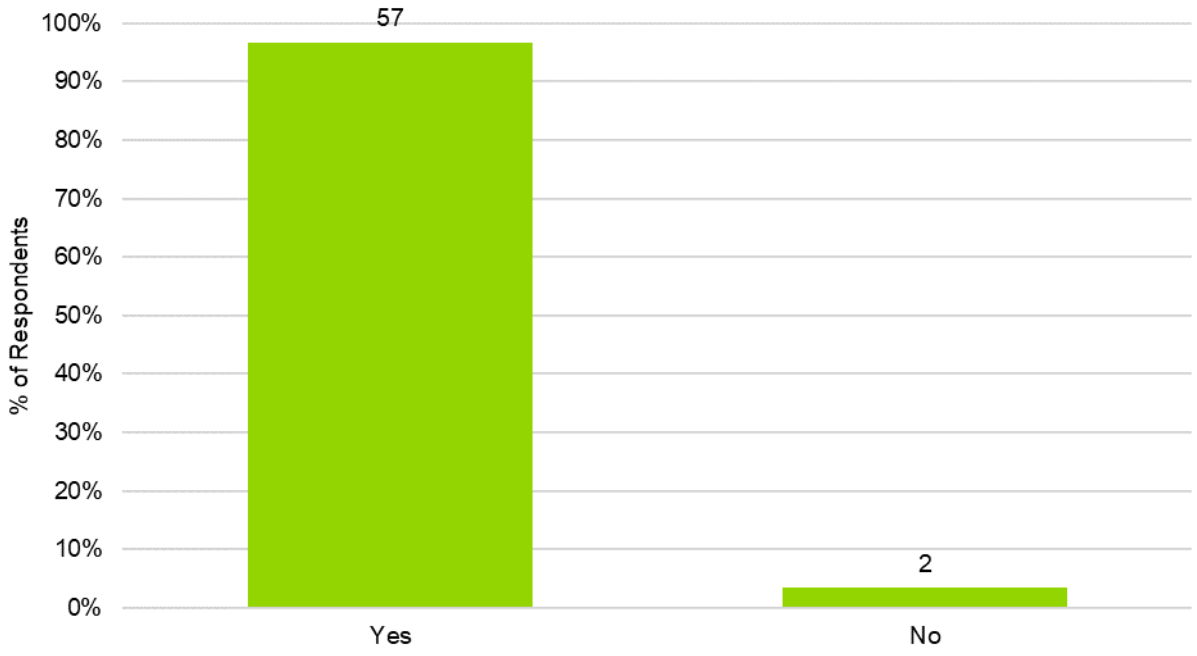
EV5. How many additional PHEVs does your household own (n=2)



Source: Guidehouse

EV6. Did this electric vehicle serve as the primary form of transportation for at least one member of the household on weekdays during summer 2021 (June through August)? (n=59)



Source: Guidehouse

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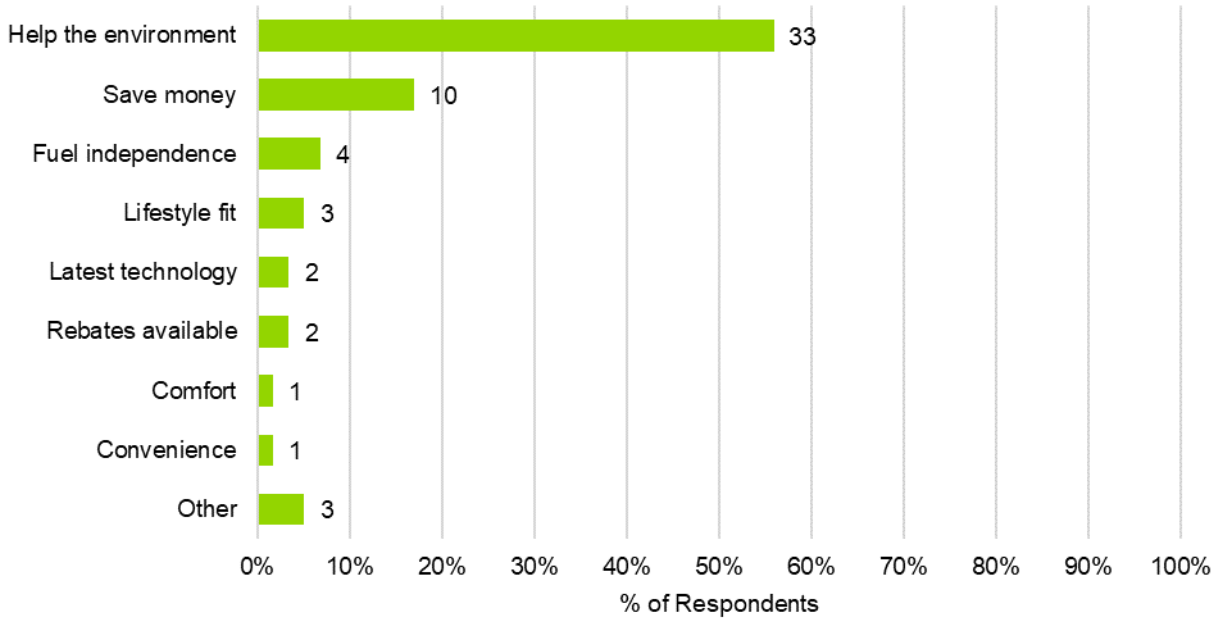
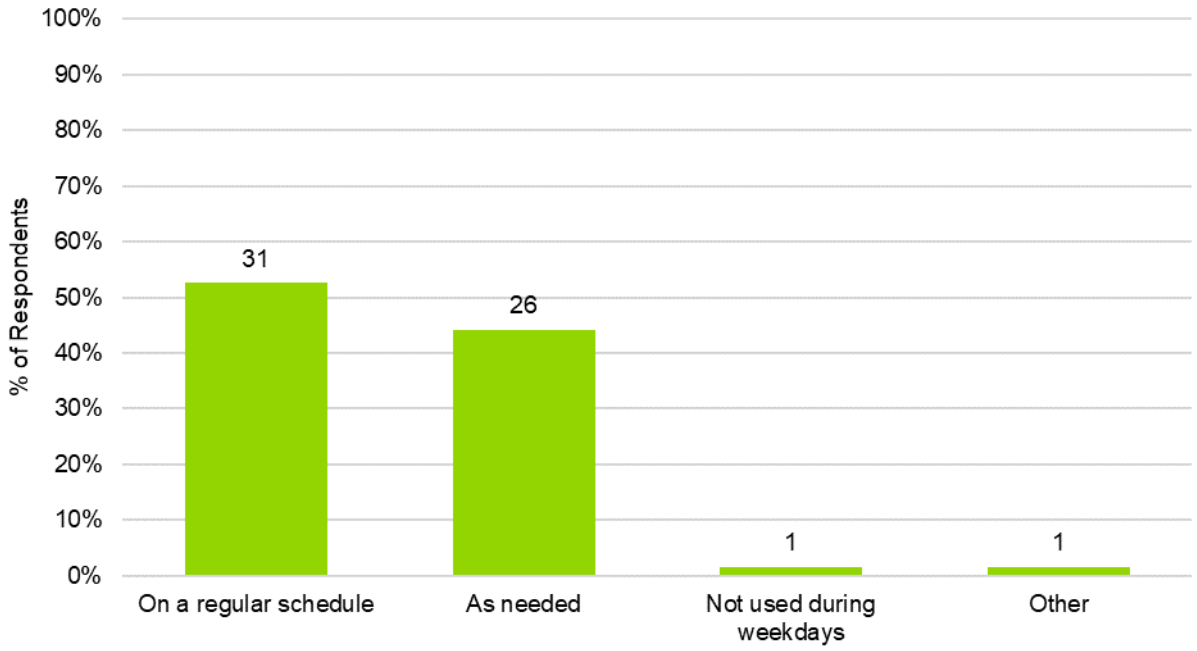
EV7. What was your household's top motivation for buying the electric vehicle? (n=59)



Source: Guidehouse

EV8. Which of the following best describes how your household typically used this electric vehicle on weekdays (Monday - Friday) during the summer of 2021 (June - August)? (n=59)



Source: Guidehouse

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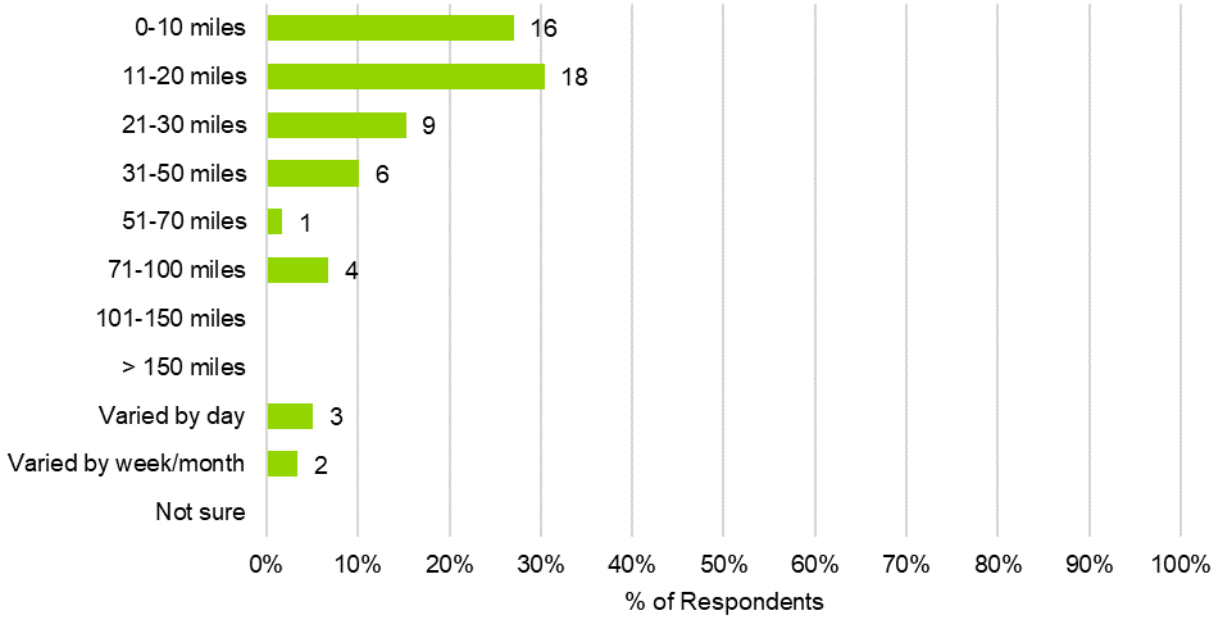
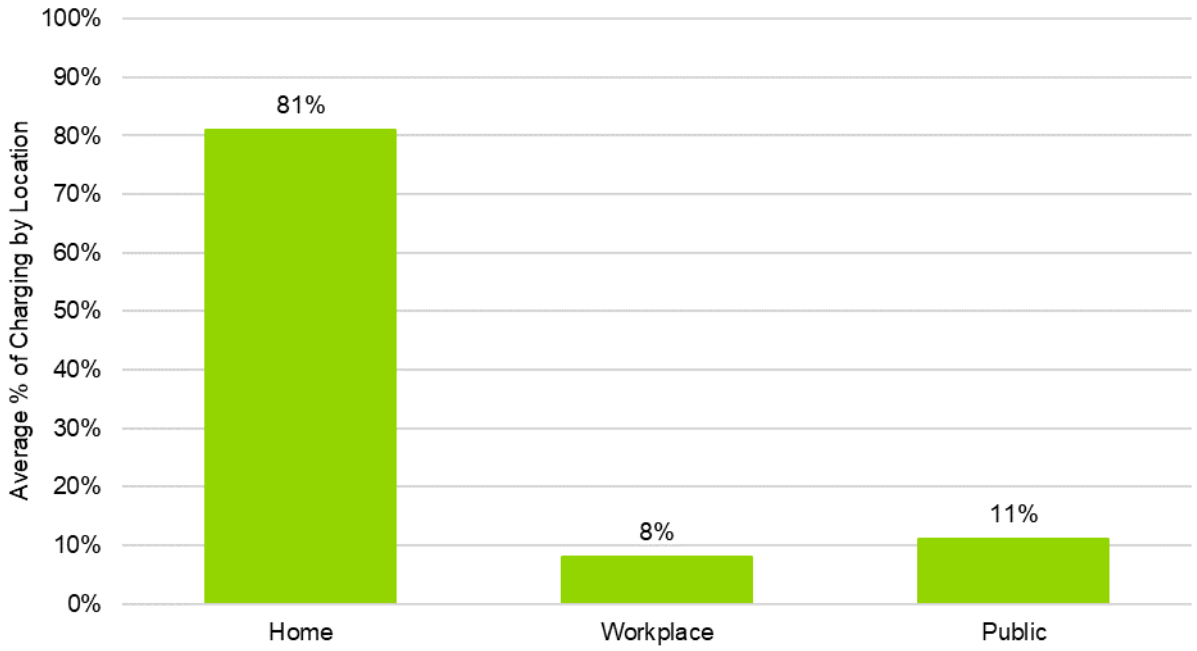
EV9. On a typical summer 2021 weekday (Monday, Tuesday, etc.), on average, how many miles was this electric vehicle driven by you and other members of your household? (n=59)



Source: Guidehouse

B.1.3 Charging Behavior During Summer 2021

CB1. Approximately what percentage of your EV's charging this past summer took place at your home, work, public, or other charging stations? (n=59)



Source: Guidehouse

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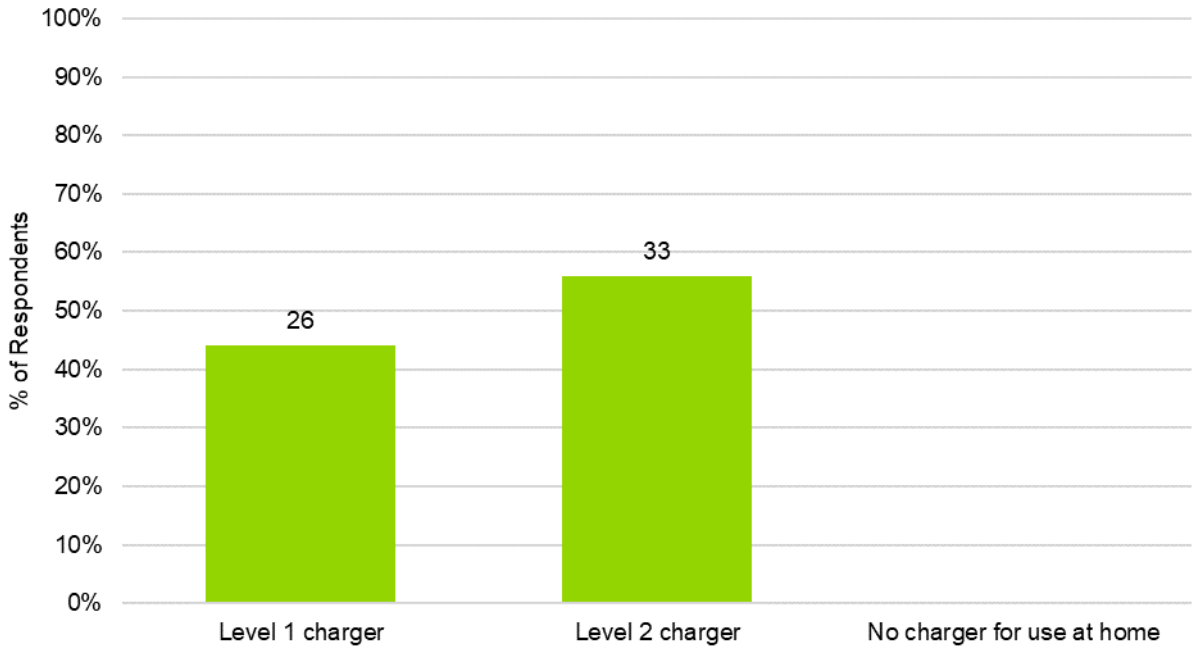
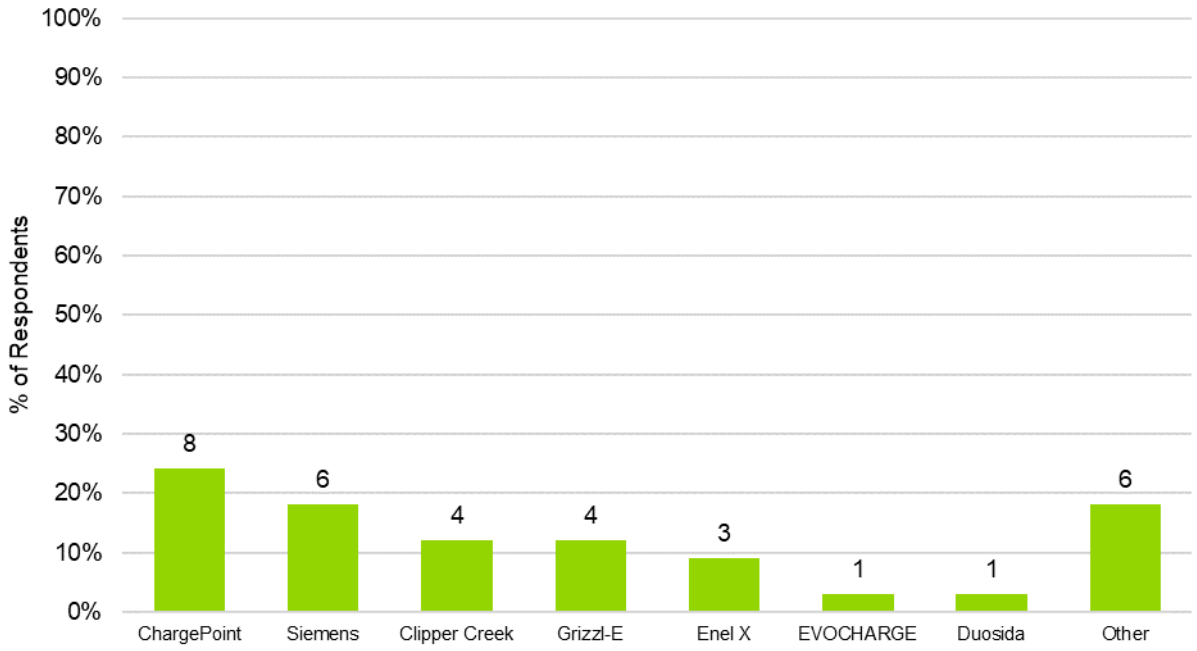
CB2. Which of the following best describes the electric vehicle charging device that you have at home? (n=59)



Source: Guidehouse

CB3. Please select the make of your Level 2 charger. (n=33)



Source: Guidehouse

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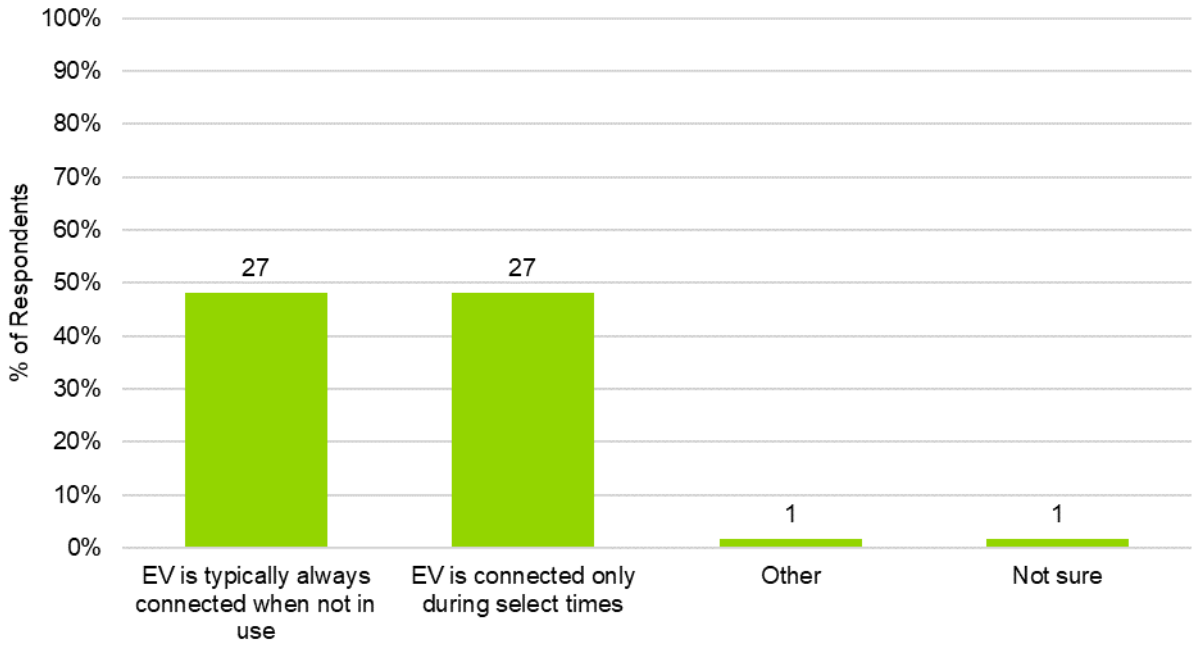
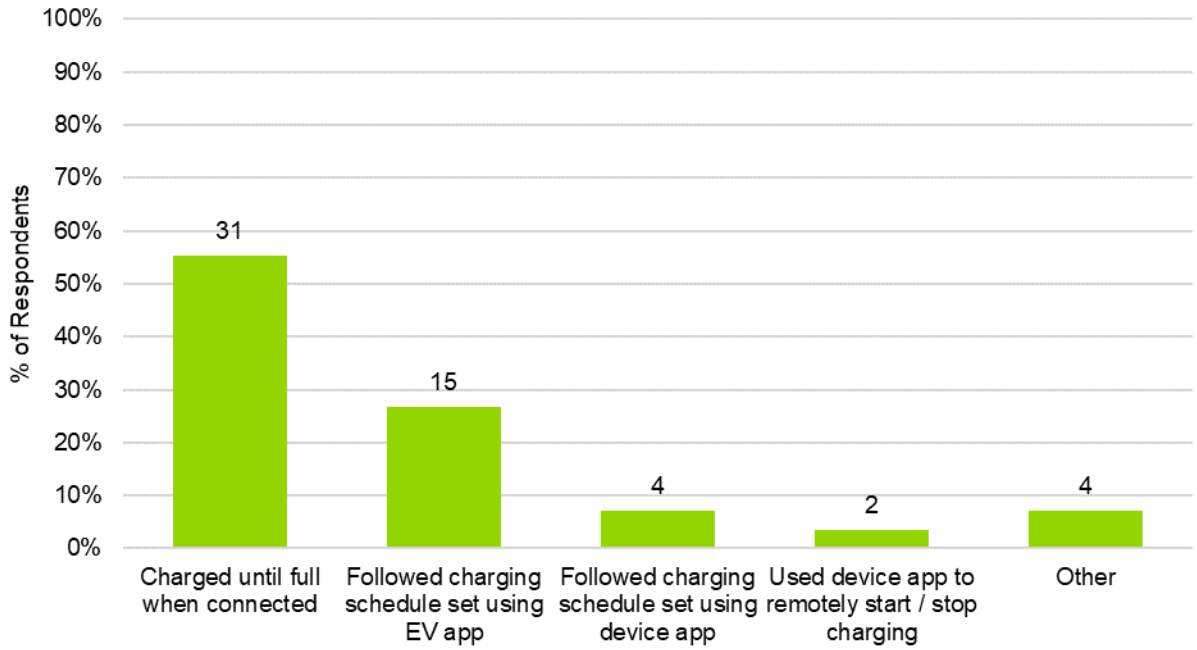
CB4. During summer 2021, when your electric vehicle was not being used and at home, was it typically connected to your home charging device? (n=56)



Source: Guidehouse

CB5. During summer 2021, which of the following best describes your household's use of your home charging device for your electric vehicle? (n=56)



Source: Guidehouse

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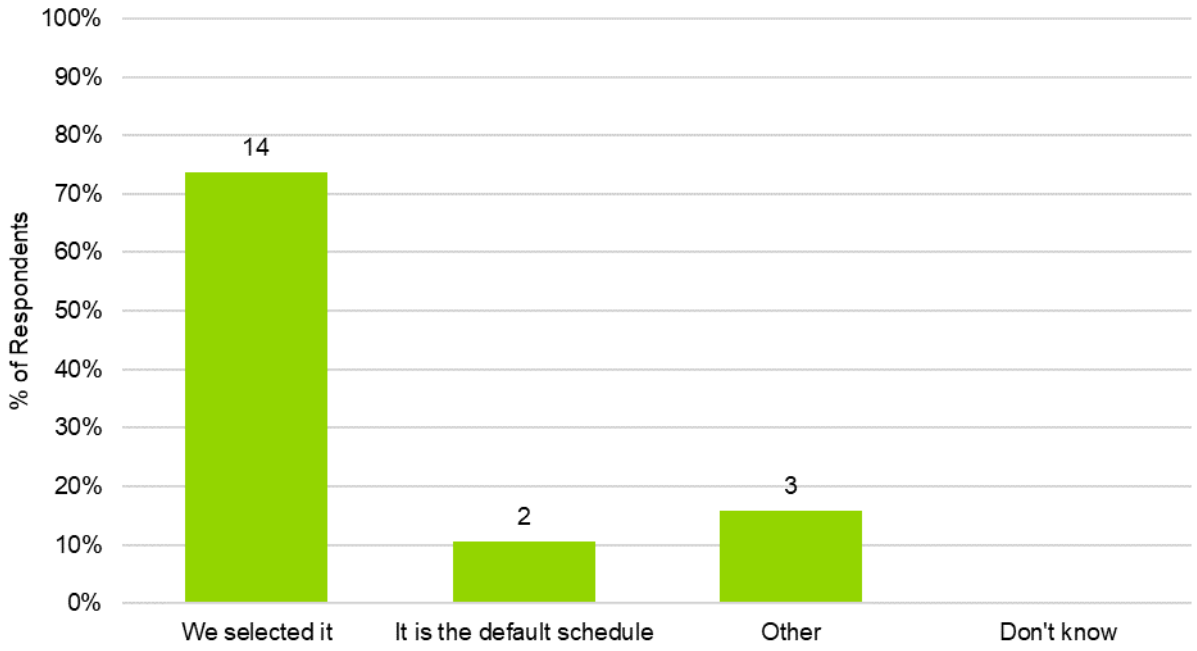
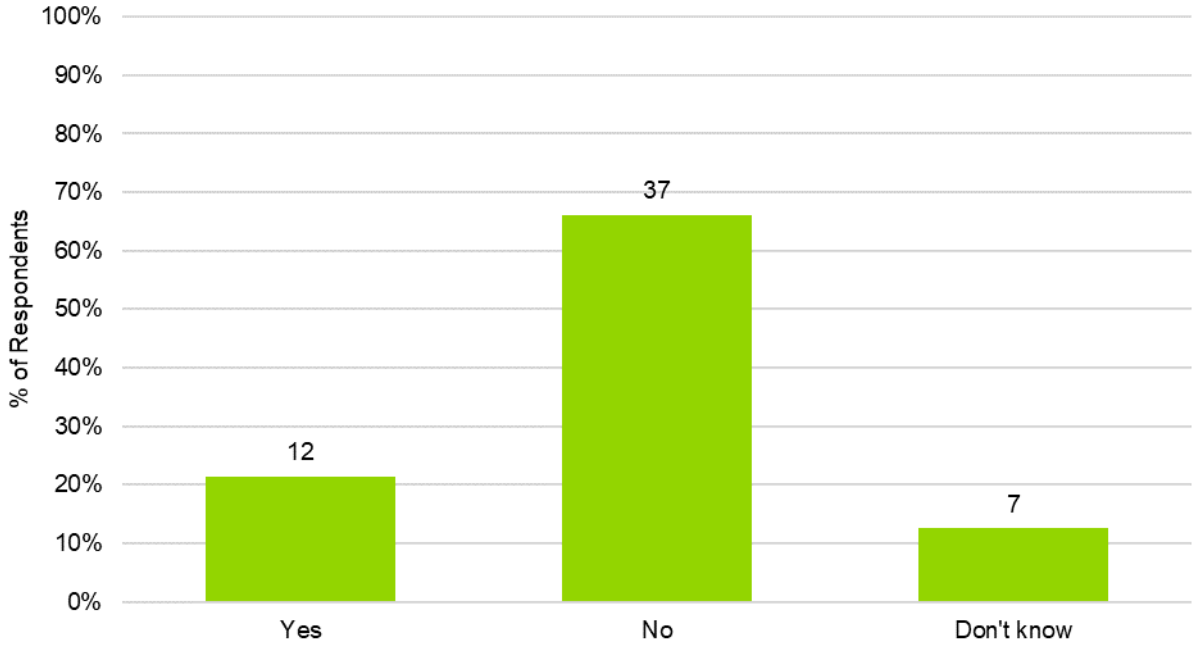
CB5_a. How was your electric vehicle's home charging schedule determined? (n=19)



Source: Guidehouse

CB5_b. Did National Grid's ConnectedSolutions EV and PHEV Demand Response Program influence your choice of home charging schedule at all? (n=56)



Source: Guidehouse

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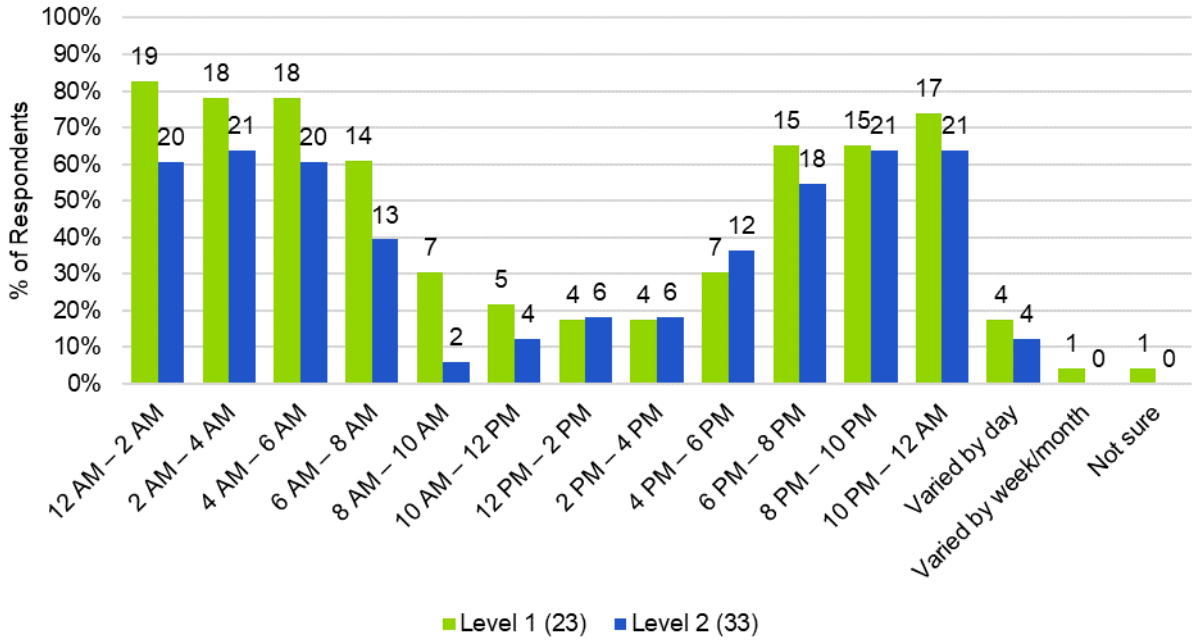
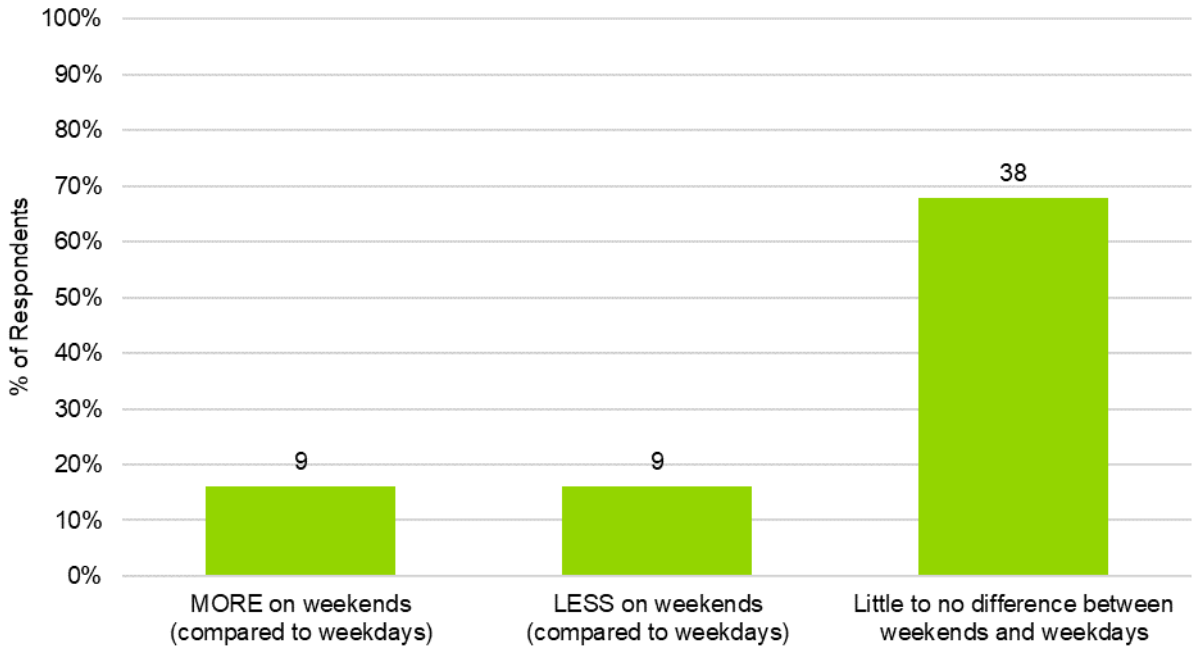
CB6. Indicate the time ranges during which the electric vehicle was *typically* **connected** (regardless of charging or not) to your ***home charging device*** on weekdays (Monday – Friday) during summer 2021 (June – August). Select all the time ranges that apply. (n=56)



Source: Guidehouse

CB9. Compared to your household's use of your home charging device on weekdays, was the ***amount of time*** this electric vehicle was typically **connected** to your home charging device in summer 2021 different on weekends? (n=56)



Source: Guidehouse

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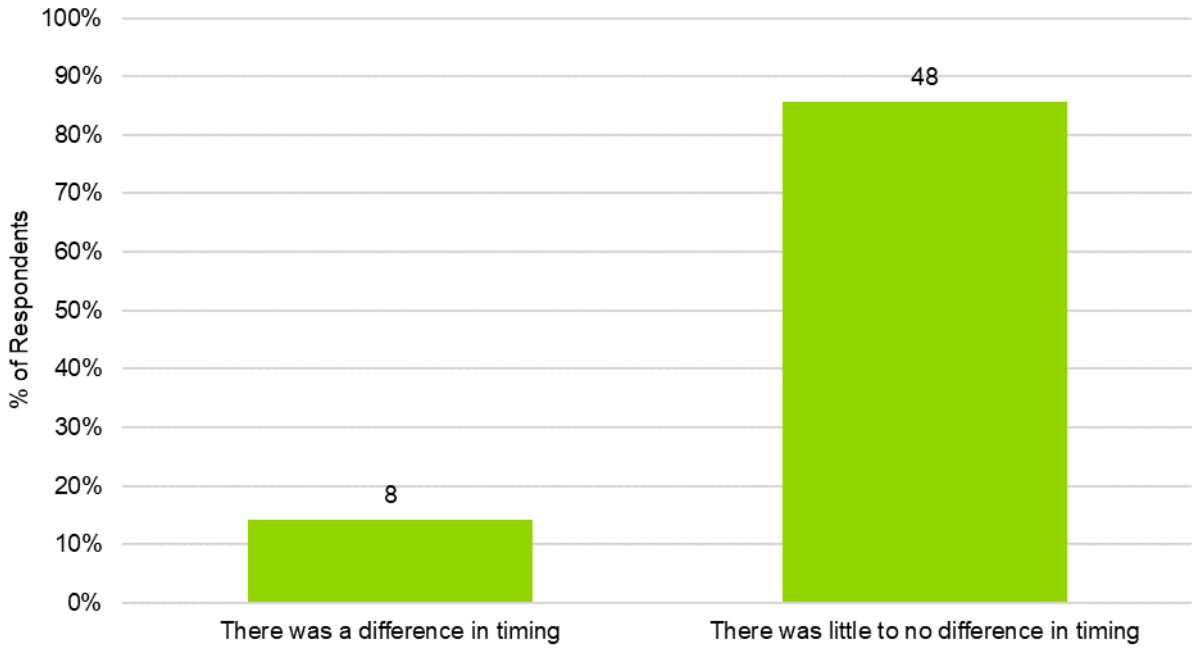
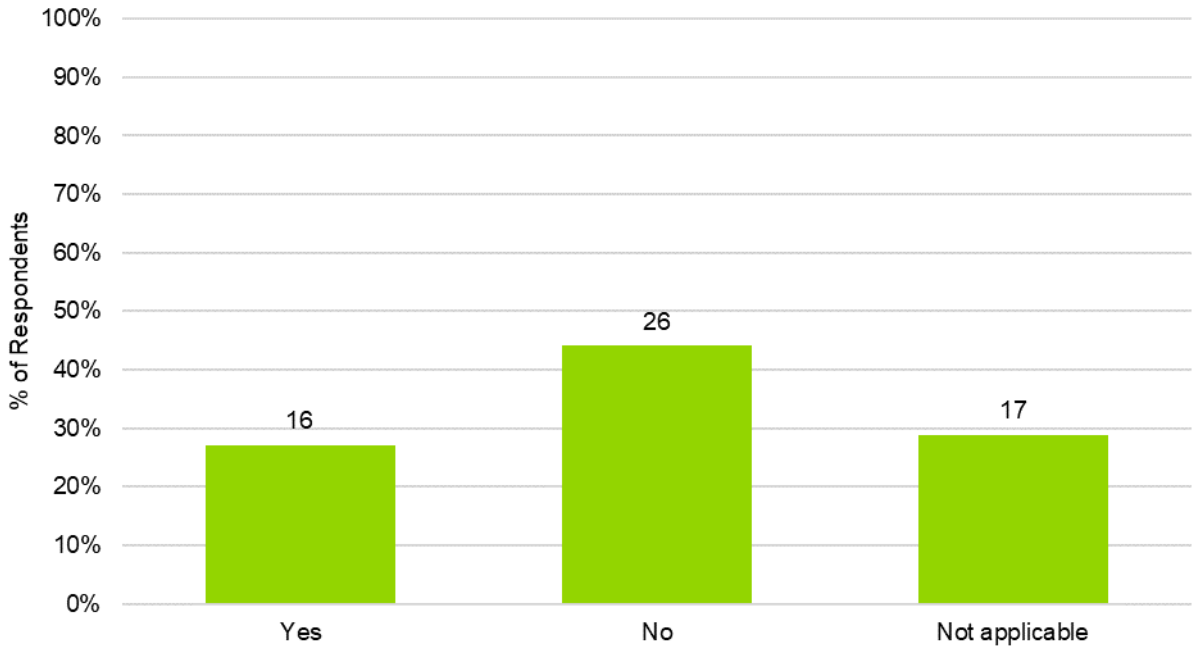
CB10. Compared to your household's use of your home charging device on weekdays, was the ***timing*** of when this electric vehicle was typically **connected** to your home charging device in summer 2021 different on weekends? (n=56)



Source: Guidehouse

CB11. Is this electric vehicle driven to a workplace that has workplace charging available? Answer this question based on whether or not charging is available at a workplace, regardless of whether you or other household members go into work regularly and/or use it. (n=59)



Source: Guidehouse

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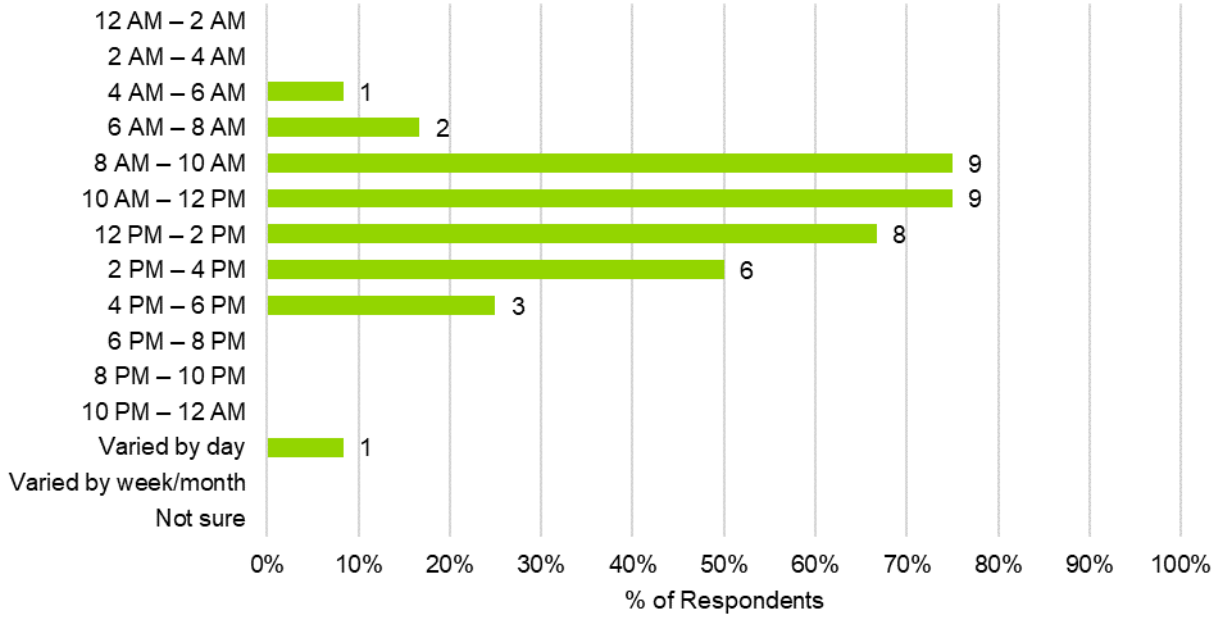
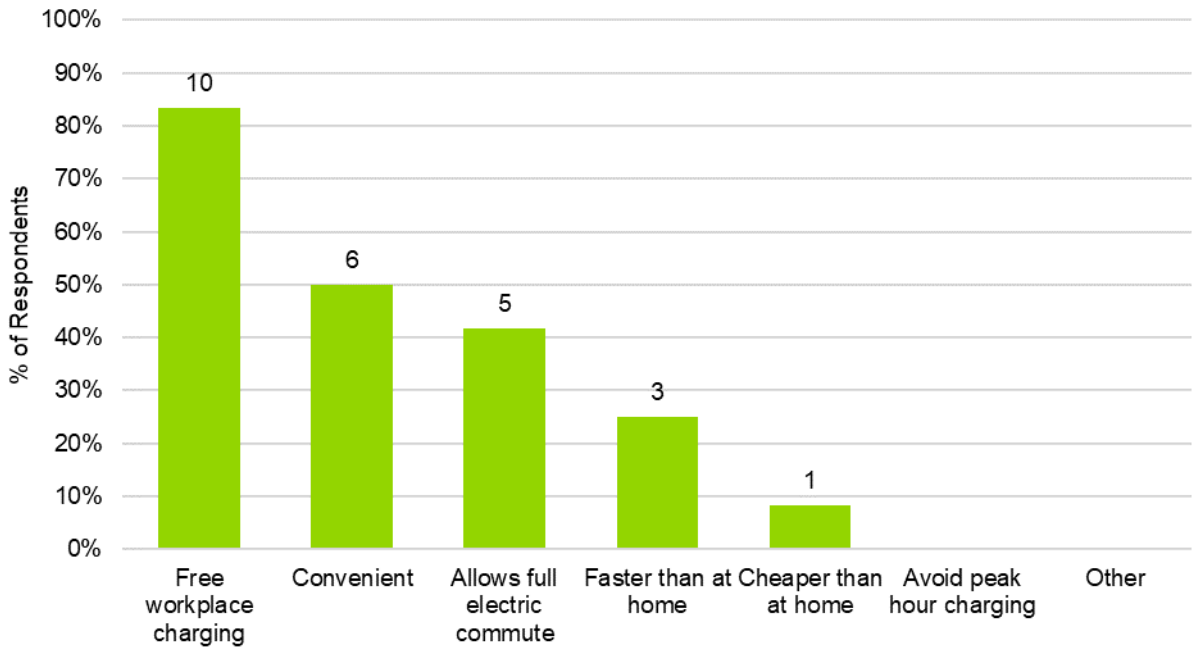
CB12. Below, please indicate when this electric vehicle was typically **connected** to a ***workplace charging station*** on weekdays (Monday – Friday) during the summer 2021 (June – August). Select all the time ranges that apply. (n=12)



Source: Guidehouse

CB13. What are your main motivations for using ***workplace charging stations***? Select all that apply. (n=12)



Source: Guidehouse

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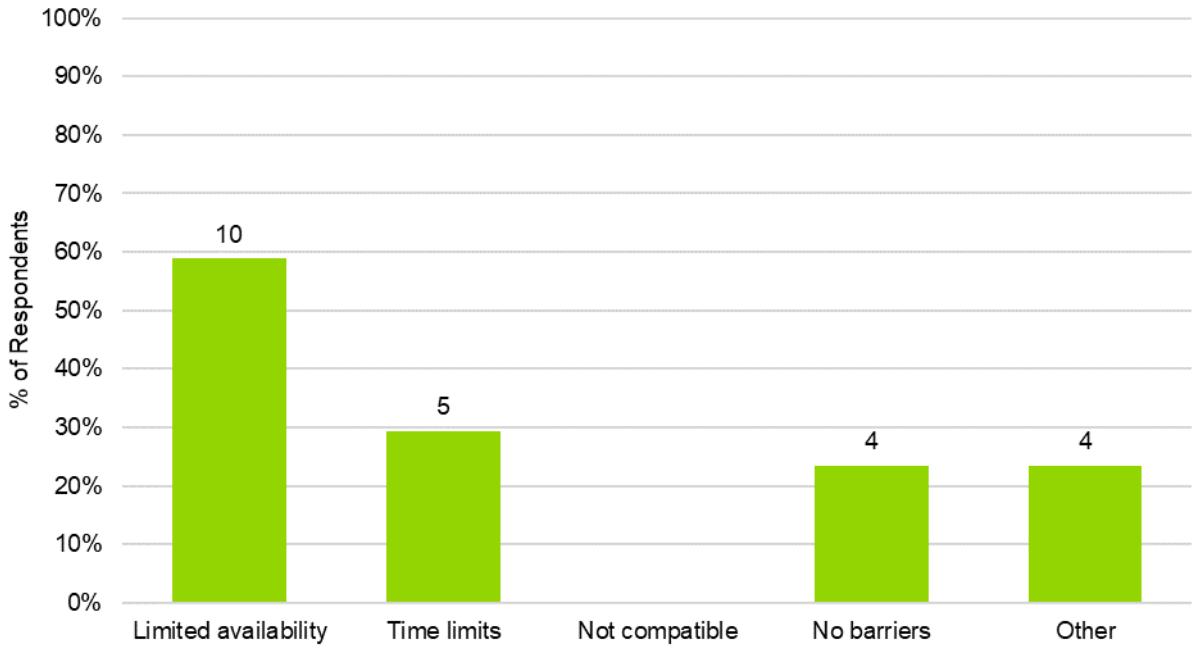
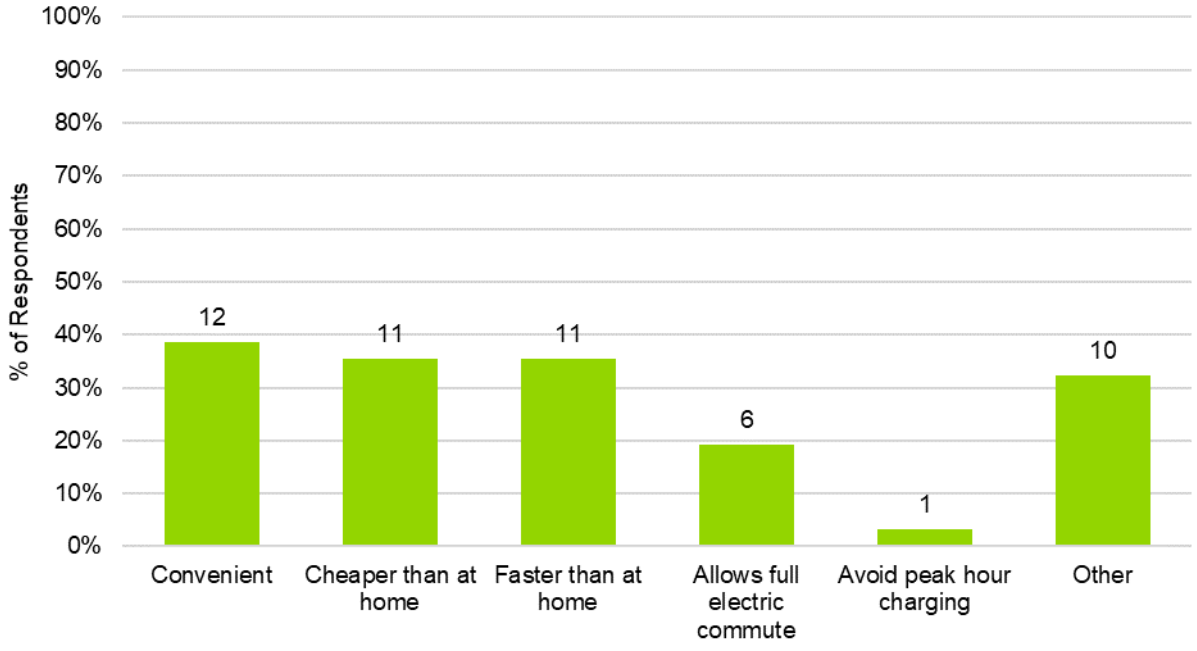
CB14. Are there are any barriers for you or your household members to use ***workplace charging stations*** to charge this electric vehicle? Select all that apply. (n=17)



Source: Guidehouse

CB15. What are your main motivations for using ***public charging stations***? Select all that apply. (n=31)



Source: Guidehouse

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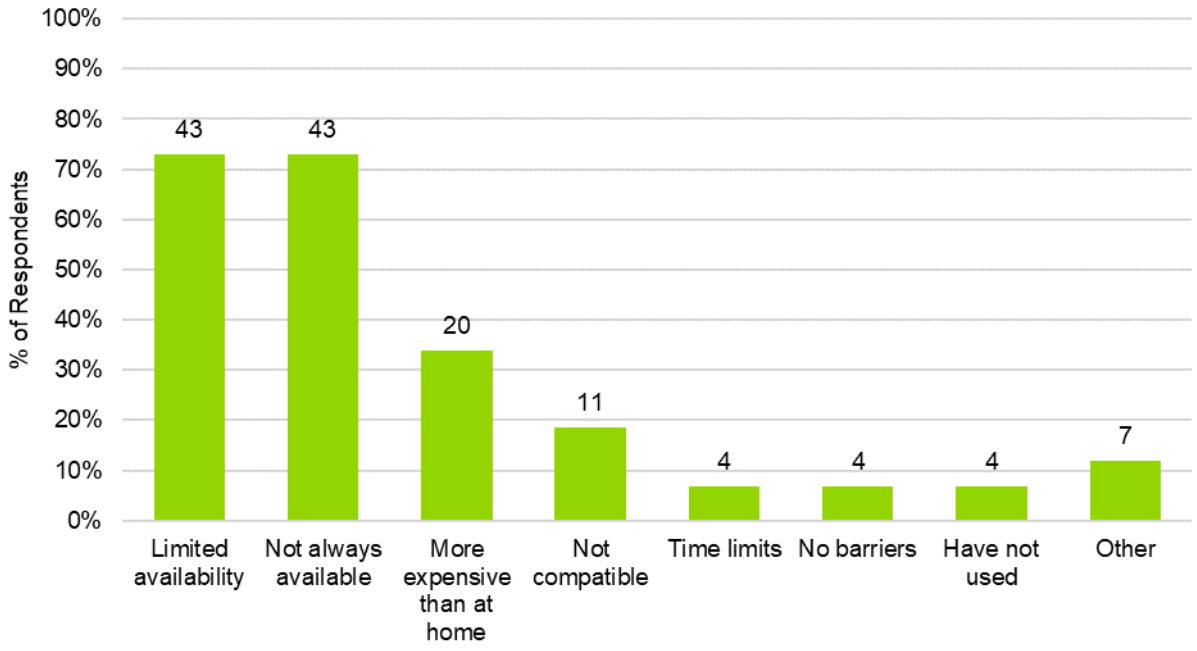
CB16. Are there are any barriers for you or your household members to use ***public charging stations*** to charge this electric vehicle? Select all that apply. (n=56)



Source: Guidehouse

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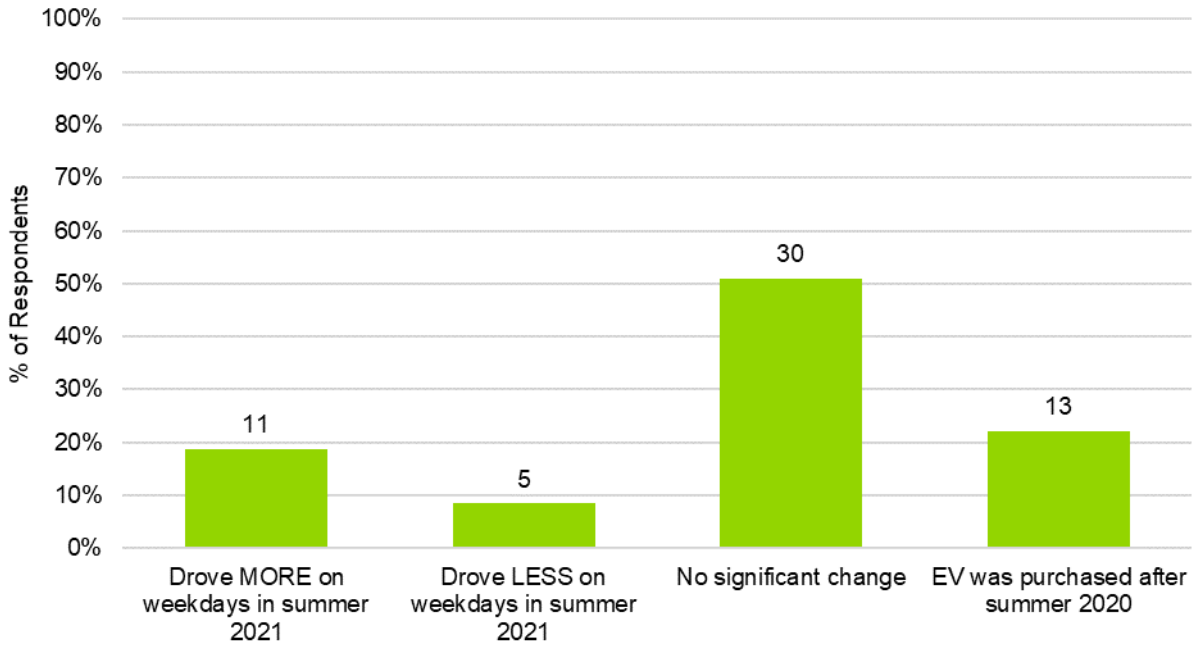
B.1.4 Changes Since Summer 2020

CS1. Compared to your household's use of your electric vehicle in the summer 2020, did the typical ***miles per day*** that this electric vehicle was driven on weekdays change in summer 2021? (n=59)



Source: Guidehouse

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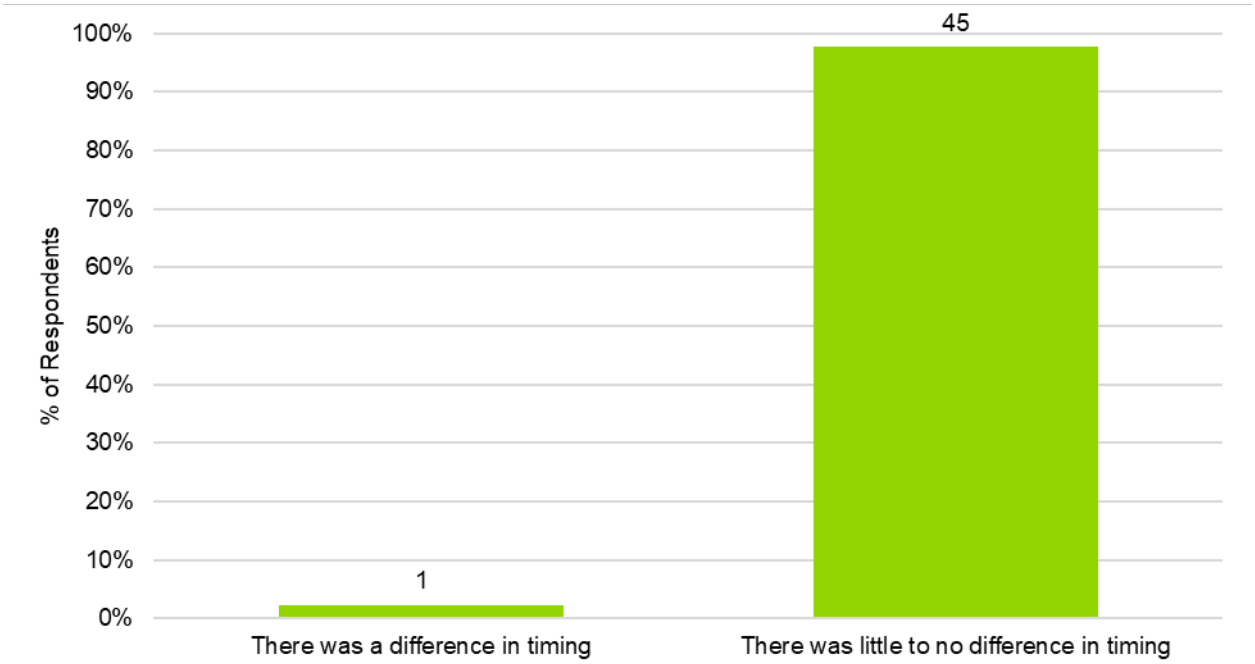
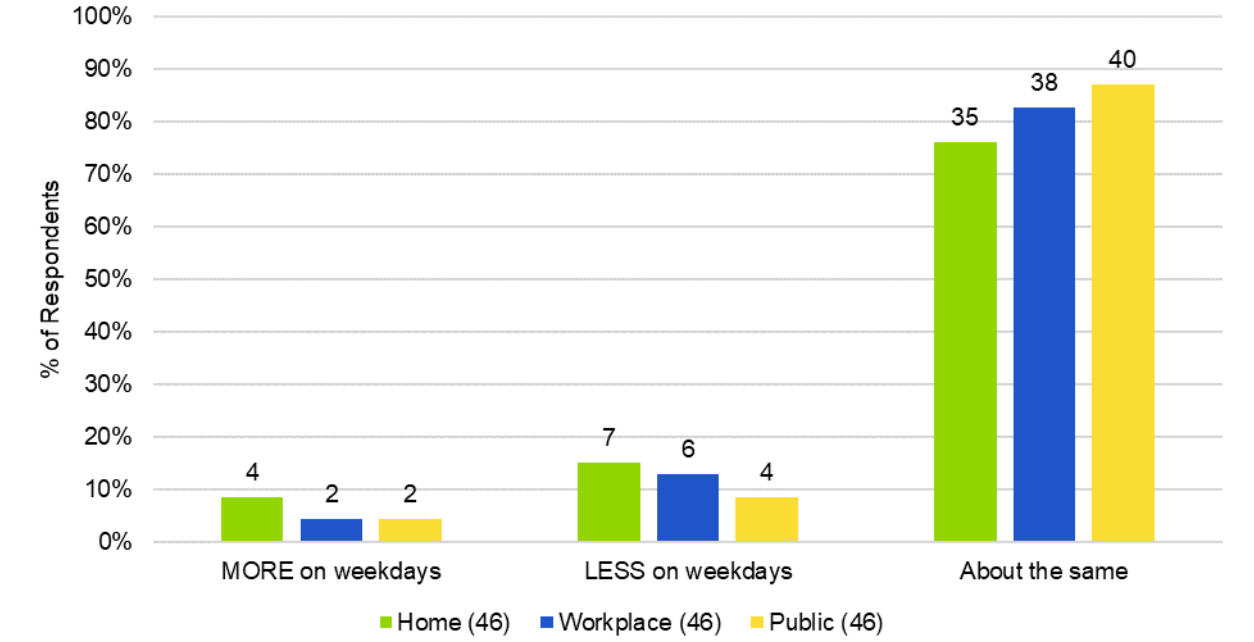
CS2. Compared to your household's use of this electric vehicle in the summer of 2020, did the ***timing*** of when this electric vehicle was typically driven on weekdays change in summer 2021? (n=46)



Source: Guidehouse

CS3. Compared to the summer of 2020, was this EV typically charging more, less, or the same amount ***on weekdays*** in summer 2021? Indicate how this varied by charging location. (n=46)



Source: Guidehouse

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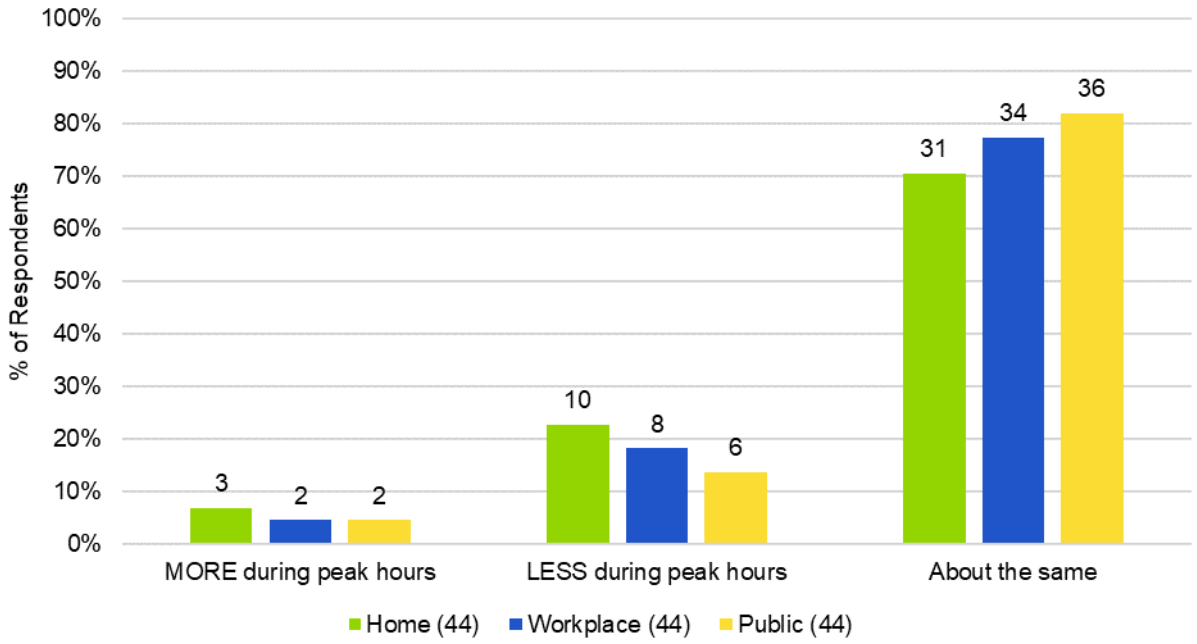
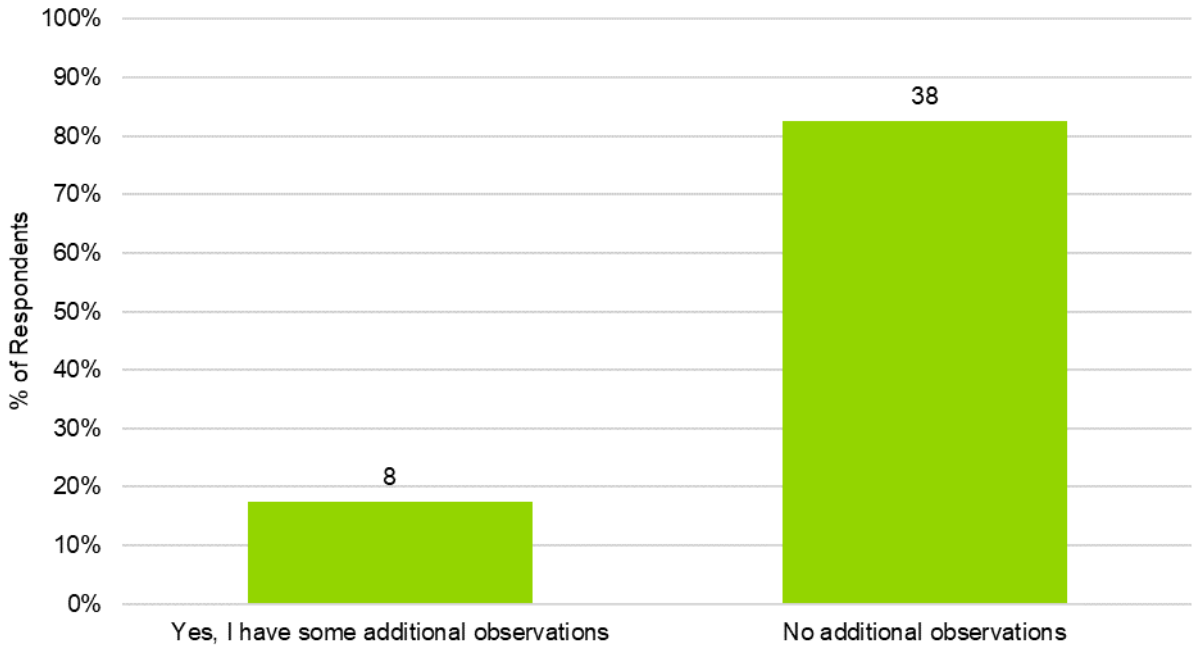
CS5. Compared to the summer of 2020, was this EV typically charging more, less, or the same amount in summer 2021 ***during the weekday hours of 2 PM to 7 PM***? Please indicate how this varied by charging location. (n=44)



Source: Guidehouse

CS7. What, if any, additional observations do you have to share related to how your household's use of this electric vehicle and/or charging stations changed between summer 2020 and summer 2021? (n=46)



Source: Guidehouse

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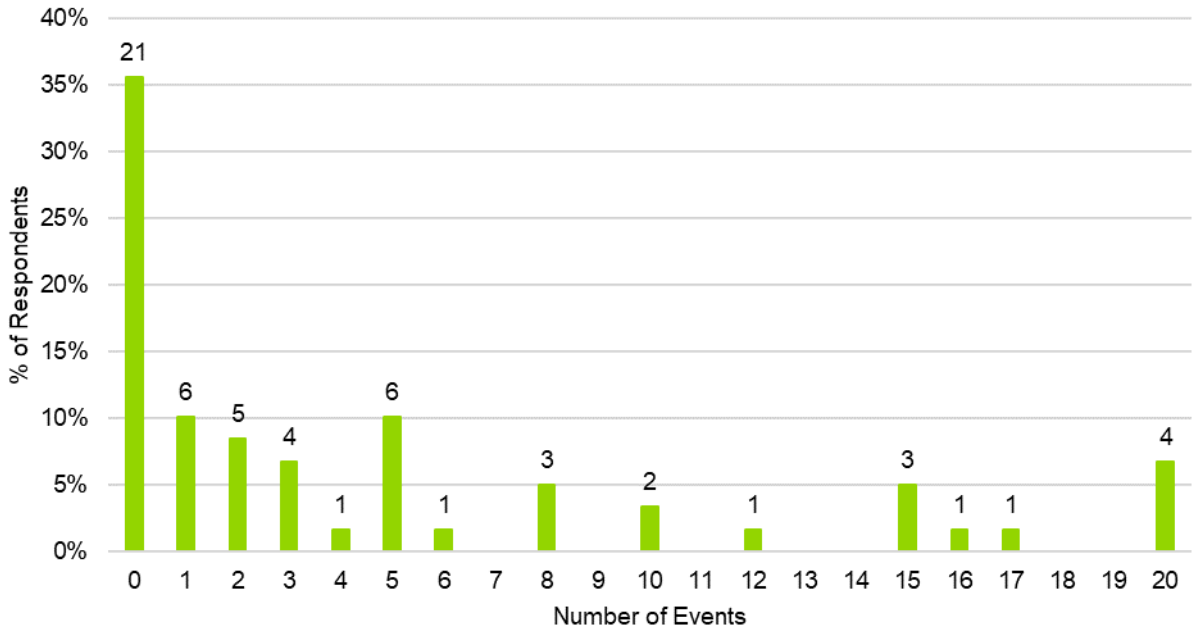
B.1.5 Behavior During Events

ET1. How many peak events do you recall in summer 2021 (June through August)? If you enrolled during this timeframe, provide the number you recall since you enrolled. (n=59)



Source: Guidehouse

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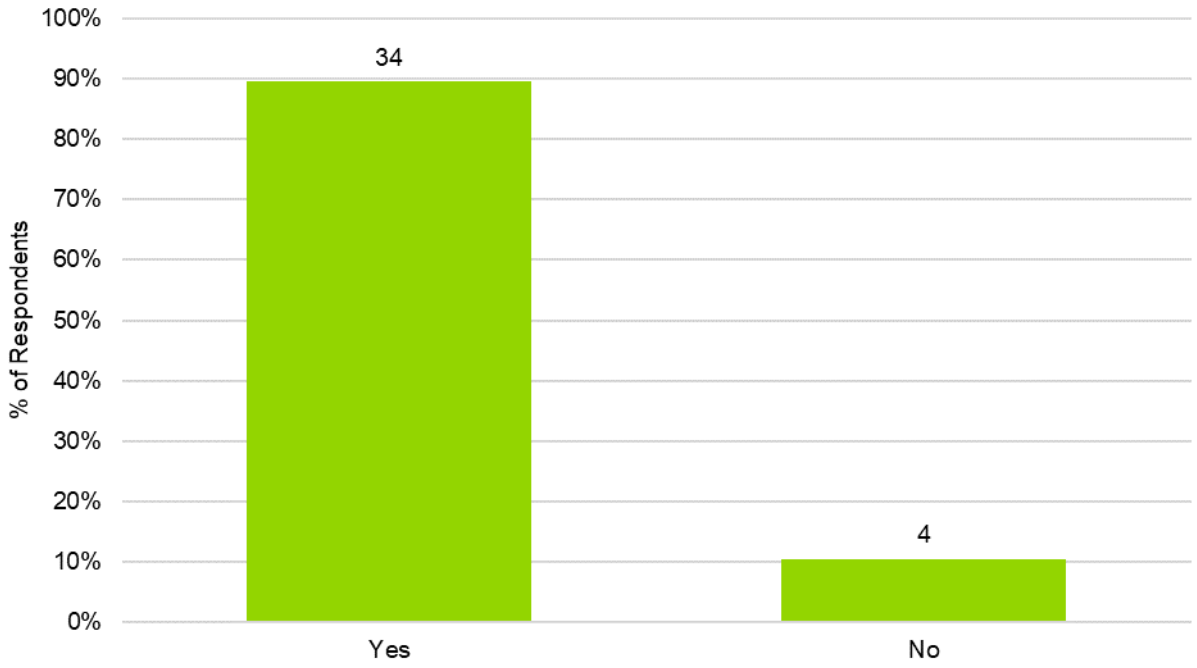
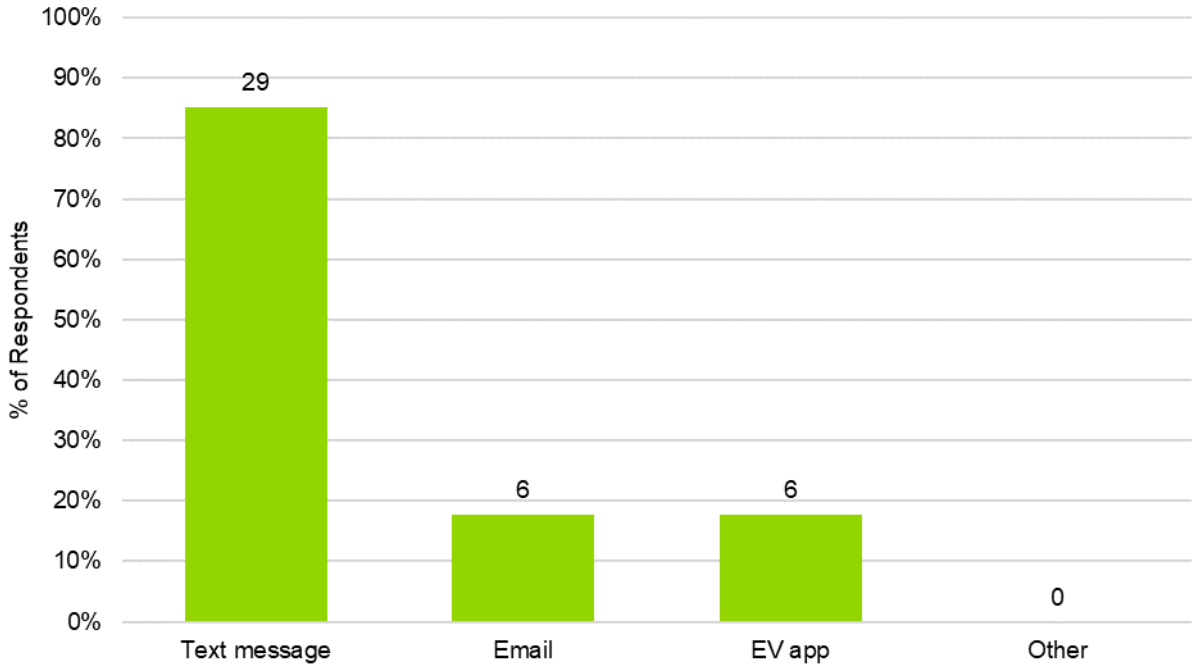
ET2. Do you recall ever receiving notifications (i.e., in-app, emails, text messages) about peak events? (n=38)



Source: Guidehouse

ET3. How did you receive notifications about peak events? Select all that apply. (n=34)



Source: Guidehouse

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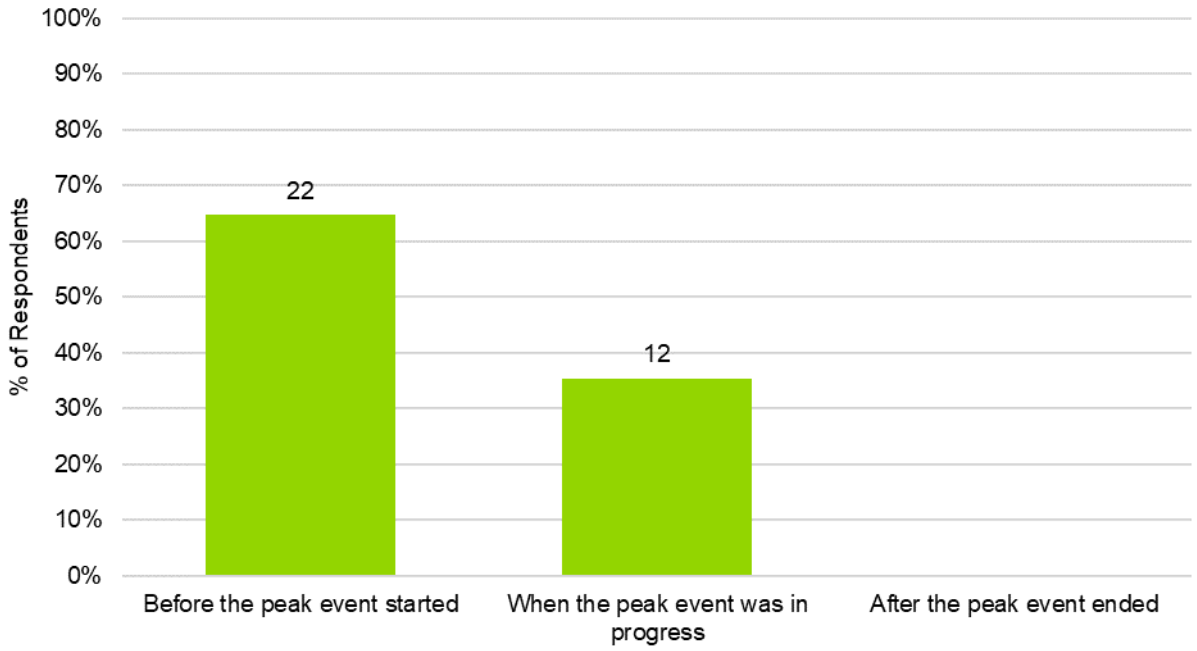
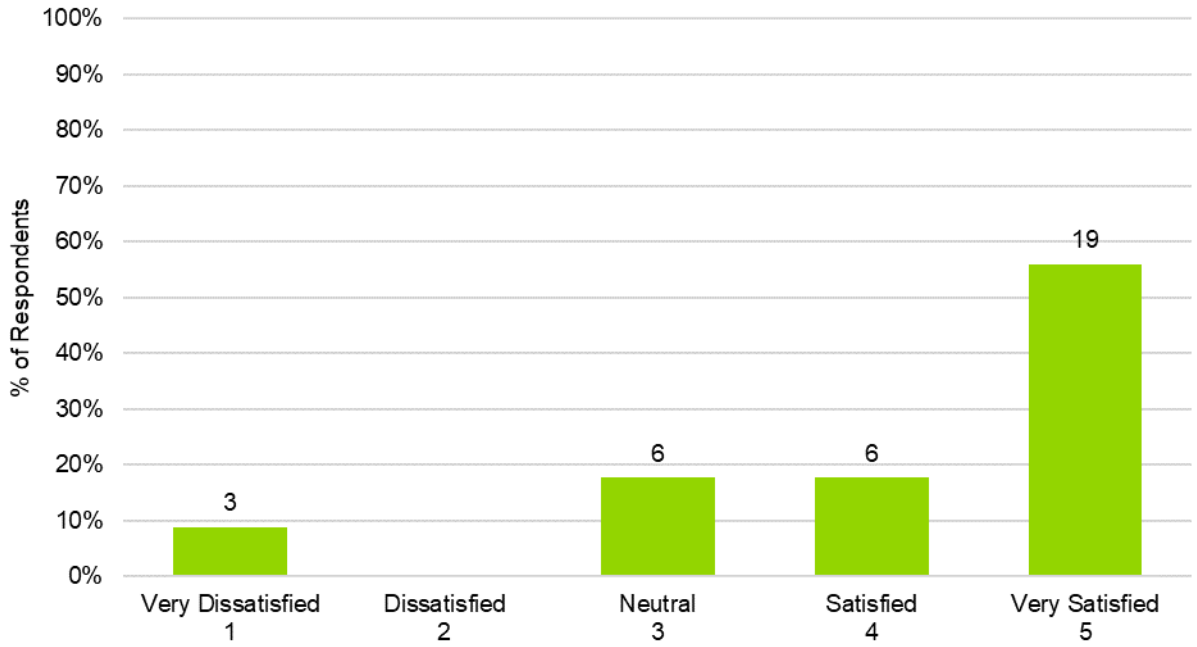
ET4. At what time do you recall receiving notifications about peak events? Select all that apply. (n=34)



Source: Guidehouse

ET5. On a scale of 1 through 5, where 1 is “Very dissatisfied” and 5 is “Very satisfied”, how would you rate your satisfaction with peak event notification? (n=34)



Source: Guidehouse

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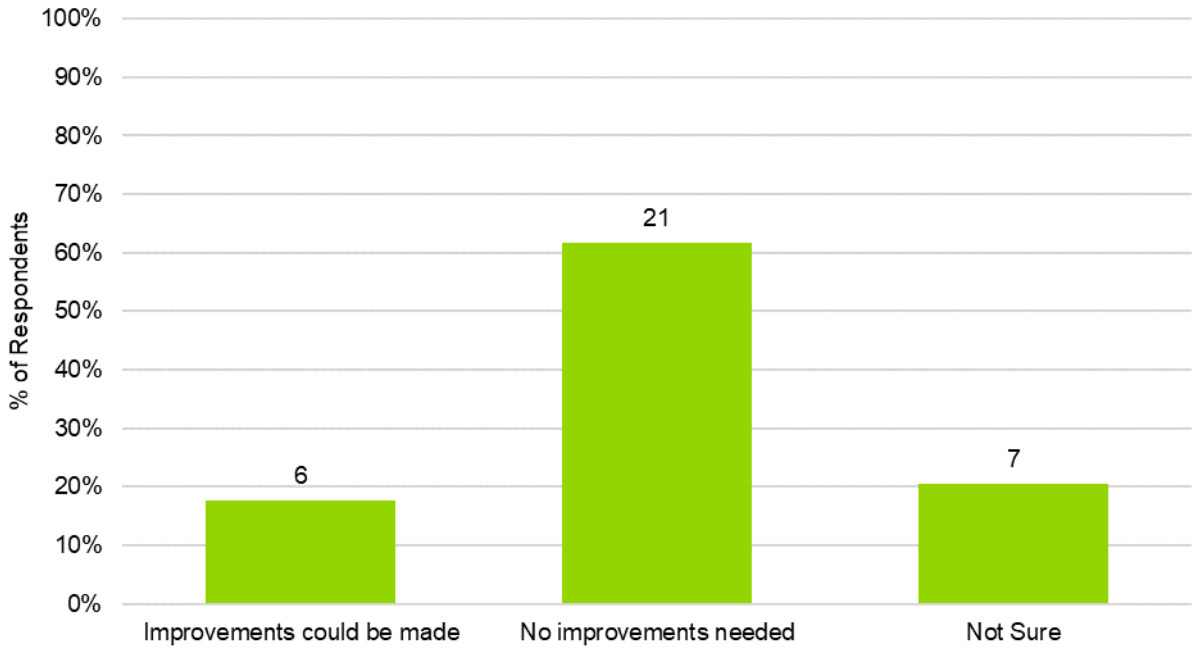
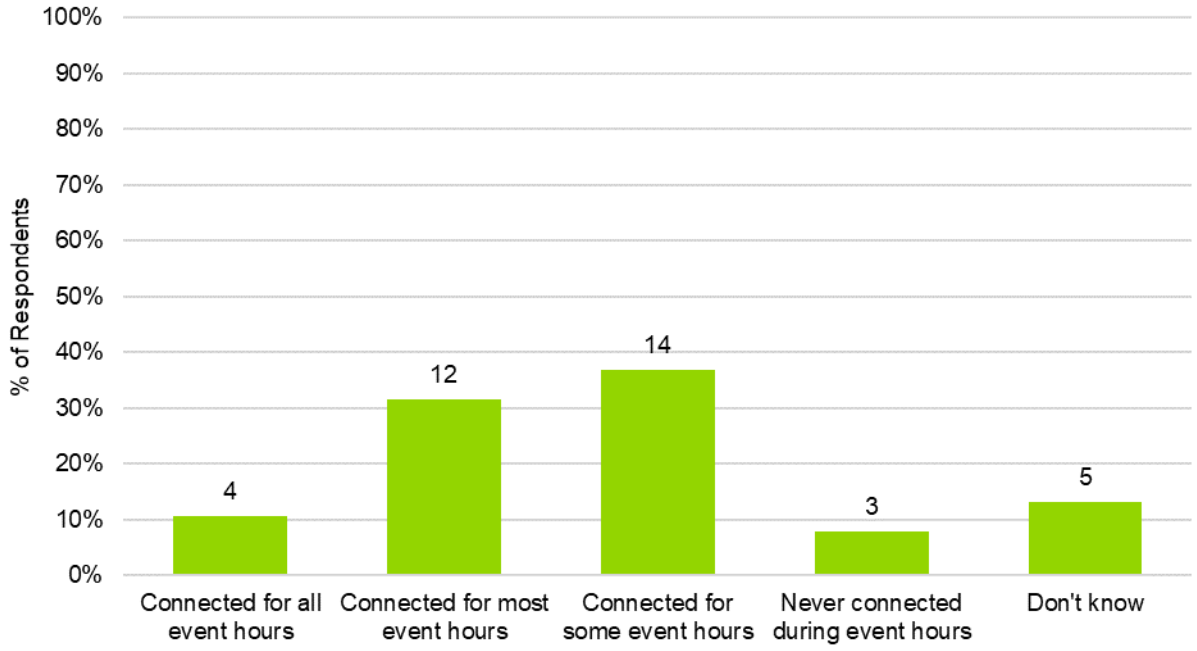
ET5_a. Are there ways that peak event notifications could be improved? (n=34)



Source: Guidehouse

ET6. For the peak events you can recall during summer 2021, how often was your electric vehicle connected to a charging device during event hours? (n=38)



Source: Guidehouse

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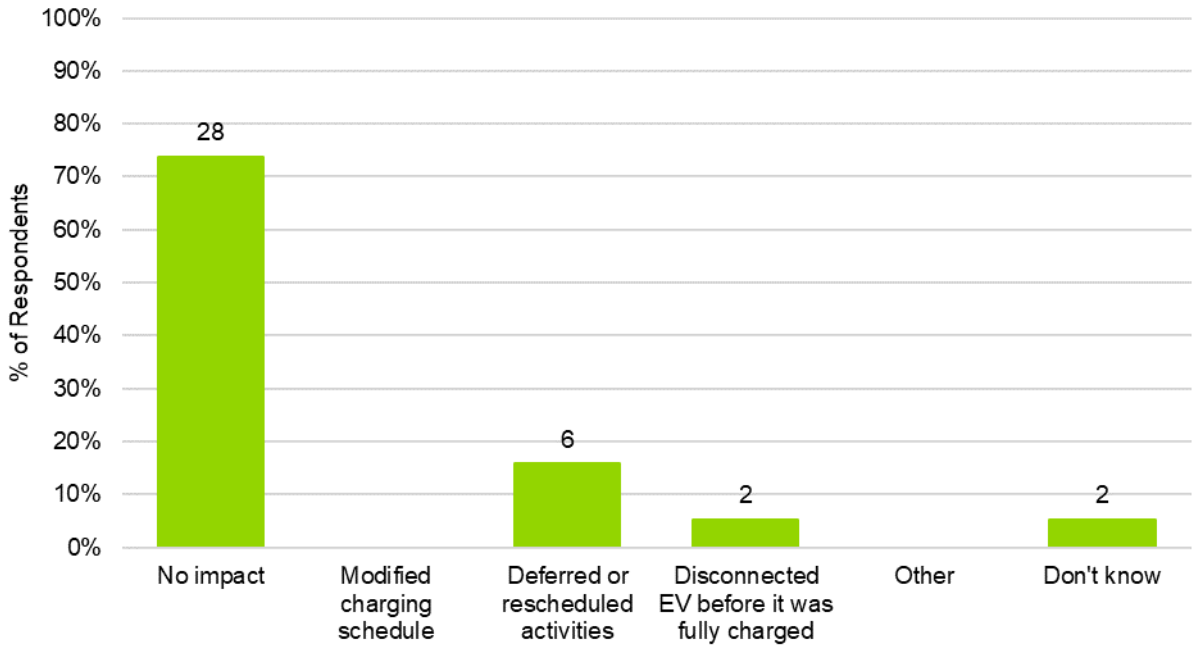
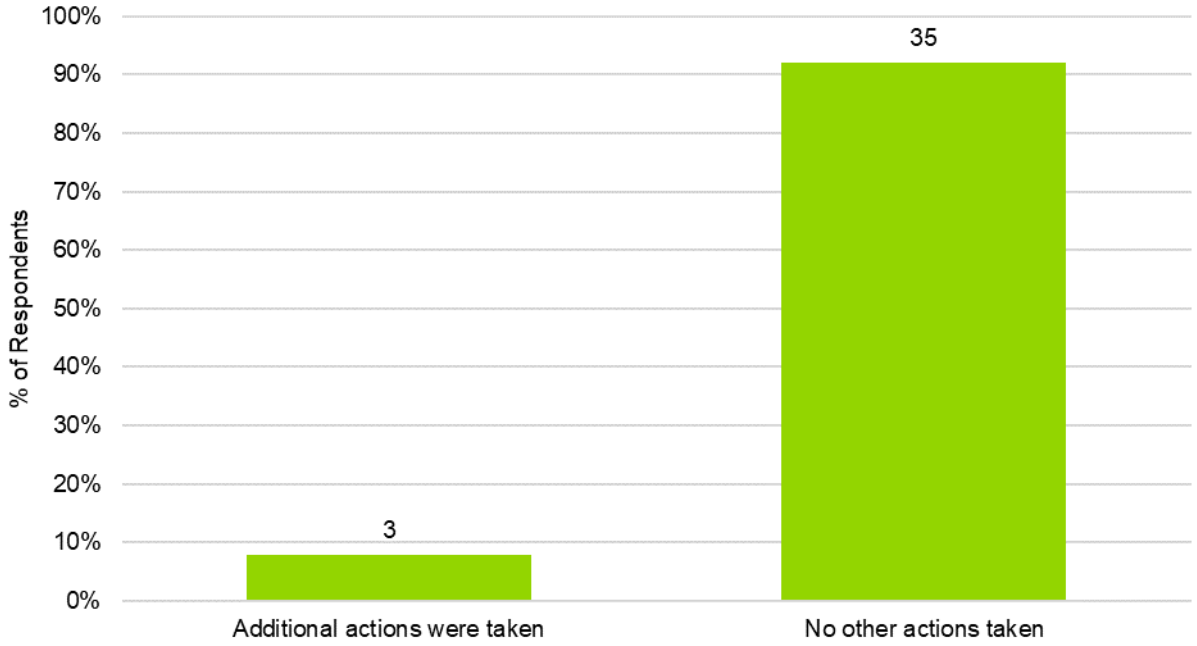
ET7. Please indicate how the peak events affected your normal charging and/or driving behavior during summer 2021. Select all that apply. (n=38)



Source: Guidehouse

ET8. Did you take any other actions in response to being notified that a peak event was occurring? (n=38)



Source: Guidehouse

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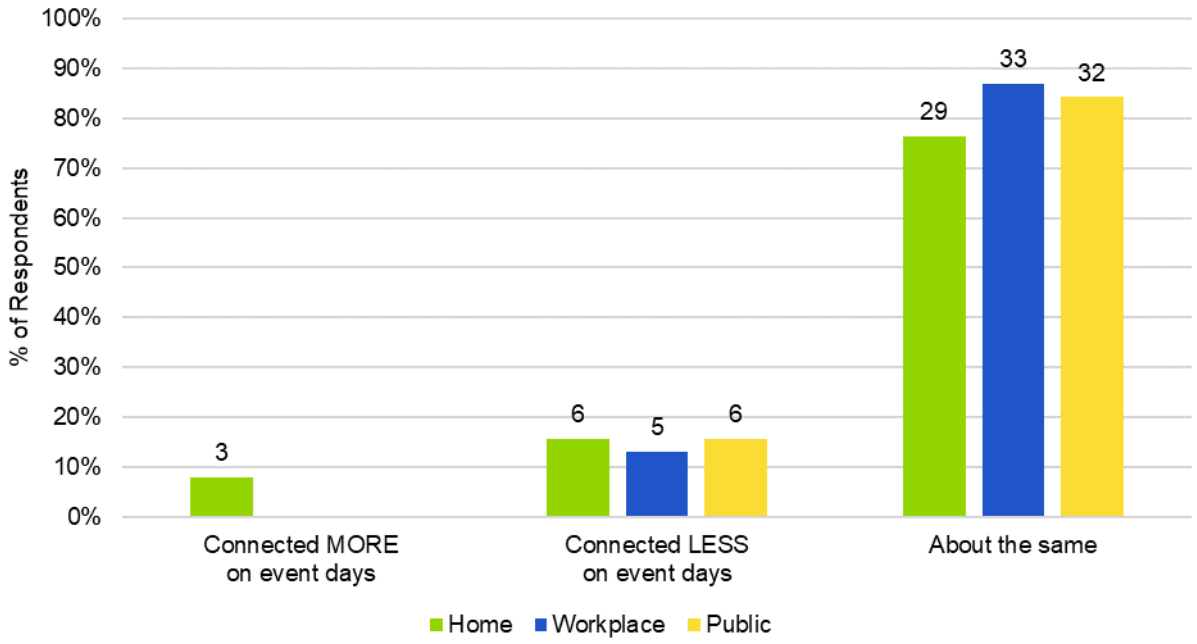
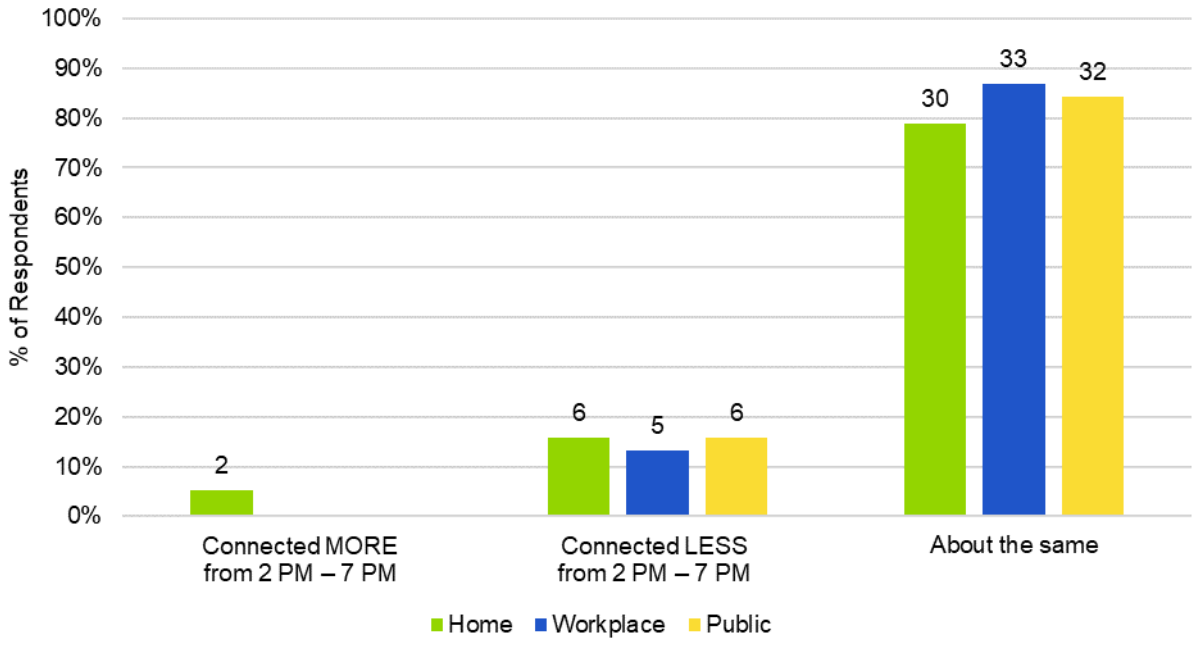
ET9. Compared to days in summer 2021 when *no* peak event was called, was this EV typically connected to a charging device more, less, or the same amount ***on peak event days***? Please indicate how the amount of time connected changed by charging location. (n=38)



Source: Guidehouse

ET11. Compared to days in summer 2021 when *no* peak event was called, was this EV typically connected to a charging device more, less, or the same amount ***from 2 PM – 7 PM*** relative to other hours? Indicate how the connected timing changed by charging location. (n=38)



Source: Guidehouse

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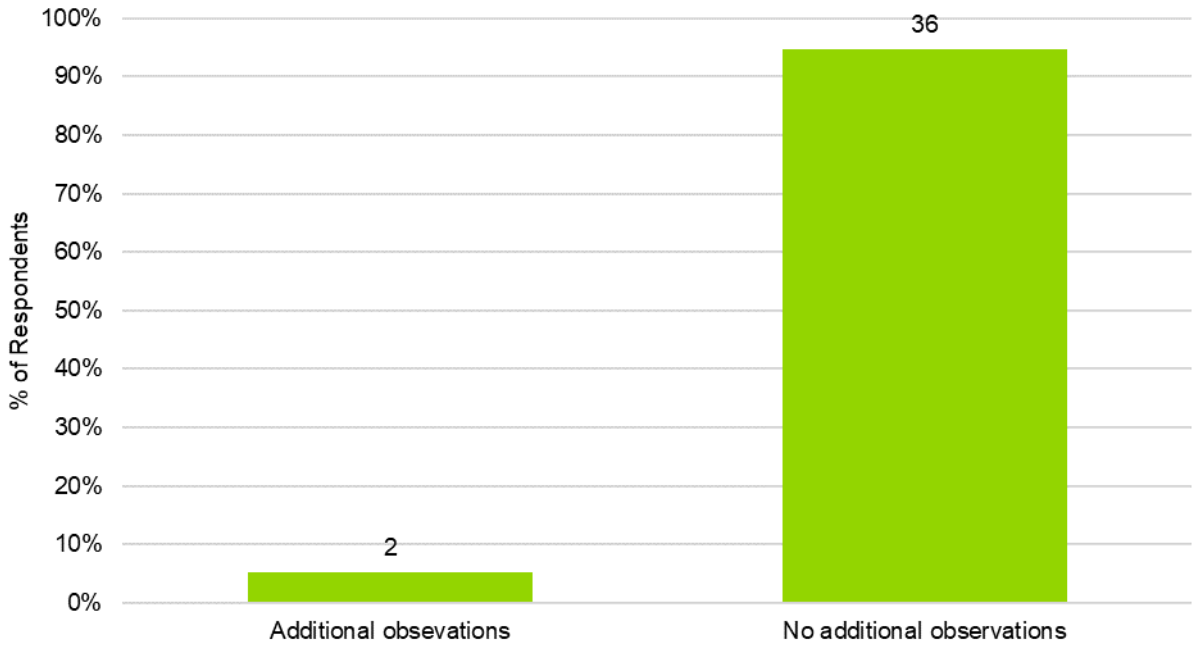
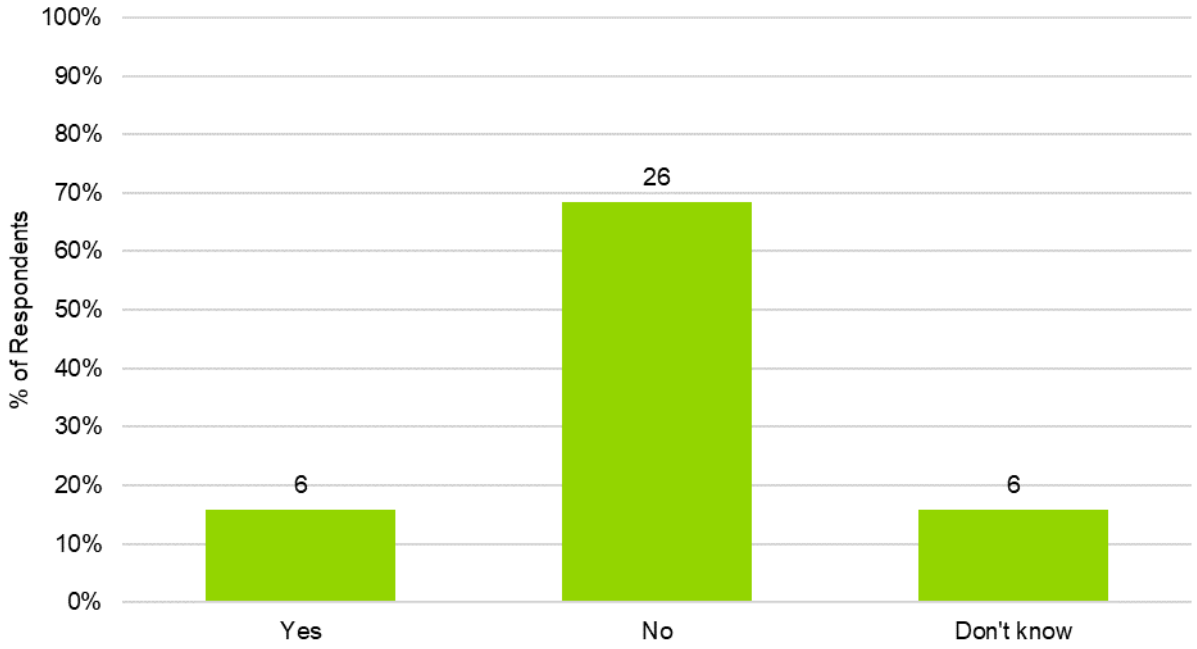
ET13. What, if any, additional observations do you have to share related to how your household's use of charging devices changed between days with no peak events and days with peak events in summer 2021? (n=38)



Source: Guidehouse

ET14. On peak event days in summer 2021, did you ever "opt-out" or override a peak event to stop the program from pausing your charging during the event? (n=38)



Source: Guidehouse

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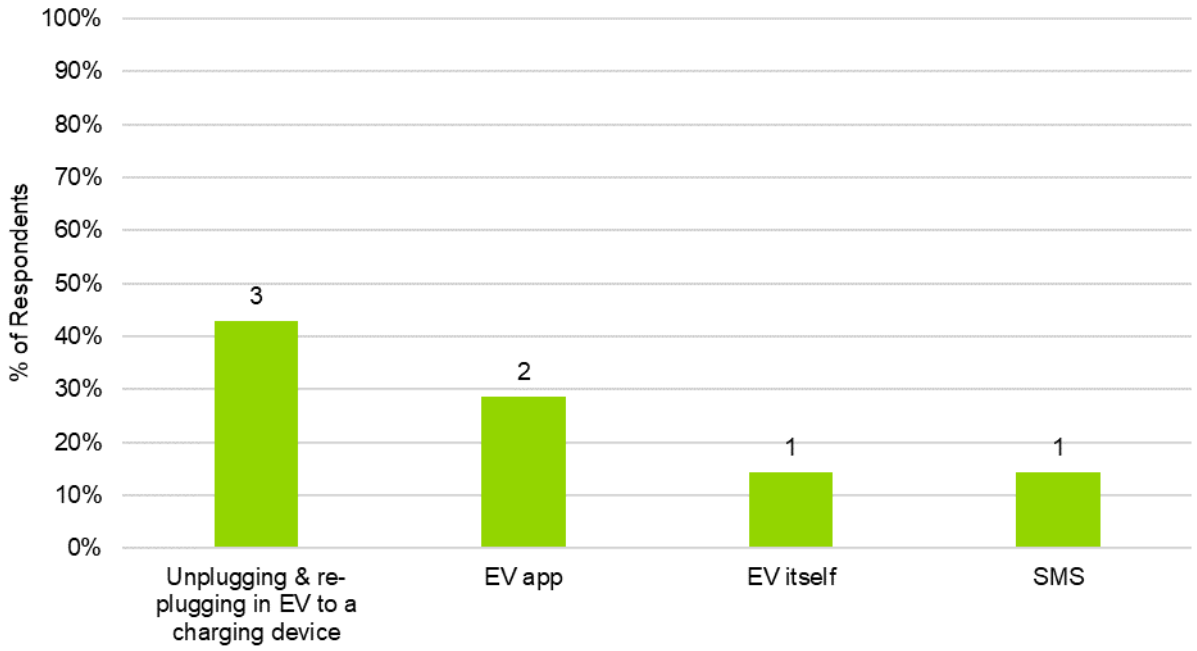
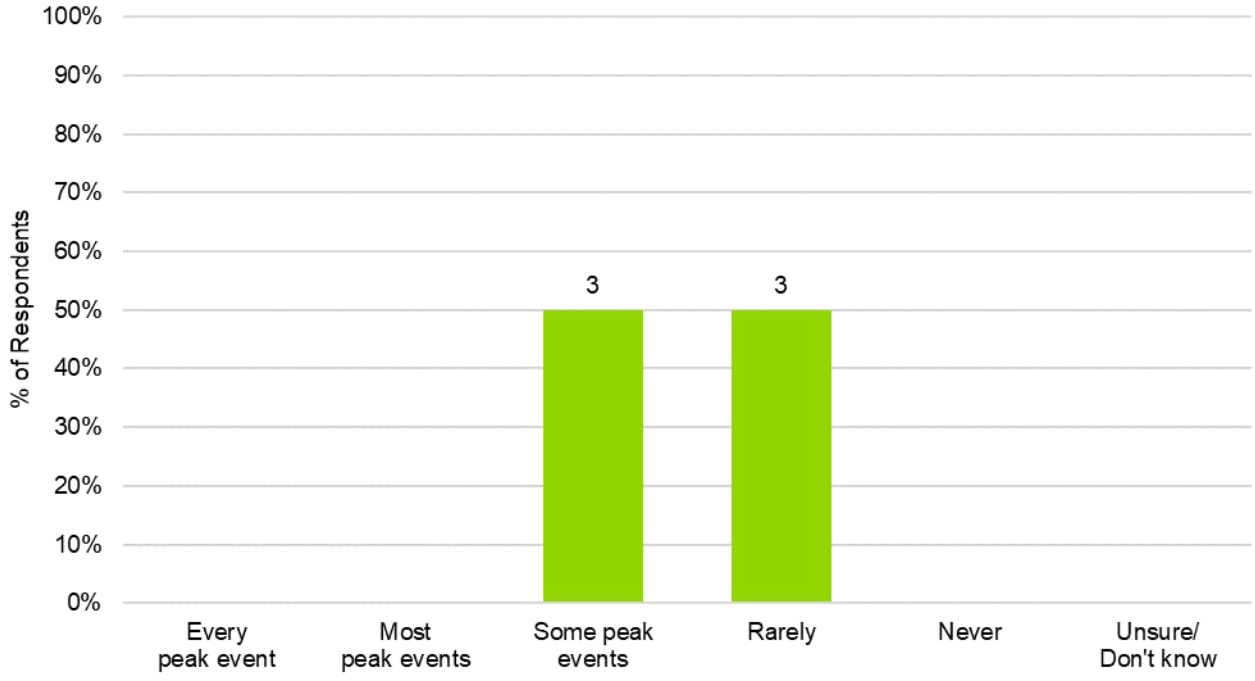
ET14_a. How did you opt-out or override a peak event(s)? Select all that apply. (n=6)



Source: Guidehouse

ET15. How often would you say you chose to opt-out or override a peak event? (n=6)



Source: Guidehouse

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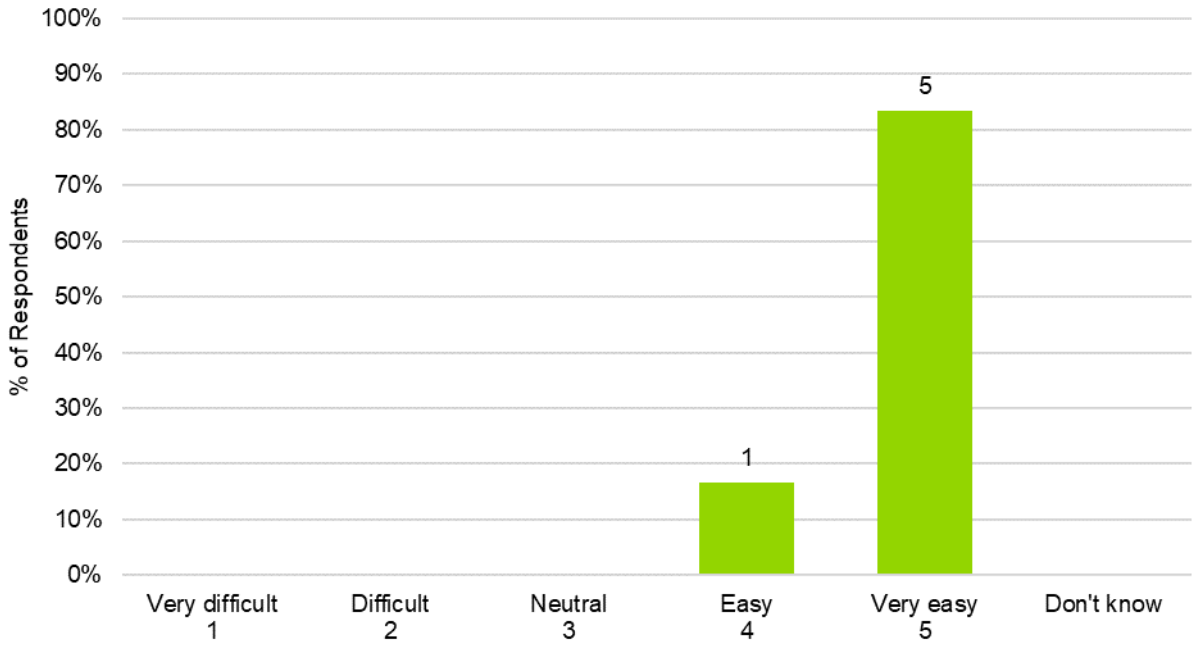
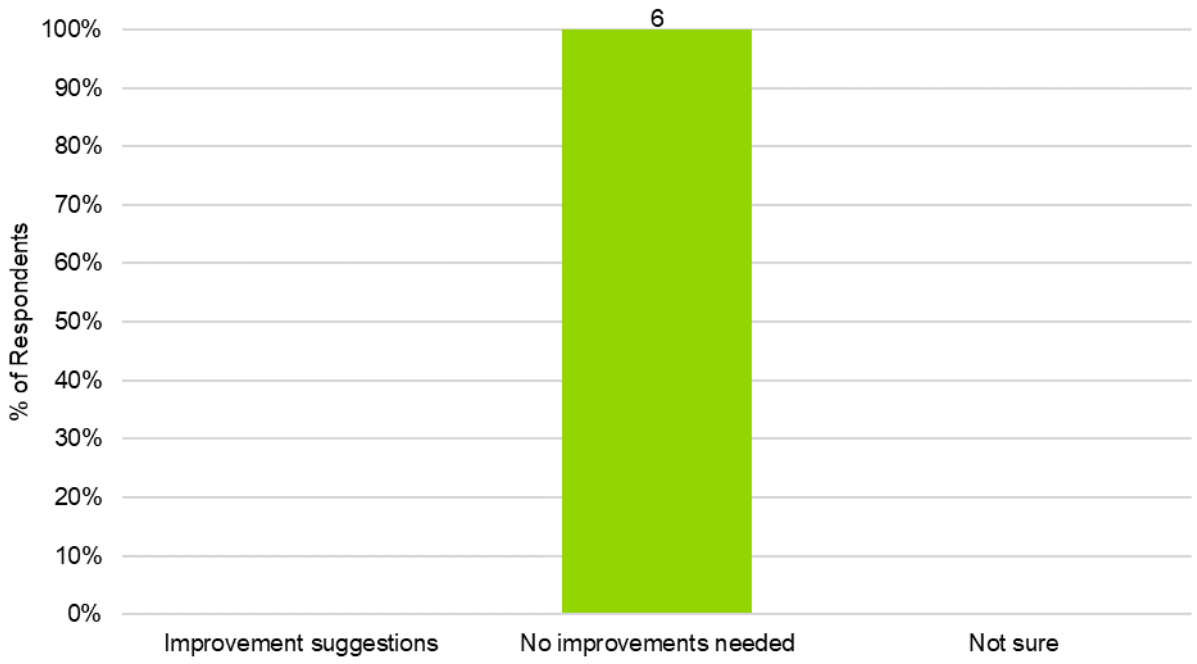
ET17. Using a scale of 1 to 5, how easy was it to opt-out of or override peak events? (n=6)



Source: Guidehouse

ET18. How could the process of opting out or overriding a peak event be improved? (n=6)



Source: Guidehouse

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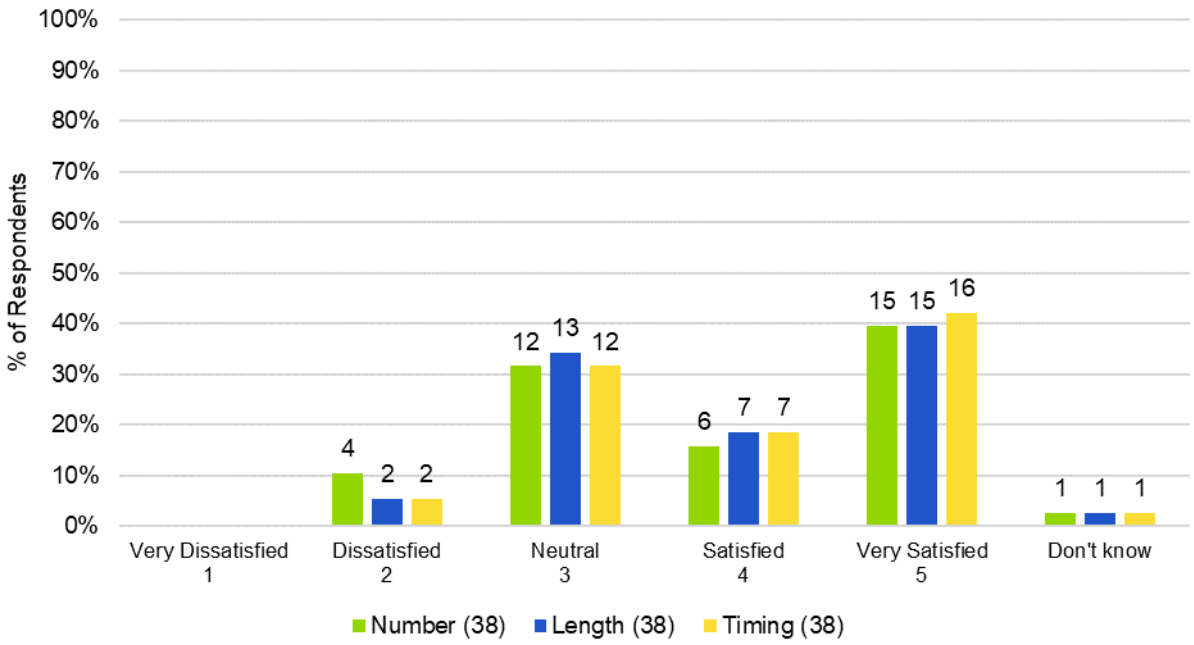
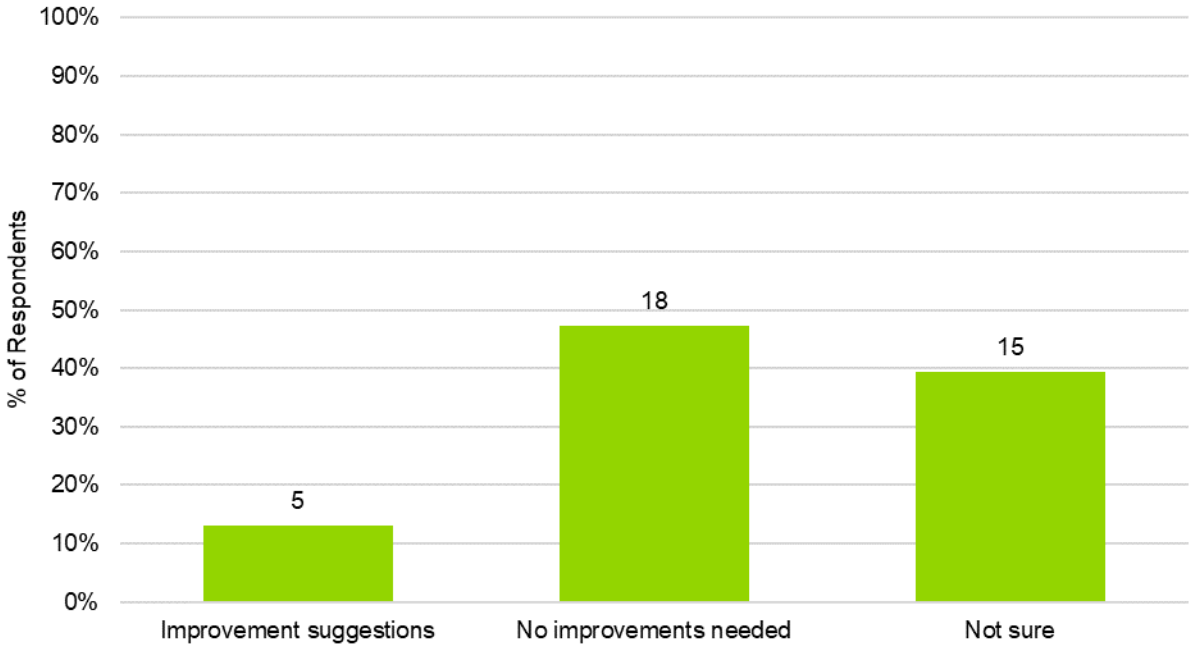
B.1.6 Program Satisfaction

S1. On a scale of 1 through 5, how would you rate your satisfaction with the following aspects (Event Number, Event Length, Event Timing) of National Grid's ConnectedSolutions EV and PHEV Demand Response Program to-date? (n=38)



Source: Guidehouse

S2. How could the number of peak events be improved? (n=38)



Source: Guidehouse

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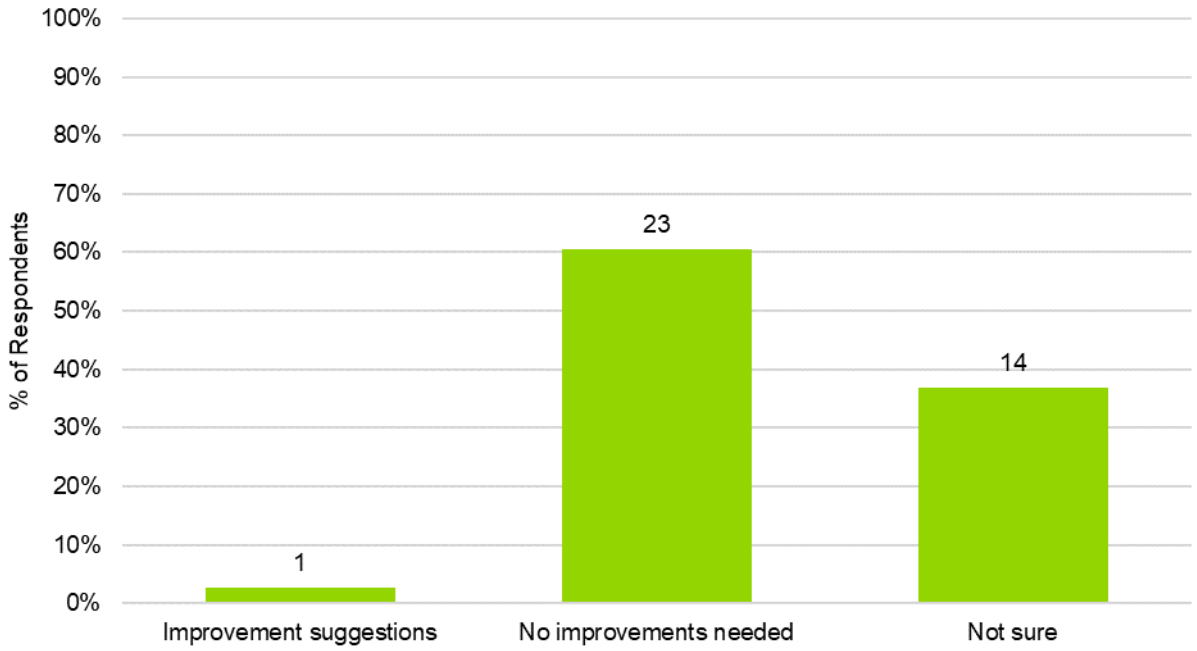
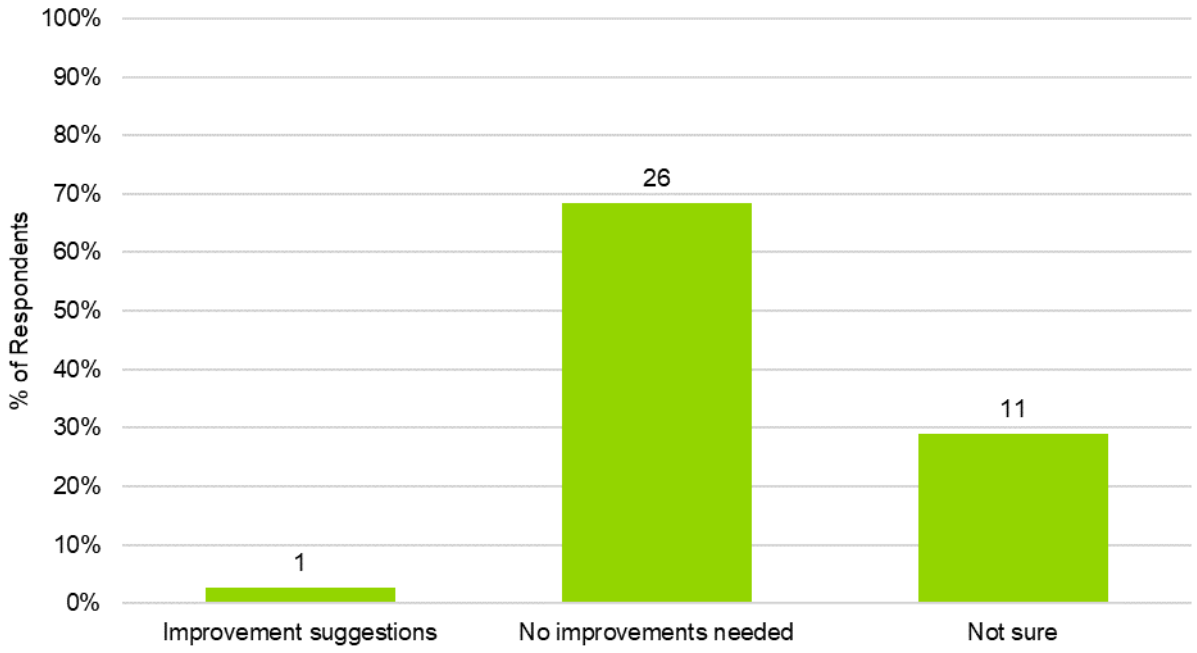
S3. How could the length of peak events be improved? (n=38)



Source: Guidehouse

S4. How could the timing of peak events be improved? (n=38)



Source: Guidehouse

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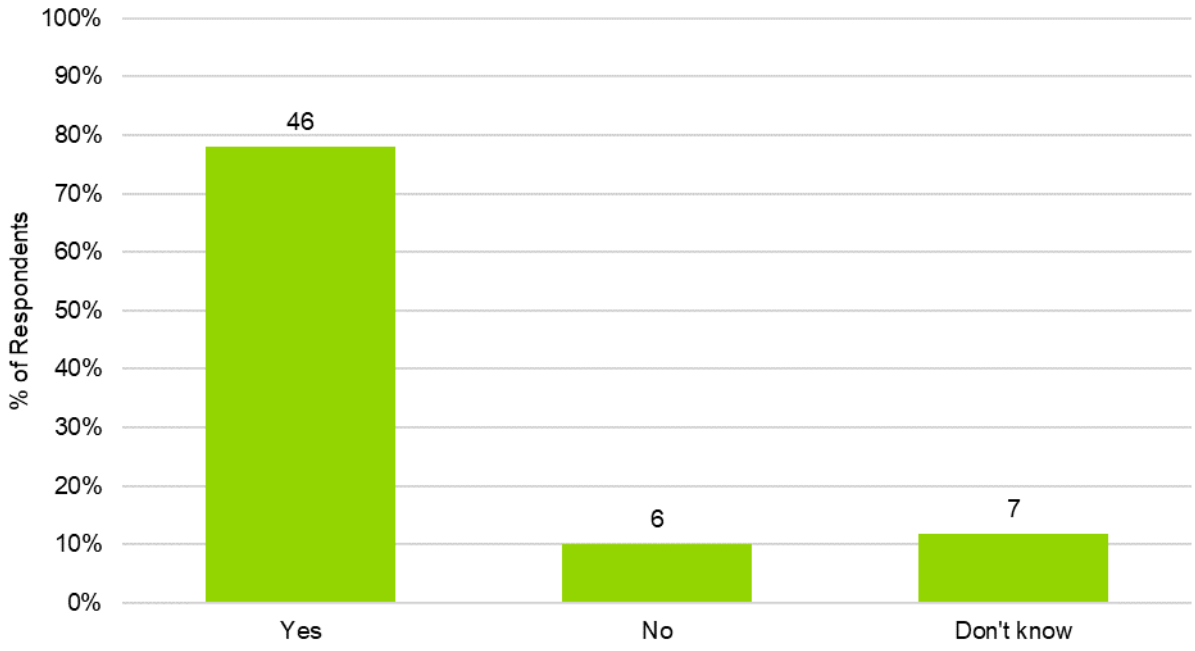
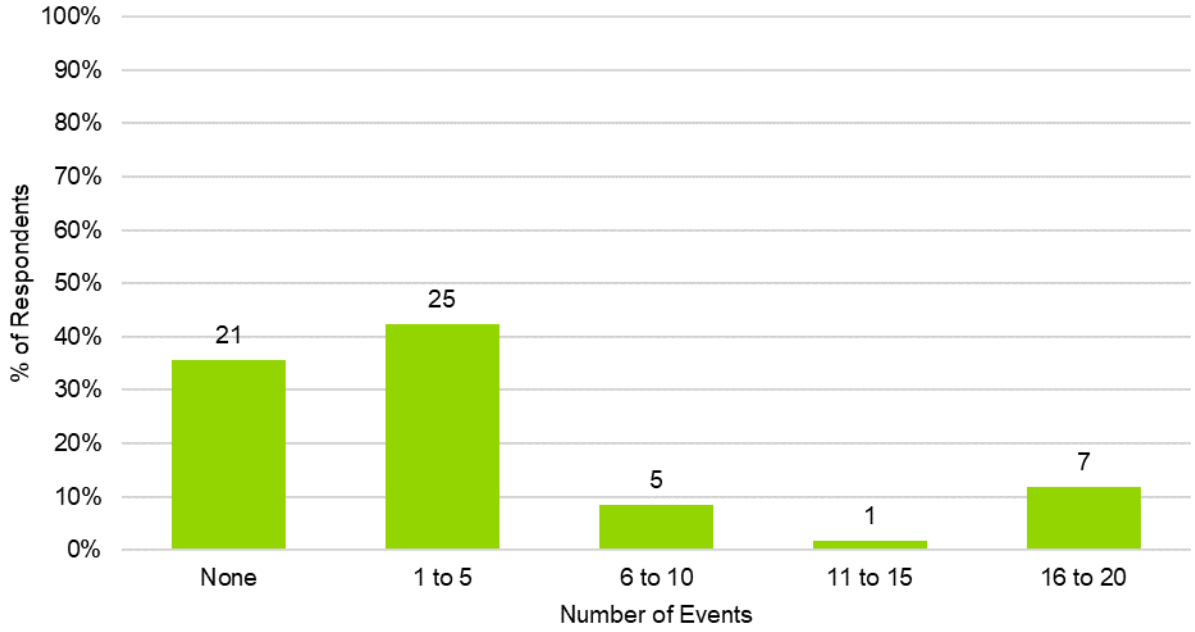
S5. Does $25 for enrolling in the program and $10-$20 (per-event) for participating in events in summer 2021 align with your understanding of the program rules? (n=59)



Source: Guidehouse

S6. Approximately how many events do you expect you earned an incentive for in summer 2021? (n=59)



Source: Guidehouse

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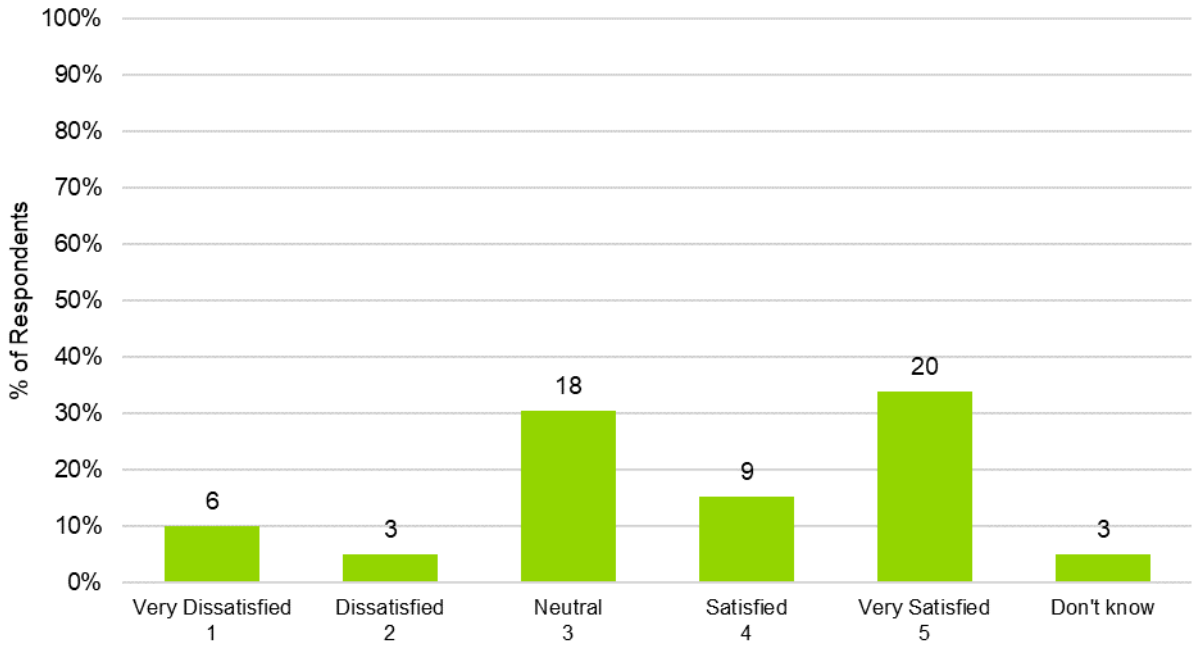
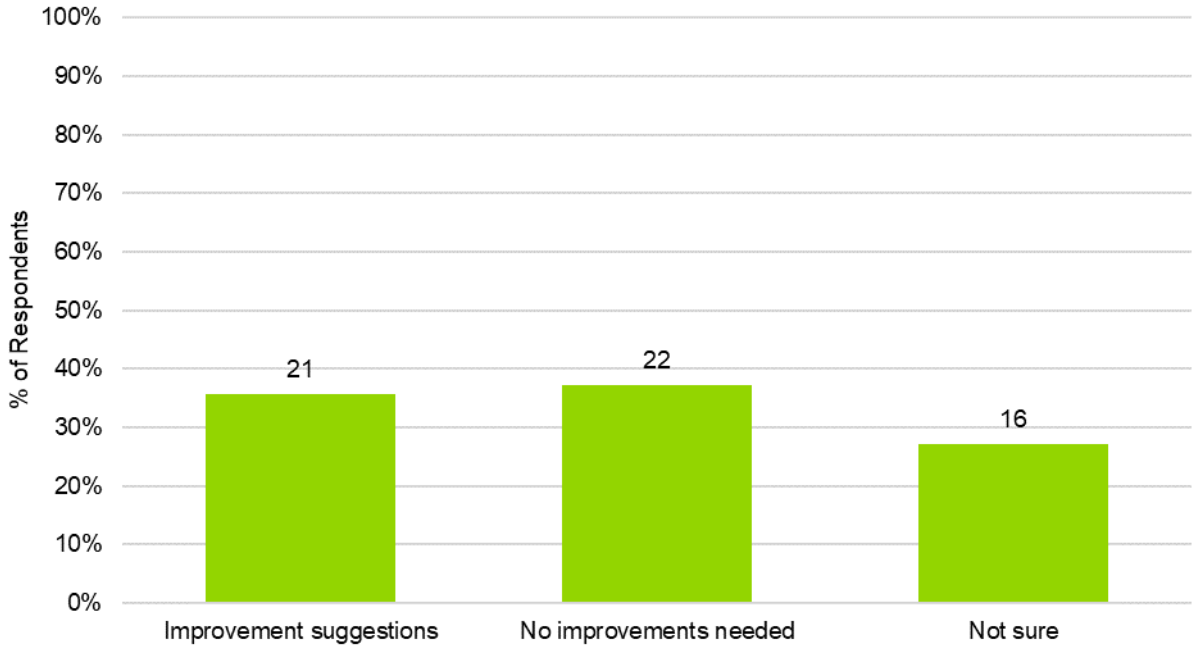
S7. On a scale of 1 through 5, how would you rate your satisfaction with the program incentives for summer 2021? (n=59)



Source: Guidehouse

S8. How could program incentives be improved? (n=59)



Source: Guidehouse

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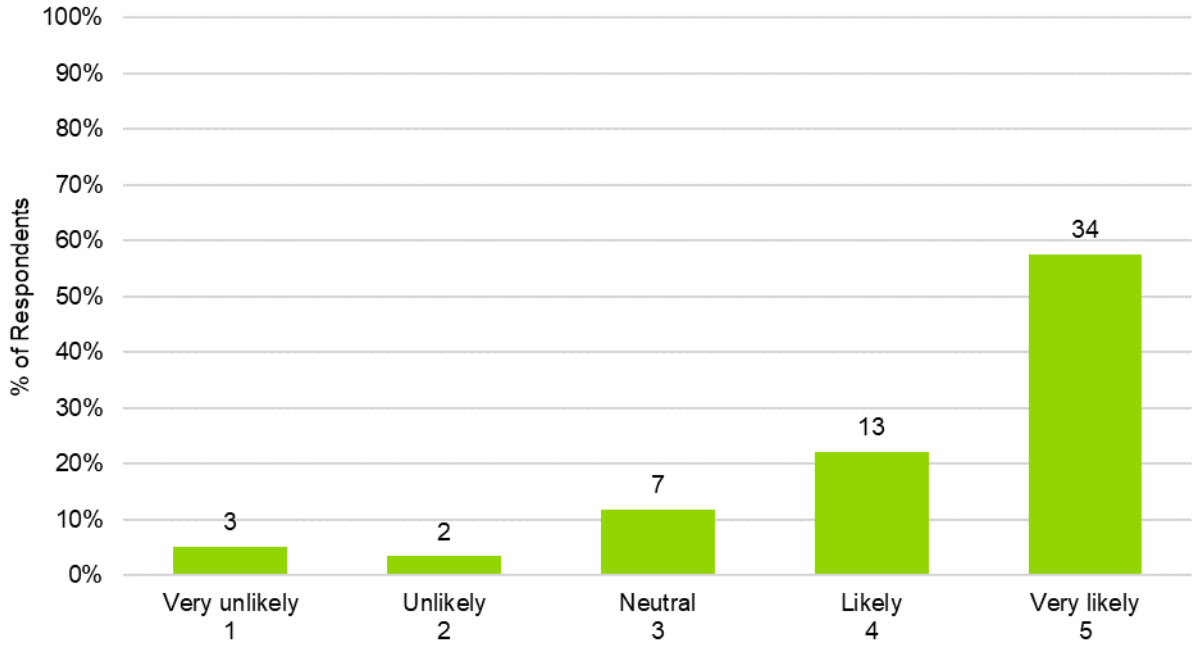
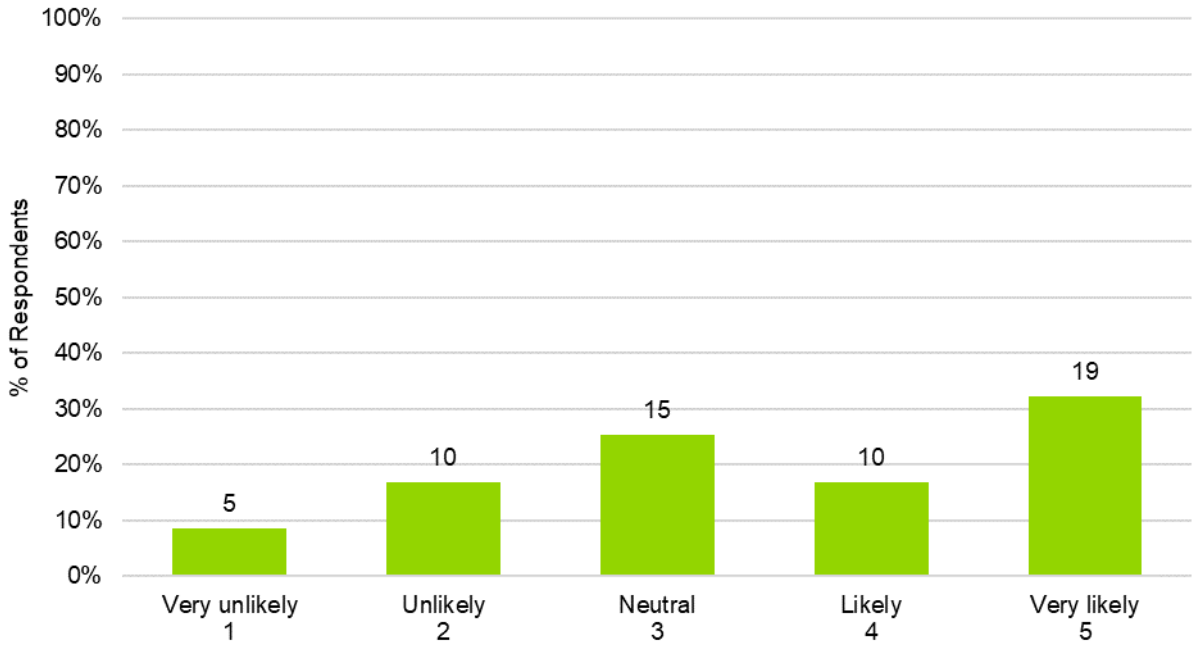
S9. On a scale of 1 to 5, How likely are you to continue to participate in National Grid's ConnectedSolutions EV and PHEV Demand Response program? (n=59)



Source: Guidehouse

S12. If the program replaced per-event incentives with one flat annual incentive of $20, on a scale of 1 to 5, how likely are you to continue to participate in National Grid's ConnectedSolutions EV and PHEV Demand Response program? (n=59)



Source: Guidehouse

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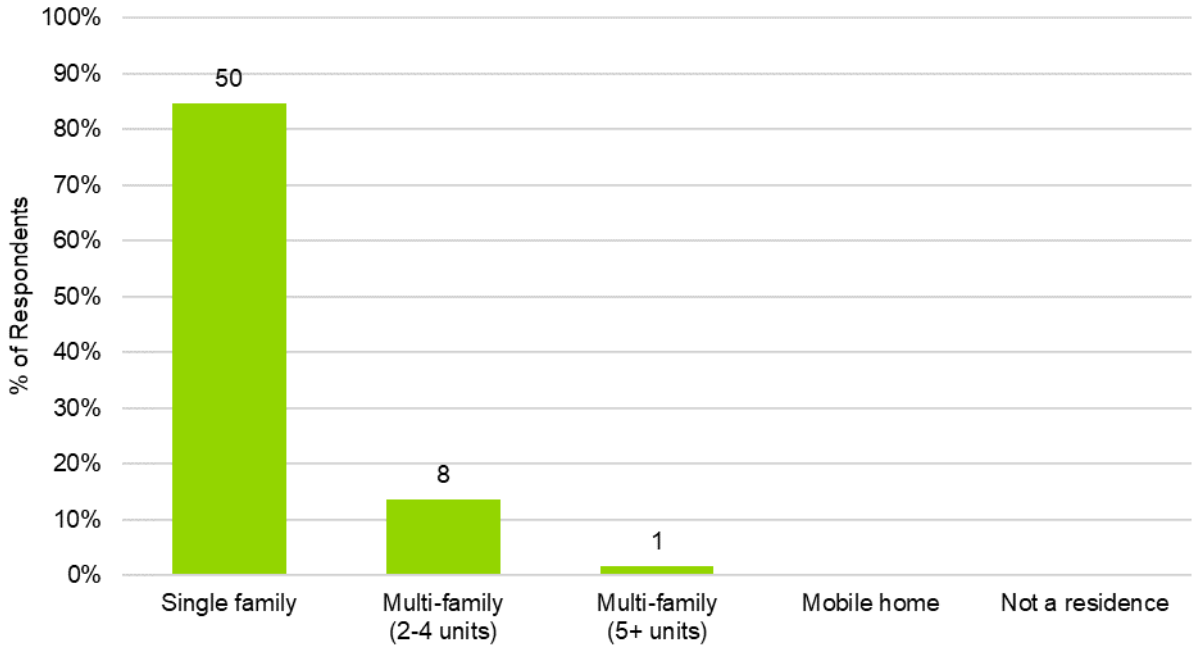
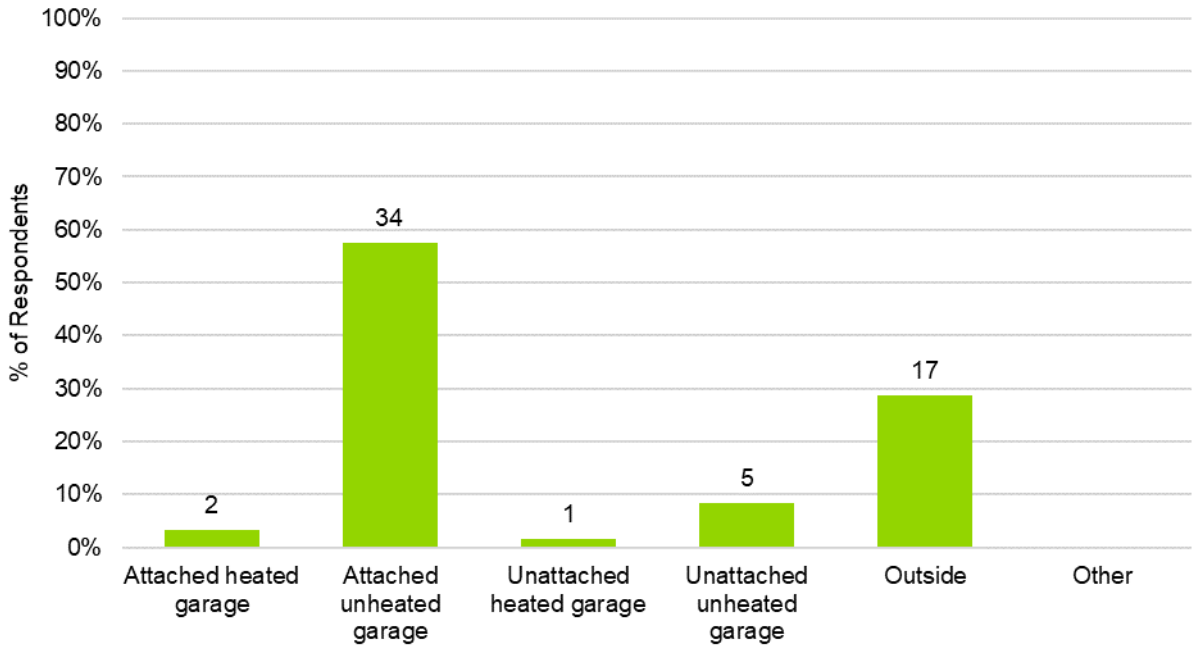
B.1.7 Demographics

D1. Which of the following best describes the property type where your home charging station is located? (n=59)



Source: Guidehouse

D2. Which of the following best describes the location of your home charging station? (n=59)



Source: Guidehouse

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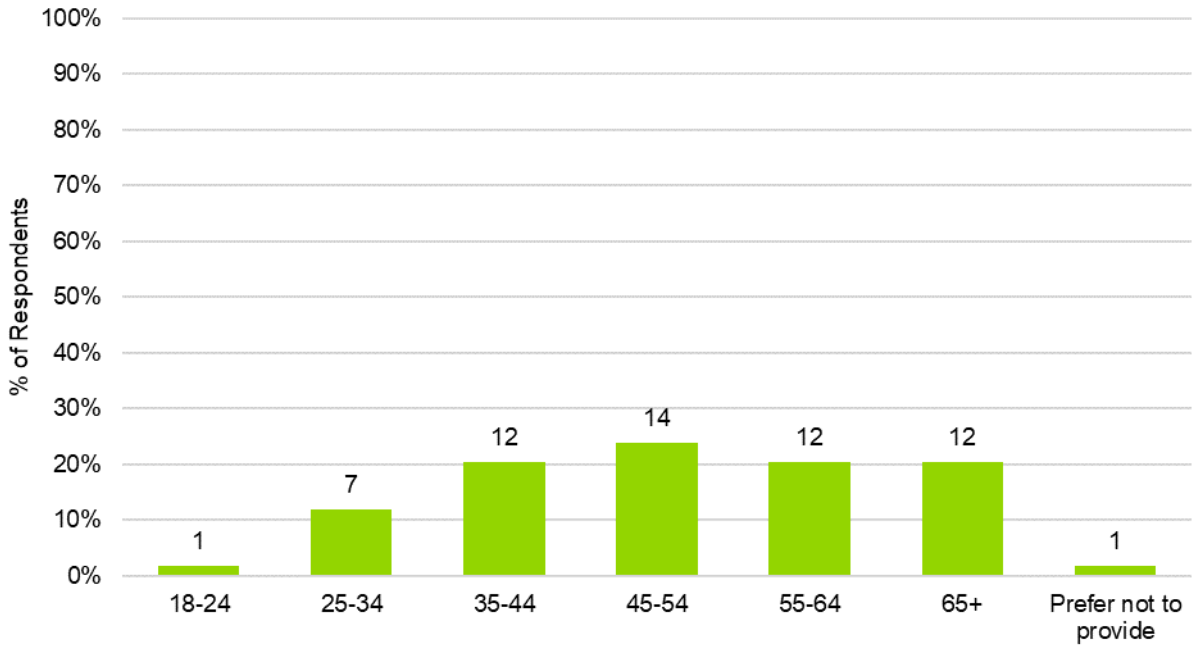
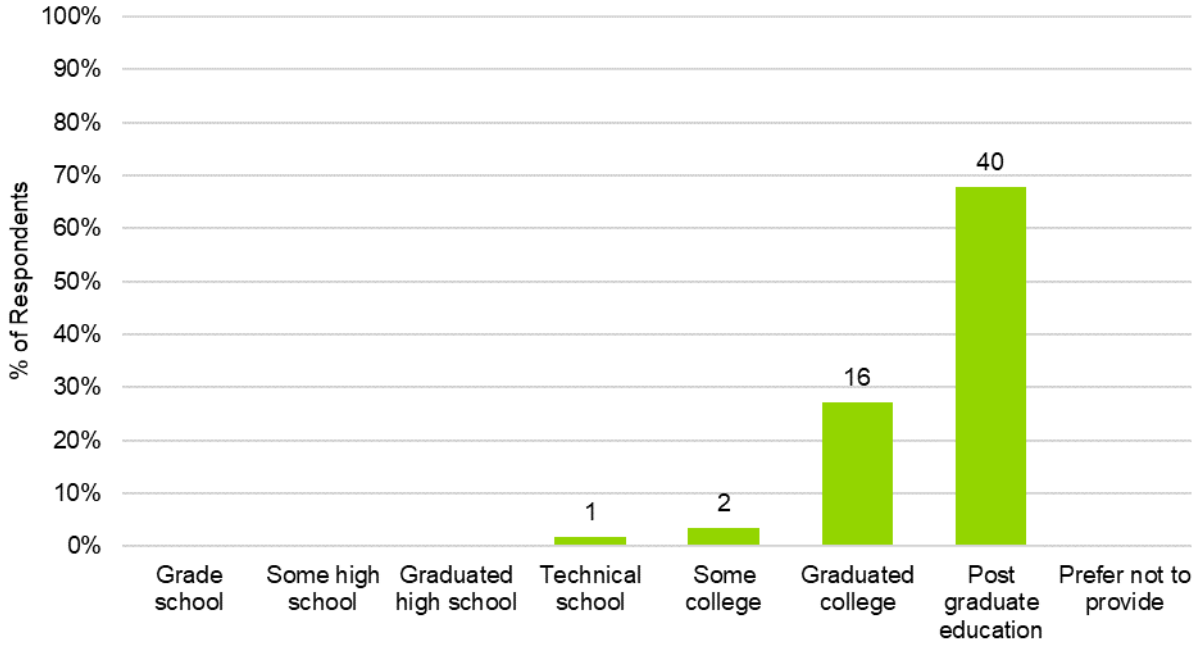
D3. Which of the following age categories do you fall into? (n=59)



Source: Guidehouse

D4. What is the last grade of school you completed? (n=59)



Source: Guidehouse

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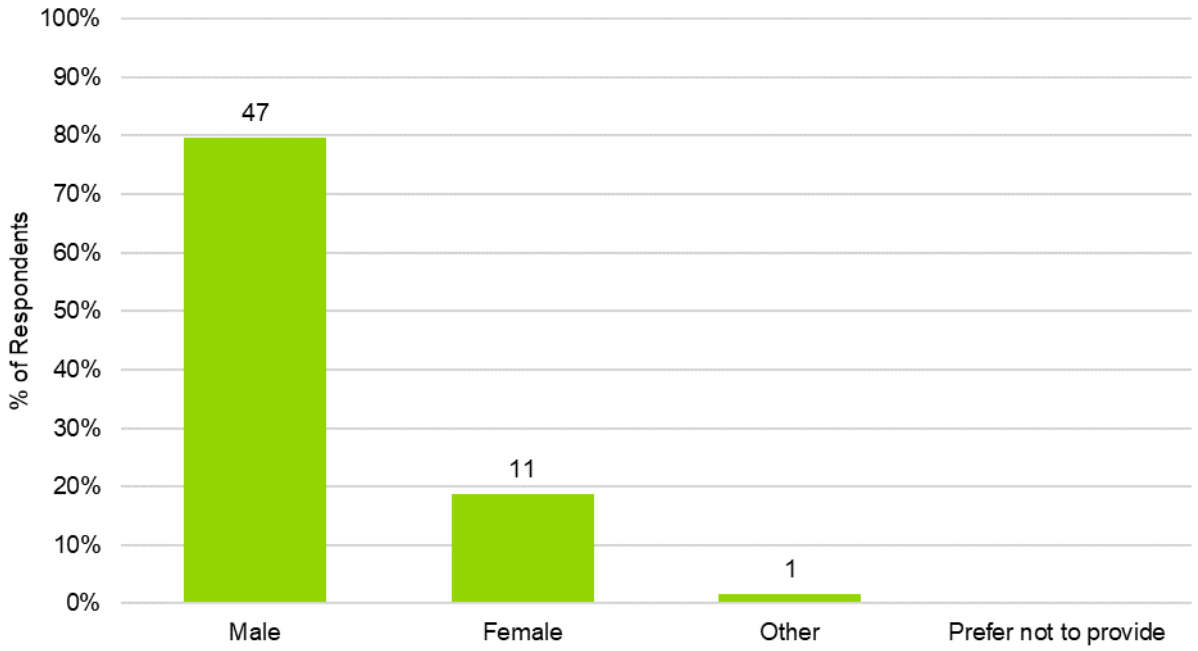
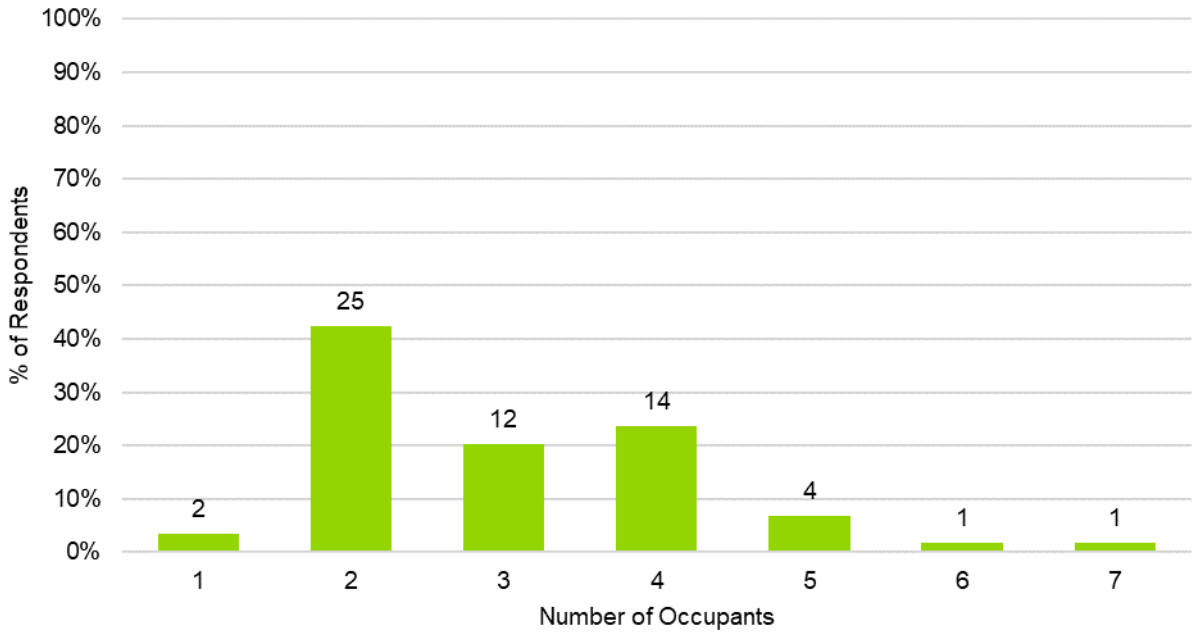
D5. Which category best describes your gender? (n=59)



Source: Guidehouse

D6. How many people occupied your home this summer 2021? Enter zero if appropriate. (n=59)



Source: Guidehouse

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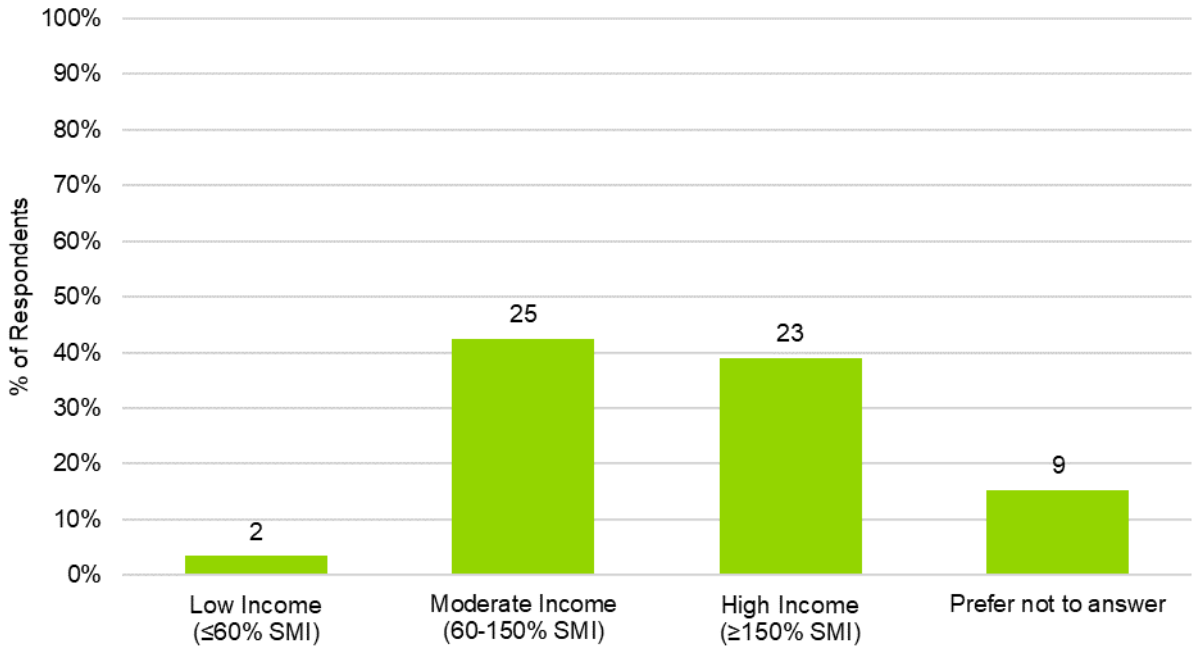
D7. What will be your estimated total annual household income in 2021 before taxes (in other words, your gross household income)? (n=59)



Source: Guidehouse

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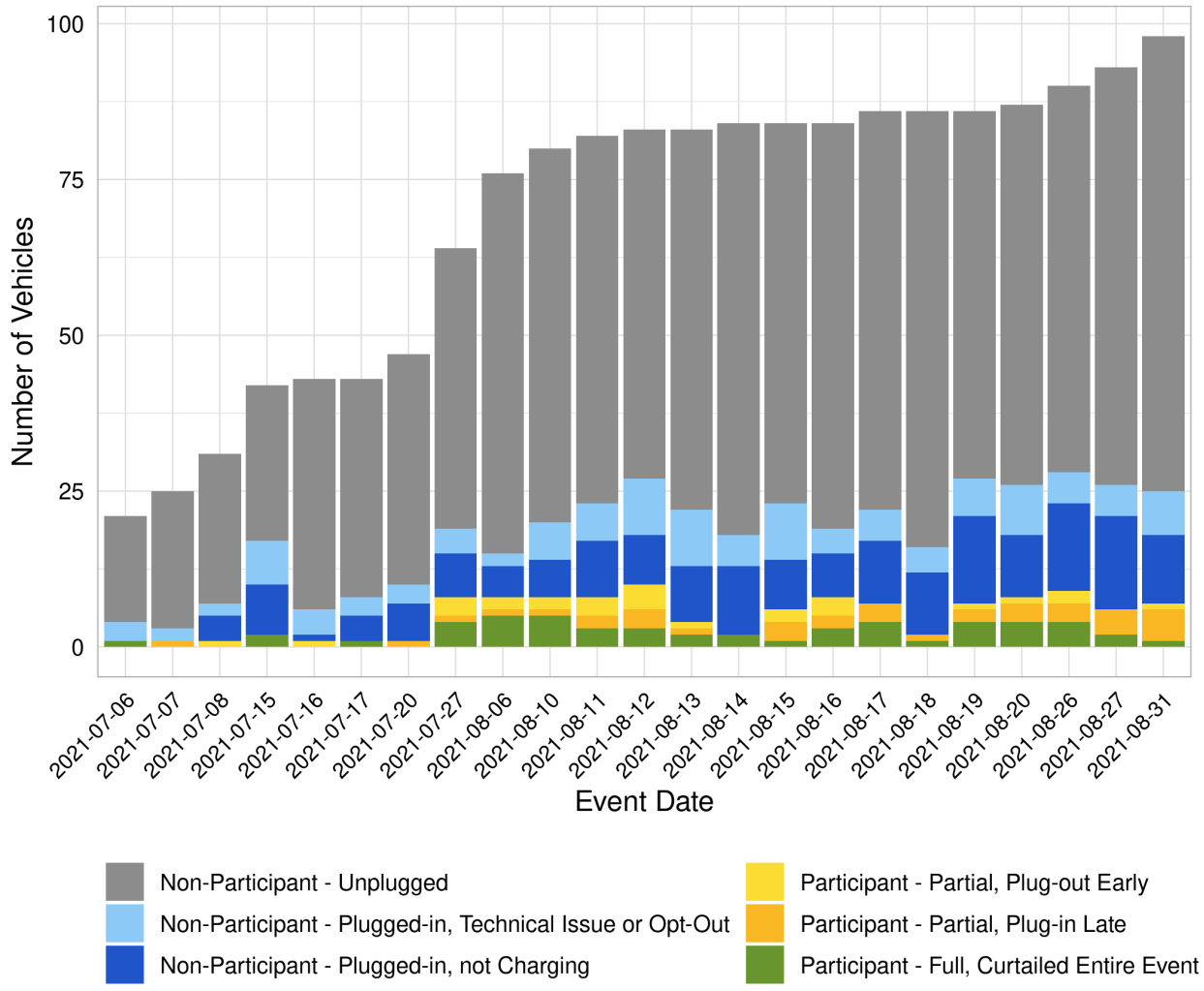
C. Event Participation – Supplemental Results

Figure 5-1 shows the participation breakdown for each of the 23 events evaluated in this report. Six of the first seven events in July only had one participant, which is partially due to fewer than 50 EVs being enrolled through the July 20th event. All events saw the majority of EVs being unplugged, with 60% to 88% being unplugged each event. The number of EVs that either experienced a technical issue or opted out of the event ranged from 2.6% to 16.7%.

Figure 5-1. Participation by Event



Source: Guidehouse analysis of EV vendor data

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D. Impact Analysis – Supplemental Results

Table 5-7 shows each event's hourly and average impacts calculated with the engineering approach for all enrolled EVs. The August 26th event had the highest overall event impact of 0.226 kW per enrolled EV and the highest single hour impact of 0.25 kW. The event called on July 20th had the lowest overall event impact of less than 0.01 kW, because there was only one participating EV and it plugged-in late. Only the two events called on July 7th and July 15th lasted three hours, and neither saw a decrease in hourly impacts over the course of the event.

Table 5-7. Hourly Impacts by Event

Event Date	Day of Week	Event Start Time	Event End Time	Enrolled EVs	Hour 1 Impact (kW)	Hour 2 Impact (kW)	Hour 3 Impact (kW)	Event Impact (kW)
7/6/2021	Tuesday	5:00 PM	7:00 PM	21	0.04	0.04	-	0.04
7/7/2021	Wednesday	4:00 PM	7:00 PM	25	0.03	0.03	0.03	0.03
7/8/2021	Thursday	4:00 PM	6:00 PM	31	< 0.01	< 0.01	-	< 0.01
7/15/2021	Thursday	4:00 PM	7:00 PM	42	0.04	0.04	0.04	0.04
7/16/2021	Friday	4:00 PM	6:00 PM	43	0.01	0.01	-	0.01
7/17/2021	Saturday	5:00 PM	7:00 PM	43	0.08	0.08	-	0.08
7/20/2021	Tuesday	4:00 PM	6:00 PM	47	< 0.01	< 0.01	-	< 0.01
7/27/2021	Tuesday	5:00 PM	7:00 PM	64	0.08	0.05	-	0.06
8/6/2021	Friday	4:00 PM	6:00 PM	76	0.19	0.16	-	0.18
8/10/2021	Tuesday	4:00 PM	6:00 PM	80	0.09	0.09	-	0.09
8/11/2021	Wednesday	4:00 PM	6:00 PM	82	0.2	0.07	-	0.13
8/12/2021	Thursday	4:00 PM	6:00 PM	83	0.16	0.16	-	0.16
8/13/2021	Friday	4:00 PM	6:00 PM	83	0.11	0.09	-	0.1
8/14/2021	Saturday	4:00 PM	6:00 PM	84	< 0.01	0.01	-	< 0.01
8/15/2021	Sunday	5:00 PM	7:00 PM	84	0.11	0.08	-	0.09
8/16/2021	Monday	5:00 PM	7:00 PM	84	0.11	0.09	-	0.1
8/17/2021	Tuesday	5:00 PM	7:00 PM	86	0.05	0.08	-	0.07
8/18/2021	Wednesday	4:00 PM	6:00 PM	86	0.02	< 0.01	-	0.01
8/19/2021	Thursday	5:00 PM	7:00 PM	86	0.12	0.13	-	0.13
8/20/2021	Friday	5:00 PM	7:00 PM	87	0.13	0.2	-	0.16
8/26/2021	Thursday	5:00 PM	7:00 PM	90	0.25	0.2	-	0.23
8/27/2021	Friday	5:00 PM	7:00 PM	93	0.08	0.13	-	0.1
8/31/2021	Tuesday	4:00 PM	6:00 PM	98	0.02	0.05	-	0.03

Note: Estimated impacts were not included for the events on June 29th, June 30th, and July 1st due to fewer than 15 EVs being enrolled on those days.
Source: Guidehouse analysis of EV vendor data

Table 5-8 is a summary of the average hourly kW impacts by EV type and participation for the entire analysis period. In order to control for rolling enrollment, Guidehouse weighted event impacts by the number of EVs when calculating the monthly and season averages. BEVs had lower average impacts in the second hour of events than in the first hour, while the impacts of PHEVs increased in the second hour of events. Although the two EV types had opposing changes in impacts over the course of events, it may be due to the small sample sizes rather than indicative of any systematic differences between the two EV types.

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Table 5-8. Weighted Hourly Impact per EV by Participation and EV Type

Customers	EV Type	Hour 1 Impact (kW)	Hour 2 Impact (kW)	Event Impact (kW)
All Enrolled	All	0.09	0.09	0.09
All Enrolled	BEV	0.11	0.10	0.11
All Enrolled	PHEV	0.06	0.07	0.07
Event Participants	All	1.30	1.22	1.26
Event Participants	BEV	1.46	1.27	1.36
Event Participants	PHEV	1.00	1.15	1.07

Note: There were two events that lasted three hours, as shown in Table 5-8. The third hour averages were not included in this table because they were not present in all events.
Source: Guidehouse analysis of EV vendor data

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