

# Moving Targets: Methods for Evaluation Evolving EV Managed Charging Programs

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## ABSTRACT

With almost 140,000 EVs on the road as of the end of 2024—and a statewide goal of 900,000 EVs by 2030—Massachusetts utilities and regulators are testing ways to shift EV charging load from peak hours to mitigate grid impacts and reduce customer energy costs.

This research offers lessons learned from the evaluation of two National Grid Massachusetts interventions delivered to distinct groups. One group (referred to as “Flexible Scheduling” participants) opted in to enable a feature in the program app that allows the implementor to control when charging begins based on user-selected departure time (e.g., 6 a.m.) and desired state of charge (e.g., 80%). The other group (referred to as “Personal Scheduling” participants) was divided into five subgroups, each of which was given a custom off-peak period start-hour of either 10 p.m., 11 p.m., midnight, 1 a.m., or 2 a.m. Both interventions were delivered to drivers who were enrolled in a preexisting program that incentivized participants to charge at 9 p.m., resulting in a concentrated peak in charging activity (referred to as a “timer peak”) that could exceed the capacity of grid assets and pose challenges to grid reliability at scale.

The trial used a Randomized Encouragement Design (RED), allowing for detailed comparison of the two intervention approaches. DNV developed a difference-in-difference (DID) analysis to measure the impacts of these interventions on timer peak mitigation and the total share of off-peak charging and found that both interventions effectively mitigated the 9 p.m. timer peak and shifted charging load to the early morning hours while resulting in load profiles with unique characteristics.

## Background and Introduction

With almost 140,000 EVs on the road as of the end of 2024—and a statewide goal of 900,000 EVs by 2030—Massachusetts utilities and regulators are testing ways to shift EV charging load away from peak hours to mitigate grid impacts and reduce customer energy costs (Commonwealth of Massachusetts 2022, 31; 2024). As managed charging programs evolve, it is critical to design programs effectively and to measure impacts accurately to inform decision-makers of the costs and benefits of managed charging.

National Grid Massachusetts’ Residential Off-Peak Charging Rebate Program (“the Charging Program”) began in 2020 and provides per-kWh rebates for participants to charge EVs off-peak. National Grid defines the peak period as 1 p.m. to 9 p.m. on weekdays, excluding holidays. While the existing Charging Program demonstrated the relative effectiveness of rebates to shift charging off-peak, its design meant many drivers simultaneously began charging their vehicles at the end of the on-peak period, creating a significant timer peak (or concentrated peak in charging activity) at 9 p.m.

Hence, in fall of 2024, National Grid Massachusetts ran the Flexible Scheduling Trial (“the trial”) designed to shift EV charging load away from the beginning of the off-peak period (9 p.m.) and to flatten the charging load shape overnight. The trial population included a subset of participants from the Charging Program and tested two intervention strategies. The Flexible Scheduling (FS) strategy used active load control to schedule participants’ charging, while the Personal Scheduling (PS) strategy encouraged drivers to set their own smart charging schedules with program-specified charging start hours of either 10 p.m., 11 p.m., 12 a.m., 1 a.m., or 2 a.m. Using a Randomized Encouragement Design (RED), the Flexible Scheduling Trial allowed for detailed analysis and comparison of the relative impacts of the two

intervention approaches and provided insight into how participants leverage technology and behavioral changes to achieve off-peak charging.

## Methodology

### Intervention Strategies

The trial's two intervention strategies were as follows:

- *Flexible Scheduling (FS)* – This intervention group consisted of Tesla drivers. Participants in this group allowed the implementor (ev.energy) to actively control their charging based on their desired departure time and state of charge. For example, a driver may plug in in the evening but specify that they want an 80% charge by 6 a.m. Charging for this vehicle would then automatically start at the time required to achieve an 80% charge by 6 a.m. The underlying calculations driving this strategy are part of the proprietary approach developed by ev.energy. A total of 2,279 vehicles were included in this intervention group.
- *Personal Scheduling (PS)* – This intervention group consisted of non-Tesla battery electric vehicles (non-Tesla BEVs) and plug-in hybrid vehicles (PHEVs). This group was split into five distinct charging start hours (10 p.m., 11 p.m., 12 a.m., 1 a.m., and 2 a.m.). Participants were notified via email of their new off-peak period start hour and directed to set their smart charging schedules to adhere to their specified start time. Participant data was collected by the implementor (ev.energy). A total of 993 vehicles were included in this intervention group.

By offering differentiated interventions, the trial design allowed the observation of any differences in impact between the FS group's active load control and the PS group's passive control.

### Randomized Encouragement Design

Recruitment of eligible participants into the trial adhered to a randomized encouragement design (RED), in which customers were first randomly assigned to treatment and control groups and then treatment customers were encouraged to enroll in the trial. The RED approach took the following form:

- National Grid identified customers eligible for trial participation.
- National Grid randomly assigned the identified eligible customers to treatment and control groups for the respective FS and PS interventions, with a 30% control group share in each case. National Grid also randomized PS customers into the five distinct schedule groups. This randomized assignment took place prior to any recruitment efforts.
- National Grid reached out to customers in each treatment group to encourage them to enroll in the trial, which included a one-time \$30 incentive. Control group customers were never offered enrollment in the trial. This experimental design ensured that the control groups had no awareness of the program, mitigating the potential customer disappointment of a recruit-and-deny approach and ensuring that the evaluation results would have external validity to any customer, rather than only to customers predisposed to opt in to this type of program.

Note that, after receiving the communications from National Grid and opting in, FS treatment participants had to complete additional steps to enable the smart charging feature through the program app, including downloading an app update and selecting the Smart Charging toggle within their phone app. Though participants were directed to enable this feature at the beginning of the trial (early August

2024), many did not enable the feature until later in the two-month trial period. The impacts of this complication are discussed further in the Results section.

### **Data Sources and Quality Control**

The DNV team requested data from National Grid and ev.energy upon completion of the trial period. The data sources used in this impact evaluation include the following for participants in all trial intervention control and treatment groups:

- *Trial roster data* – National Grid provided a trial roster containing the list of customers in each trial intervention group.
- *Vehicle and charger data* – ev.energy provided vehicle and charger data through a web dashboard. This included vehicle make, model, and trim, as well as charger make and model for each customer in the Off-Peak Charging Program. DNV mapped the vehicle and charger data to the trial roster data to identify the intervention used for each individual vehicle.
- *Charging interval data* – ev.energy provided charging interval data through a web dashboard. This data consisted of 30-minute intervals of kWh charging load for each vehicle. Charging interval data formed the basis of all load shapes and charging behavior analysis in this evaluation.
- *Charging session data* – ev.energy provided charging session data through a web dashboard. This data contained a single row for every recorded charging session. DNV used charging session data to flag any sessions with unexpectedly high or low session duration and merged session data onto interval data to complete all analyses. We will refer to this merged dataset as the “charging data” for the remainder of this paper.

While the pilot period only included August and September 2024, the scope of this analysis included charging data recorded from January 2024 through September 2024. Pre-pilot data was used to analyze “pre-period” behavior in the difference-in-difference regression. Upon data receipt, DNV performed the following data cleaning steps:

- *Filtering for participants with sufficient data*– DNV filtered out data for any participants with no charging data due to missing account numbers, incompatible hardware, or unknown vehicle makes. Of the 5,365 vehicles listed in the roster, 4,752 vehicles provided charging data (89%). From the pool of vehicles with available data, 20 (<1%) were removed due to incompatible hardware or unknown vehicle make.
- *Quality control* – DNV performed QC checks to ensure that blank, invalid, and inaccurate data was flagged for removal from the analysis. Examples of data the team omitted from the analysis include negative kWh or kW data, charge rates that exceeded a given EV model’s maximum charge acceptance rate (kW), and charging sessions with durations greater than 10 days. Of the over 10 million charging intervals analyzed for compatible participants, 81.5% of intervals passed QC.

After all data QC and filtering, DNV included a total of 4,036 vehicles in the trial analysis, with 2,811 FS vehicles and 1,225 PS vehicles. Vehicle counts by intervention and control/treatment group are included in Table 3.

### **Difference-in-Difference Regression Analysis**

DNV conducted a difference-in-difference (DID) analysis using a panel model to estimate the hourly impact of the program for each intervention strategy. Before conducting the regression, DNV applied de-meaning, a statistical technique used to neutralize or eliminate the influence of individual

vehicles or dates. De-meaning first subtracts each vehicle’s average load from every interval for that vehicle. Second, de-meaning subtracts the daily average load across all vehicles from each date. As a result, fixed effects associated with individual vehicles and dates were removed, specifically effects related to the FS treatment participants who enabled smart charging at various dates throughout the trial period (resulting in varied trial-period start dates). De-meaning thus isolated the program’s effect and eliminated any unwanted effects of variable start dates. The model specification is defined as follows:

$$\begin{aligned}
 Load_{h,p,t} = & \sum_{h=1}^{24} \beta_{base,h} \times Hour_h + \sum_{h=1}^{24} \beta_{treat,h} \times Hour_h \times 1_{(If\ treatment)} \\
 & + \sum_{h=1}^{24} \beta_{post,h} \times Hour_h \times 1_{(If\ post)} \\
 & + \sum_{h=1}^{24} \beta_{interaction,h} \times Hour_h \times 1_{(If\ treatment)} \times 1_{(If\ post)} + \varepsilon
 \end{aligned}$$

where:

- $Load_{h,p,t}$  = Hourly load (kW) for hour h, period p, and group t
- $\beta_{base,h}$  = Baseline hourly load
- $\beta_{treat,h}$  = Treatment group effect on the hourly load
- $\beta_{post,h}$  = Post-period effect on the hourly load
- $\beta_{interaction,h}$  = DID result of the program effect
- $Hour_h$  = Hour of the day (categorical variable, from 0 to 23)
- $1_{(If\ treatment)}$  = Treatment Boolean (0 for control group; 1 for treatment group)
- $1_{(If\ post)}$  = Post-period Boolean (0 for pre-period; 1 for post-period)
- $\varepsilon$  = Error terms

The coefficient results  $\beta_{interaction,h}$  represent the program impact of interest. These coefficients form the basis of the DID results presented in this paper.

## Results

### Participation Analysis

Table 1 provides further details on trial opt-in rates within each intervention’s treatment group. Per the RED, participants were first segmented and randomly assigned to the treatment group by National Grid, after which they received a short web survey that explained the trial and offered the option to participate (opt in) or decline. Treatment group participants who declined to participate were still considered part of the treatment group for experiment validity reasons (discussed further in the “Statistical Difference-in-Difference Analysis” section below), but did not receive any subsequent communications regarding the trial and were not directed to change their charging behavior.

Table 2 details treatment group opt-in rates based on the number of vehicles in the trial roster data. This includes vehicles that were later excluded from the analysis due to failing QC to provide the most complete picture of opt-in rates, which were independent of subsequent data quality.

Table 1. Vehicle opt-in rate breakdown

Vehicle group		Vehicles assigned	Vehicles opted in	Opt-in rate
Flexible Scheduling (FS)	FS, Treatment	2,279	770	34%
	PS, Treatment, 10 p.m.	197	66	34%
	PS, Treatment, 11 p.m.	187	62	33%
Personal Scheduling (PS)	PS, Treatment, 12 a.m.	192	68	35%
	PS, Treatment, 1 a.m.	214	59	28%
	PS, Treatment, 2 a.m.	203	61	30%
	<b>Total PS</b>	<b>993</b>	<b>316</b>	<b>32%</b>
<b>Total</b>		<b>3,272</b>	<b>1,086</b>	<b>33%</b>

\*National Grid moved 11 PS treatment customers to the FS program and 19 FS treatment customers to the PS program during the recruitment process. Those customers' vehicles were left out of the counts in these tables.

Opt-in rates varied for PS participants. Table 1 shows that the vehicle opt-in rate was highest for the 12 a.m. group (35%) and second highest for the 10 p.m. and 11 p.m. groups (33-34%). The 1 a.m. and 2 a.m. PS groups saw the lowest opt-in rates of all treatment groups, at 28% and 30% respectively. It is possible that participants may be less willing to postpone their charging until these early morning hours, resulting in lower opt-in rates. Future customer research could explore this hypothesis to understand any effects on program impact and inform future program design.

FS treatment participants showed a 34% opt-in rate. However, to enable the smart charging feature, these participants had to download an app update and select the Smart Charging toggle within their phone app. Though these participants were first notified of the ability to enable by around August 8, 2024, many did not enable until later, with 80% of opted-in vehicles enabled by August 18. The latest enablement date was September 30, meaning some vehicles did not enable smart charging until the very end of the trial period. To streamline full feature enablement, future programs should ensure that requirements such as app enablement are clear to participants at the time of program initiation.

### Summary Statistics

Table 2 shows a breakdown of charging session types for FS treatment, opted-in, smart-charged participants. The "Home – Unmanaged" tag is applied by ev.energy to charging sessions that were not directly managed, while the "Home – Smart" tag applies to sessions that were controlled by ev.energy. The "Home – Boost" tag applies when a participant overrode the smart charging control. This override is an in-app feature and applies for a single session. Participants in the FS group were allowed to enable and disable smart charging throughout the trial period, as well as override individual smart charging sessions. Overrides of individual smart charging sessions appear as "Home – Boost," while "Home – Unmanaged" sessions indicate that a participant disabled their smart charging.

Table 2. Flexible Scheduling (treatment, opted-in, smart charged) session type breakdown

Session type	Number of sessions		kWh charged*		
	Total	Percent of total	Total	Percent of total	Average kWh per session
Away from Home	1,699	18%	40,920	22%	24.1

Home – Unmanaged**	1,321	14%	29,250	16%	22.1
Home – Smart	6,066	64%	109,707	59%	18.1
Home – Boost	387	4%	6,031	3%	15.6
All	9,473	100%	185,908	100%	19.6

\*Note that charging intervals with less than 0.05 kWh are removed from the analysis as “phantom charging” and are not counted in this table.

\*\*Note that 1% of “Home – Unmanaged” sessions occurred on the same day that smart charging was enabled, though before the vehicle recorded its first “Home – Boost” or “Home – Smart” session. However, this accounts for <1% of the total kWh charged across all “Home – Unmanaged” sessions, indicating that the vast majority of these sessions occurred after smart charging was first enabled.

“Home – Unmanaged” made up 14% of all sessions for this FS group, indicating that a significant number of participants disabled smart charging control sometime within the trial period. However, only 4% of sessions were “Home – Boost” sessions, showing a willingness of enabled participants to let the program manage charging and only infrequently override these controls.

Table 3 shows the percent of kWh charged off-peak for each intervention group in total and split by home and away charging. Note that, while the Charging Program rewards home and away off-peak charging equally, the trial intervention was focused on home charging. FS charger controls only affected home charging, and schedules set on smart chargers by PS participants would, by definition, only apply at home. Table 3 shows that the trial clearly resulted in higher levels of off-peak home charging:

Table 3. Percent kWh charged off-peak

Group	Subgroup	Vehicle count	Percent of kWh charged off-peak (all charging)	Percent of kWh charged off-peak (Home)	Percent of kWh charged off-peak (Away)
Flexible Scheduling (FS)	Control	838	81.8%	90.6%	60.6%
	Treatment, not opted-in	1,301	81.9%	89.1%	62.2%
	Treatment, opted-in, did not smart charge	344	80.5%	90.4%	64.8%
	Treatment, opted-in, smart charged	328	88.9%	95.9%	58.0%
Personal Scheduling (PS)	Control	375	84.5%	88.1%	67.6%
	Treatment, not opted-in	565	79.8%	83.9%	65.7%
	Treatment, opted-in	285	87.5%	92.7%	63.2%

The takeaways from Table 3 are summarized below:

#### Flexible Scheduling (FS)

- *All charging* – The FS treatment, opted-in, smart-charged, participants charged 7.1 percentage points more off-peak than the respective control group, indicating the success of the trial in shifting additional charging off-peak.
- *Home charging* – Even more significantly, the FS treatment, opted-in, smart-charged participants conducted almost 96% of all home charging off-peak, which was 5.3 percentage points more than the control group and also higher than the PS treatment group.

## Personal Scheduling (PS)

- *All charging* – The PS treatment, opted-in participants charged 3.0 percentage points more overall off-peak than the PS control group, showing a slightly smaller but still notable increase in charging off-peak.

*Home charging* – At home, the PS treatment, opted-in group charged 92.7% off-peak, only 3.2 percentage points lower than the Flexible Scheduling treatment, opted-in group and 4.6 percentage points more than the PS control group.

## Statistical Difference-in-Difference Analysis

Details of the DID approach are discussed in the Methodology. Note that the treatment groups in the DID analysis include both the opted-in and non-opted-in participants, which allowed us to take full advantage of the Randomized Encouragement Design. The magnitude of impacts shown in the figures below are thus reflective of customers with and without trial awareness. Following each figure, we incorporate the opt-in rates to calculate the actual program impact for opted-in participants.

### Flexible Scheduling (FS) group

Figure 3 shows the hourly impacts for the full FS treatment group. The blue bars represent the average hourly kW impact per vehicle, measured from the difference between the treatment and control group charging load, while the black lines on each bar indicate the error, showing the 95% confidence interval. For hours in which the error bar crosses the line  $y=0$ , the impact is not statistically significant at a 95% confidence interval. The hours in the plot are hour-starting, and midnight is centered on the x-axis

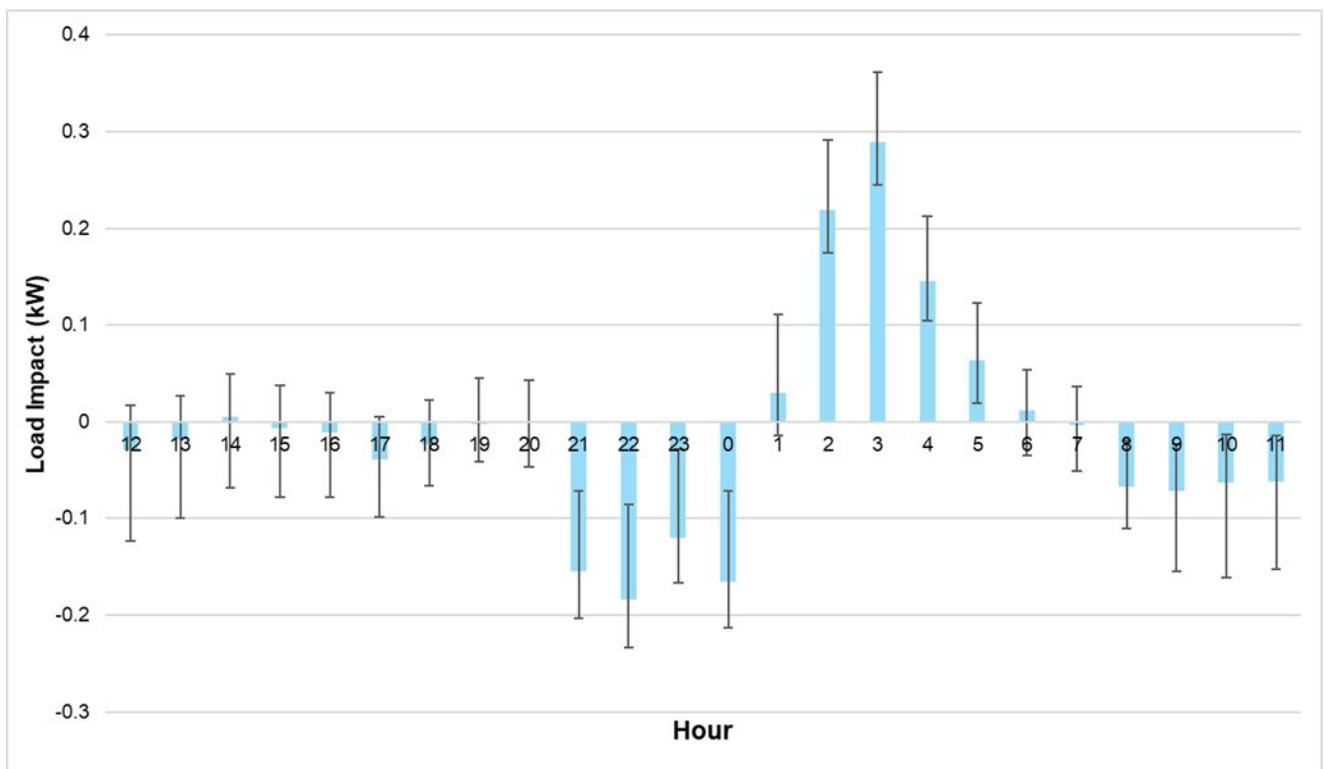


Figure 3. Flexible Scheduling (FS), difference-in-difference hourly impact

The FS trial demonstrated a statistically significant load increase of 0.15–0.29 kW per vehicle from 2 to 5 a.m. (hour-starting) and an average statistically significant load reduction of 0.15 kW per vehicle from 9 p.m. to midnight. This illustrates that the trial, encompassing both recruitment and load management, effectively reduced the charging demand for the FS group around the beginning of the off-peak period at 9 p.m.

Note that this is the combined impact of all treatment participants recruited for the program, including customers who opted in and enabled smart charging, opted in and did not enable, and those who did not opt in. Roughly one-third (34.4%) opted in to the FS trial while about 50% of those participants who opted in successfully enabled smart charging (17.9%). Per the Randomized Encouragement Design approach, we estimate the impacts for opted-in participants by dividing the hourly values in the figure by the FS opt-in rate of 34.4%. We apply the 34.4% opt-in rate adjustment here rather than the 17.9% who successfully enabled the smart charging feature because there is evidence that opting in to the intervention, even if the feature was never enabled, was associated with load shifting. The result is that the “FS Treatment, achieved” profile presented in Figure 4 likely underestimates the full effect of the enabled app. Had we adjusted with the smaller 17.9% opted-in and enabled rate, the adjusted profile would overestimate both load reduction and load increase. Load profiles include the following:

- The dotted dark green line: the average control group charging load during the trial (post) period
- The light green line: the average treatment group load for the entire group, regardless of whether participants opted in to the trial
- The solid dark green line: the average treatment charging load for the opted-in (though not necessarily enabled) 34.4% subset of the treatment group

The resulting load shapes are shown below. The x-axis “Time of Day” is hour-starting.

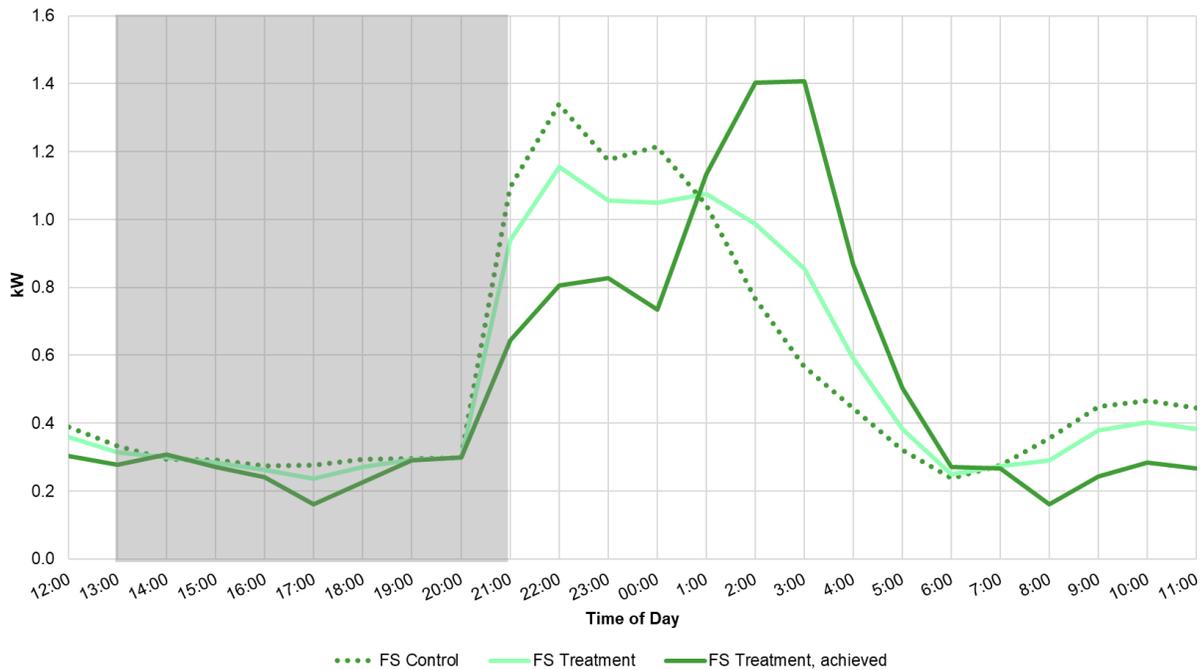


Figure 4. Flexible Scheduling: Average hourly load profile, from DID regression analysis

The “FS Treatment, achieved” load shape in Figure 4 shows the estimated behavior of all opted-in treatment participants. It represents the load that may be expected in comparison to the control group if the FS intervention were instituted in a future program, all participants opted in, and approximately 50% successfully enabled the smart charging functionality.

DNV identified the following additional takeaways based on Figure 4:

- As evidenced in the figure, the FS intervention’s use of “ready by” times to determine charging start times resulted in a substantial timer peak around 3 a.m. While the load ramps up more slowly than the control group’s peak, potential implementers should consider whether additional load shaping is required to avoid the early morning concentration of charging observed in the “FS Treatment, achieved” group’s load profile.
- FS treatment participants still show a prominent increase in load between 8 and 10 p.m. While this is partially driven by the inclusion of participants who opted in but did not enable smart charging in the “FS treatment, achieved” line, this may also be partially driven by participants disabling the smart charging feature during the trial period or overriding smart charging for a single session. Of the participants who opted in and enabled smart charging, 18% of sessions in the trial period were unmanaged or overrides. While further research would be required to explain the persistence of this 8 to 10 p.m. charging load, we hypothesize that it may also be due to one of the following:
  - Valid charging behavior resulting from FS participants’ user-provided state-of-charge and departure time preferences—if, for example, a user entered an earlier than expected departure time (midnight) or inadvertently programmed 11 p.m. instead of 11 a.m. Data on these user-provided inputs was not provided for this evaluation.
  - An effect of the active load control mechanism being unable to overcome previously programmed charging schedules or otherwise not working as effectively as expected.

### **Personal Scheduling (PS) group**

Figure 5 shows the hourly impacts for the PS group. The blue bars represent the hourly kW impact per vehicle, measured from the difference between the treatment and control group charging load, while the black lines on each bar indicate the error, showing the 95% confidence interval. For hours in which the error bar crosses the line  $y=0$ , the impact is not statistically significant at a 95% confidence interval. The hours in the plot are hour-starting, and midnight is centered on the x-axis.

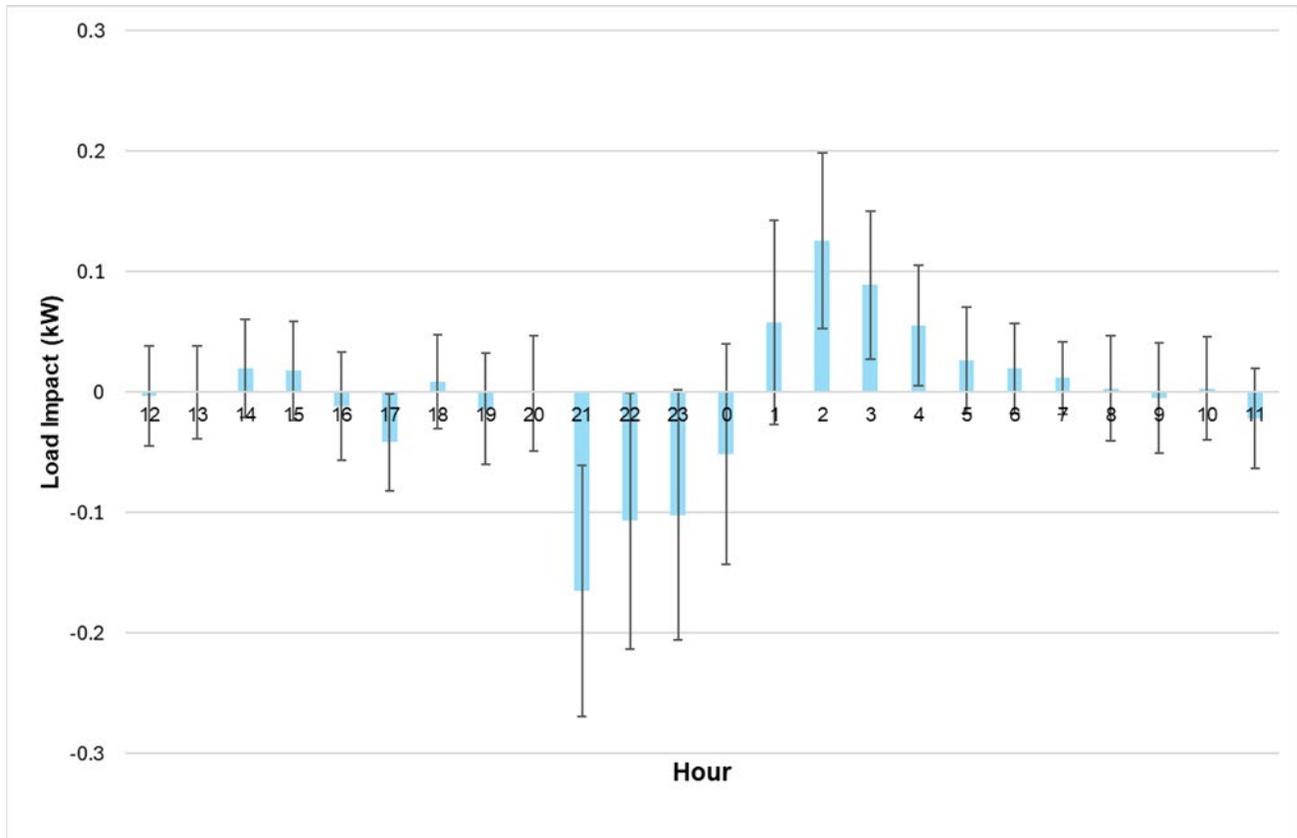


Figure 5. Personal scheduling (PS), difference-in-difference hourly impact

The PS treatment group shows a significant increase in load from 2 to 4 a.m. (hour-starting), and a significant load decrease of 0.16 kW per vehicle at 9 p.m. (hour-starting). The estimated impact at 10 p.m. is negative—indicating a load reduction—and on the threshold between statistical significance and non-significance. This result is likely influenced by the combination of the five PS treatment groups. Because this analysis includes participants from all five hour-starting groups, there are hours that experience coincident additions and subtractions of load, resulting in non-significant effects at certain hours. For example, at 10 p.m., four of the five groups were directed to delay charging, one group was instructed to start charging, and the lingering load of those who continued to charge at 9 p.m. was still present. Despite the lack of significance at certain hours, this graph clearly shows the load shift from late evening to early morning and indicates that the trial achieved its goal of mitigating the timer peak and redistributing energy use to less congested times.

The magnitude of estimated impacts shown in Figure 5 is reflective of the entire PS treatment group (including opted-in and non-opted-in participants). Per the randomized encouragement design approach, we estimate the impacts for opted-in participants by dividing the hourly values in the figure by the PS opt-in rate of 33.6%. This calculation results in the scale of impacts displayed as a load profile in Figure 6. Load profiles include the following:

- The dotted dark blue line: the average control group charging load during the trial (post) period
- The light blue line: the average treatment group load for the entire treatment group, regardless of whether participants opted into the trial
- The solid dark blue line: the average treatment charging load for the opted-in subset of the treatment group

The resulting load shapes are shown below. The x-axis “Time of Day” is hour-starting.

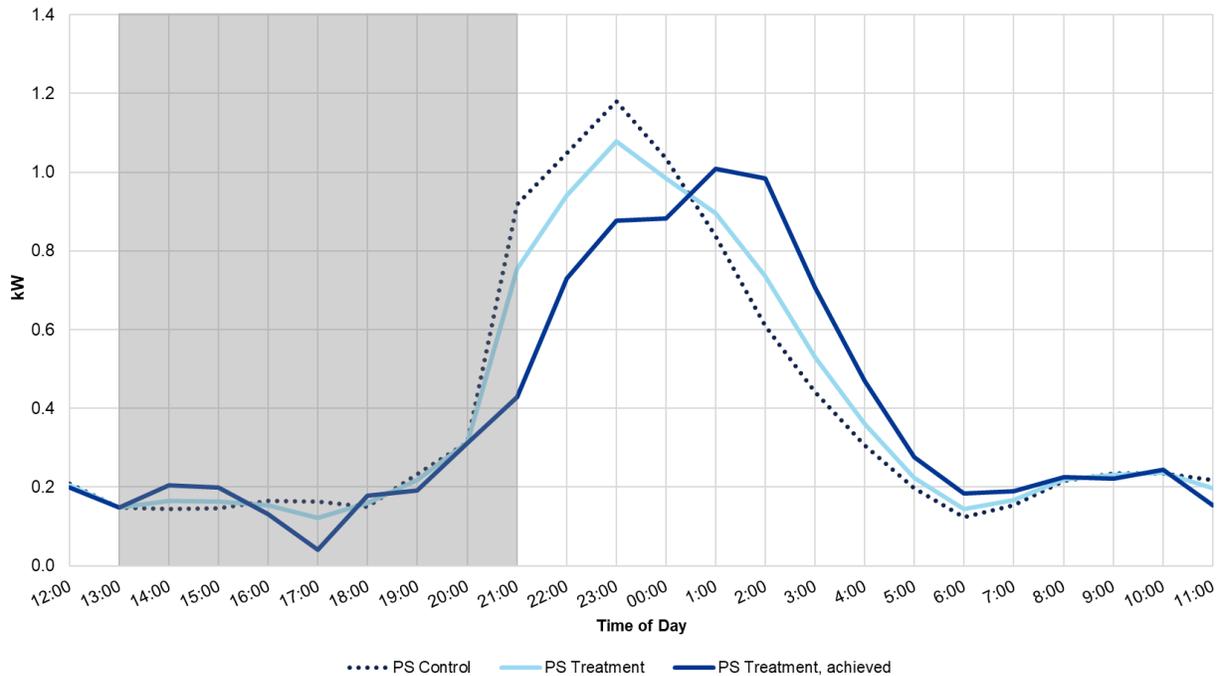


Figure 6. Personal Scheduling: Average hourly load profile, from DID regression analysis

The “PS Treatment” profile shows the load profile of all treatment group customers, those who opted in and those who did nothing. The “PS Treatment, achieved” profile adjusts the full treatment group charging profile to reflect the profile of only those who opted in. Note that the “PS Treatment, achieved” load shape represents the load that may be expected in comparison to the control group if the PS intervention were instituted in a future program with a 100% opt-in rate and comparable hour-group enrollment levels.

DNV identified the following additional takeaways based on Figure 6:

- Relative to the “PS Control” profile, the “PS treatment” profile shows a definite shift of load from the 9 p.m. – 12 a.m. period to after 1 a.m. As expected, the “PS treatment, achieved” profile makes this shift more extreme.
- There is also a clear shift in the average peak load from 11 p.m. to 1 – 2 a.m. Peak load for the “PS Treatment, achieved” shape is slightly lower than the peak load for control participants as load for the treatment group is spread out over more hours of the night.
- The average treatment group charging load ramps up more gradually than the control group’s, indicating that the trial is succeeding in delaying and staggering participants’ charging.
- Total average charging per day remains approximately equivalent between the two groups, which aligns with the trial’s objective of time-shifting charging as opposed to affecting the total amount of charging.

## Conclusions

From the evaluation activities described, DNV identified the following findings, recommendations, and research opportunities:

- **Both the PS and FS trial groups effectively mitigated the 9 p.m. timer peak and shifted charging load to the early morning hours.** Both interventions achieved statistically significant load reductions (kW/vehicle) at 9 p.m., with corresponding increases in charging load (also statistically significant) in the early morning. While the two interventions used different strategies and were targeted toward different vehicle types, both proved to be effective.
  - The PS group showed a maximum decrease of 0.49 kW per opted-in participant at 9 p.m. and a maximum increase of 0.37 kW per opted-in participant at 2 a.m.
  - The FS group showed a maximum achieved decrease of 0.53 kW per opted-in participant at 10 p.m. and a maximum achieved increase of 0.84 kW per participant at 3 a.m.
- **The PS intervention resulted in a slightly larger 9 p.m. load reduction than the FS, on a percentage point basis.** The PS group benefitted from staggered hour-start groups, which resulted in a less prominent post-intervention peak and smoother load ramps. On the other hand, the FS group, whose charging started at various times throughout the night, still exhibited a prominent peak at 3 a.m. as the accumulated load from many charging sessions converged before earlier sessions ended and load fell.
  - **In future programs, utilities should consider either intervention option given that they both performed effectively and resulted in distinct overnight charging load shapes.** Utilities may determine the preferable intervention strategy based on unique customer characteristics or grid conditions. As additional smart charging capabilities evolve and become effective across a wider swath of EVs, it may be preferable to hone in on the smart charging approach.
  - National Grid indicated that future programs may use aggregate load shaping to further optimize the overall EV population’s charging curve, smoothing out unintended overnight timer peaks that could result from many participants providing similar inputs—departure times, for example. This trial focused on the state-of-charge method, as it was simpler to implement and aligned with the trial’s current objectives.
- **The FS intervention achieved an opt-in rate of 34% and the PS trial achieved an overall opt-in rate of 32%, varying from 28% to 35% depending on the assigned hour-starting group. While both interventions achieved comparable opt-in rates, many FS participants did not successfully enable smart charging functionality through the program app.**
  - Within the PS group, opt-in rates varied by hour-starting group, indicating potential differences in participants’ willingness to delay charging to later hours of the night. The lower opt-in rates at 1 a.m. and 2 a.m. suggest that participants may be less willing to delay their charging later into the night. Additional customer research could explore this hypothesis to understand the extent to which customers are concerned about plugging in too late, along with any effects on program impact and future program design.
  - Slightly more than half (51.2%) of the opted-in FS participants recorded a smart charging session at some point during the trial. To maximize impact and minimize attrition, future programs should identify ways to streamline smart charging enablement and/or more clearly communicate the required steps to interested participants.

## References

Commonwealth of Massachusetts. May 2025. [“2024 Massachusetts Climate Report Card – Transportation Decarbonization.”](#) *Mass.gov*.

Commonwealth of Massachusetts. 2022. [“Massachusetts Clean Energy and Climate Plan for 2025 and 2030.”](#) *Mass.gov*.