Portland General Electric
121 SW Salmon Street · Portland, Ore. 97204

October 11, 2022

Via Electronic Filing

Public Utility Commission of Oregon
Attn: Filing Center
201 High Street, S.E., Suite 100
P.O. Box 1088
Salem, OR 97308-1088

Re: UM 1514 Evaluations of PGE's Energy Partner Schedule 25 Direct Load Control Pilot for the Summer 2021 and Winter 2021/2022 Seasons

Dear Filing Center:

Enclosed is Guidehouse's (formerly Navigant) evaluations of the Portland General Electric Company (PGE's) Energy Partner Schedule 25 nonresidential direct load control pilot. The evaluation provides pilot impact estimates and process recommendations for Summer 2021 and Winter 2021/22. This memo summarizes Schedule 25 evaluation outcomes from Summer 2021 and Winter 2021/22 and provides a summary of next steps for pilot evaluation.

The Summer 2021 and Winter 2021/22 evaluation reported the following:

The evaluation resulted in the following key impact and process observations:

- The pilot delivered an average total demand reduction of 390 kW in Summer 2021, and 219 kW in Winter 2021-22.
- The average curtailment per installed thermostat for the summer and winter seasons was estimated to be 0.27 kW and 0.34 kW, respectively.
- Data completeness was a challenge during the Summer 2021 analysis; 108 of 632 participants were excluded from analysis due to data completeness issues.
- Total event demand reduction is driven by the number of Participating Thermostats and the reduction achieved by those thermostats. Participating Thermostat is defined as a thermostat that participated in at least one hour of the event. Out of the 524 summer participants analyzed, there were 57 customers who had enabled thermostats but did not participate in any event hours, 414 customers who participated in the at least half of the event hours, and 197 customers who participated in every event hour.

- The Opt-Out Rate During Event stayed relatively consistent with prior years' seasons. The Summer 2021 was between 2-4%, which is slightly lower than Summer 2020. The Winter Opt-Out Rate During Event stayed consistent with prior winter seasons at 6%.
- Process-related findings indicate the following:
  - Program team must address challenges with the event notification following the Winter 2021-22 season.
  - PGE internal data teams and CLEAResult should work to optimize exchange of data on customer characteristics and status to facilitate outreach to ideal customers for participant recruitment.

Key current/next steps for PGE staff based on evaluation findings:

The evaluation findings highlighted specific issues that are currently being addressed by PGE program staff and its implementation vendor. Specifically:

- High opt-out rate of customers who did not participate in any events highlighted the need to review customer participation and thermostat connectivity. PGE's program vendor is reviewing the state of non-participating customer thermostats to verify Internet connectivity and ensure that thermostats are online and available to receive event participation signals. Review of active businesses is also underway to ensure that non-participants who are no longer on the premises are unenrolled from the pilot.
- Program staff is continuing to review association between customer Service Point IDs (SPID) and connected thermostats, and presence of customer HVAC load on the same SPID, to ensure that data associated with HVAC load is represented and measured correctly for each participating customer.
- The impact evaluation methodology is being reviewed and a methodology revision is being considered to measure energy curtailment during Peak Time Events.
  - Current methodology relies on a meter-level approach to measuring HVAC energy curtailment. Program staff has concerns that additional loads on the same meter are impacting the amount of energy curtailment being measured.
  - PGE program team is considering how to calculate HVAC system curtailment using thermostat telemetry and field observation data. Specifically, staff is reviewing methodology to calculate each participant's HVAC heating/cooling rated power values and system telemetry showing runtime in various states (heat, cool, fan, off).
- Targeted outreach to customers with ideal operating characteristics (i.e., measured HVAC capacity available to curtail load during typical Peak Time Event hours) has been initiated in Autumn 2022.

Updates to data availability and energy curtailment capacity are integral to the continued viability of the pilot. Updates to outcomes of this work will be addressed in the annual deferral filing due May 31, 2023.

These high-level findings, together with the detailed results outlined in the attached report, point to current challenges and opportunities to grow the pilot in a cost-effective manner.

If you have any questions or require further information, please contact Megan Stratman at (503) 464-2144. Please direct all formal correspondence and requests to the following e-mail address pge.opuc.filings@pgn.com.

Sincerely,

/s/ *Jaki Ferchland*
Jaki Ferchland
Manager, Revenue Requirement

JF: np
Enclosures

cc: UM 1514 Service List

Memorandum

To: Adam Gardels, Danny Grady, Portland General Electric

From: Robin Maslowski, Isabeau Hitzman, Presley Batchelor, Glory Scheel

Date: August 31, 2022

Re: PGE Energy Partner Schedule 25 Impact Evaluation – 2021-22 Season Summary

Introduction

Portland General Electric Company's (PGE's) Energy Partner demand response (DR) program offers non-residential customers the opportunity to participate in PGE's efforts to maintain the grid and lower the cost of supplying power. The goals of Guidehouse's evaluation were to estimate demand impacts for Schedule 25 customers (small commercial customers) using smart thermostats for demand response (DR) and to understand areas of program success and areas of improvement, based upon program manager interviews.

Guidehouse calculated that PGE's Energy Partner Smart Thermostat program achieved an average total demand reduction of 390 kW in Summer 2021, with relative precision of 1% at a 90% confidence interval. In Winter 2021-22, the program achieved a total demand reduction of 219 kW from Schedule 25 customers with a relative precision of 6% at a 90% confidence interval. Guidehouse also calculated the hourly level curtailment per installed thermostat which is a key input for PGE's cost benefit model for the pilot. The average curtailment per installed thermostat for the summer and winter seasons was estimated to be 0.27 kW and 0.34 kW respectively, which is sensitive to event day temperature.

This report describes the process and impact evaluation findings program over the Summer 2021 and Winter 2021-22 seasons. The report is divided into the following sections, with accompanying attachments:

- Approach and Data Sources
- Impact Evaluation
- Process Evaluation
- Recommendations
- Appendix A: Technical Approach
- Attachment 1: "PGE Sch 25 Seasons 2021-22 - Program Impact Data Tables 2022-08-29.xlsx"
- Attachment 2: "Summer 2021 Supporting Docs.zip"
  - A2a: "Summer 2021 DR Results – Event Day Plots – Event Average.pdf"
  - A2b: "Summer 2021 DR Results – Event Day Plots – by Customer.pdf"
  - A2c: "Summer 2021 Event vs Non-Event Weather Plots.pdf"
  - A2d: "Summer 2021 Event vs. Non-Event Load Profiles by Event.pdf"
  - A2e: "Summer 2021 DR Results – Event Day Plots – Event Average by Linkage.pdf"
- Attachment 3: "Winter 2021-22 Supporting Docs.zip"
  - A3a: "Winter 2021-22 DR Results – Event Day Plots – Event Average.pdf"
  - A3b: "Winter 2021-22 DR Results – Event Day Plots – by Customer.pdf"
  - A3c: "Winter 2021-22 Event vs Non-Event Weather Plots.pdf"
  - A3d: "Winter 2021-22 Event vs. Non-Event Load Profiles by Event.pdf"
- Attachment 4: "Winter Non-Event Day Selection.zip"
  - A4a: "Weighted Whole Day - Event vs Non-Event Weather Plots.pdf"
  - A4b: "Partial Day - Event vs Non-Event Weather Plots.pdf"
  - A4c: "Weighted Whole Day - Event vs Non-Event Load Profiles by Event.pdf"
  - A4d: "Partial Day - Event vs Non-Event Load Profiles by Event.pdf"

- A4e: "Model Prediction vs. Actual Non-Event Day Usage (Weighted Whole Day).pdf"
- A4f: "Model Prediction vs. Actual Non-Event Day Usage (Partial Day).pdf"

Approach and Data Sources

This section presents the data available to support the impact evaluation including the AMI interval data, weather data, cross-sectional data (i.e., total number of participating customers and number of thermostats), HVAC data, and event schedule. Guidehouse obtained the weather data from the National Oceanic and Atmospheric Administration's (NOAA) Climatic Data Center, and the remainder of the data from PGE and CLEAResult. [1]

For each season's impact evaluation, Guidehouse used participants' hourly AMI interval data, weather data, cross-sectional data, HVAC data, and event schedule (Table 1) to estimate the average counterfactual (baseline) demand per meter during the DR event. Guidehouse also employed the weather data to select event-like non-event days to include in the baseline estimation data set. The impact analysis methodology is discussed in more detail in Appendix A: Technical Approach.

Table 1 Description of Data Used for Analysis

Category	Description	Fields
Participant Interval Data	Consumption data for all program participants for whom AMI data are available for all months of the Summer 2021[2] and Winter 2021-22 seasons. The interval data ranged from quarter-hour to hourly across different service point IDs (SPID). Guidehouse calculated the hourly consumption for each SPID and used this as a basis for the regression analysis.	• Consumption (kWh) • Date • Hour ending in which the demand in that interval was observed • SPID
Weather Data	Average hourly weather data for Portland International Airport, Portland Troutdale Airport, Portland Hillsboro Airport, Minnville Municipal Airport, Aurora State Airport, Scappoose Airport and McNary Field Airport weather stations[3]	• Dry bulb temperature • Time stamp of the period ending in which the weather in that interval was observed
Participant Cross-Sectional Data	Program tracking data	• SPID • Customer name • Thermostat ID • Enablement date • Thermostat participation by event • Testbed flag

[1] Participant cross-sectional data from Summer 2021 evaluation, such as testbed assignment and business type, was used to supplement data provided for Winter 2021-22 due to delays in data delivery.

[2] AMI data was unavailable for 79 out of 634 participants for the Summer 2021 season.

[3] Obtained from NOAA's Climatic Data Center https://www.ncdc.noaa.gov/cdo-web/

Category	Description	Fields
HVAC Data	Location and HVAC details per device	• SPID • Device serial number • Address • Zip code • Business type • HVAC equipment capacity
Event Schedule	DR event schedule	• Day • Date • Event hours and time zone

Data completeness was a challenge during the Summer 2021 analysis. As of the end of Summer 2021, there were 632 participants enrolled in the summer program. There were 108 customers excluded from analysis due to data completeness issues[4], of which 79 were missing entirely from the AMI data received from PGE and the other 29 were removed due to high proportions of missing or zero reads on event and matched non-event days. This issue was resolved for the Winter 2021-22 impact evaluation, where only seven participants were excluded from analysis due to data completeness issues.

Given Schedule 25 has been undergoing a pilot redesign, Guidehouse's process evalution activities for the Winter 2021-22 season consisted of interviewing the PGE program manager on recent pilot activities and anticipated changes through the redesign. The Process Summary section summarizes the takeaways from this discussion.

Impact Evaluation

For Summer 2021, Guidehouse calculated that PGE's Energy Partner Smart Thermostat program achieved up to 502 kW of total demand reduction from Schedule 25 customers with a relative precision of 3% at a 90% confidence interval. The average impact across all events was 390 kW with relative precision of 1% at a 90% confidence interval. For Winter 2021-22, Guidehouse calculated that PGE's Energy Partner Smart Thermostat program achieved 219 kW of total demand reduction from Schedule 25 customers with a relative precision of 6% at a 90% confidence interval. Only one event was called for Winter 2021-22.

The average demand by event day, along with the calculated baseline demand, can be seen below in Figure 1. This includes all enrolled customers with AMI data covering at least 90% of the relevant season (April through September for Summer 2021 and October through March for Winter 2021-22) and at least 90% of event day hours. Guidehouse noted that average demand per customer decreased from around 13 kW during the Summer 2020 season to less than 6 kW during the Summer 2021 and Winter 2021-22 seasons. This is due to a large increase in smaller size customers in the program.

[4] Event participation rates for customers excluded from analysis followed the same general distribution as those included.

Figure 1 Summer Event Day Average Demand

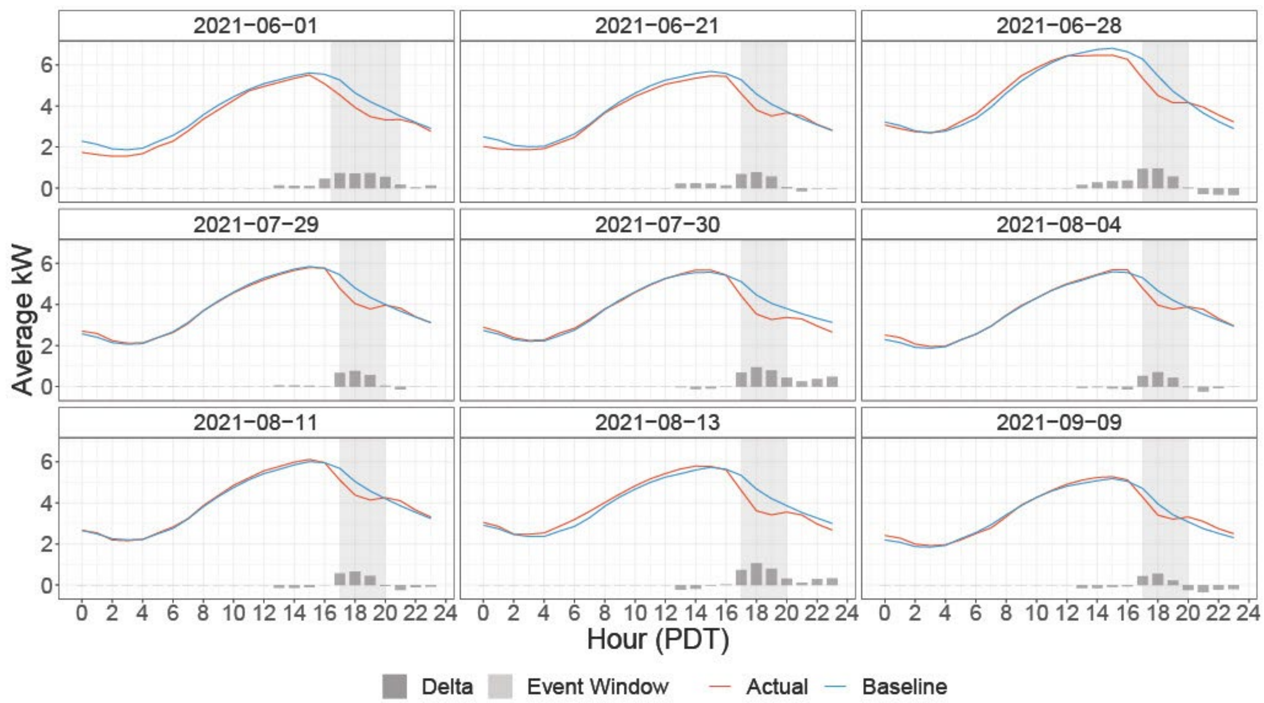
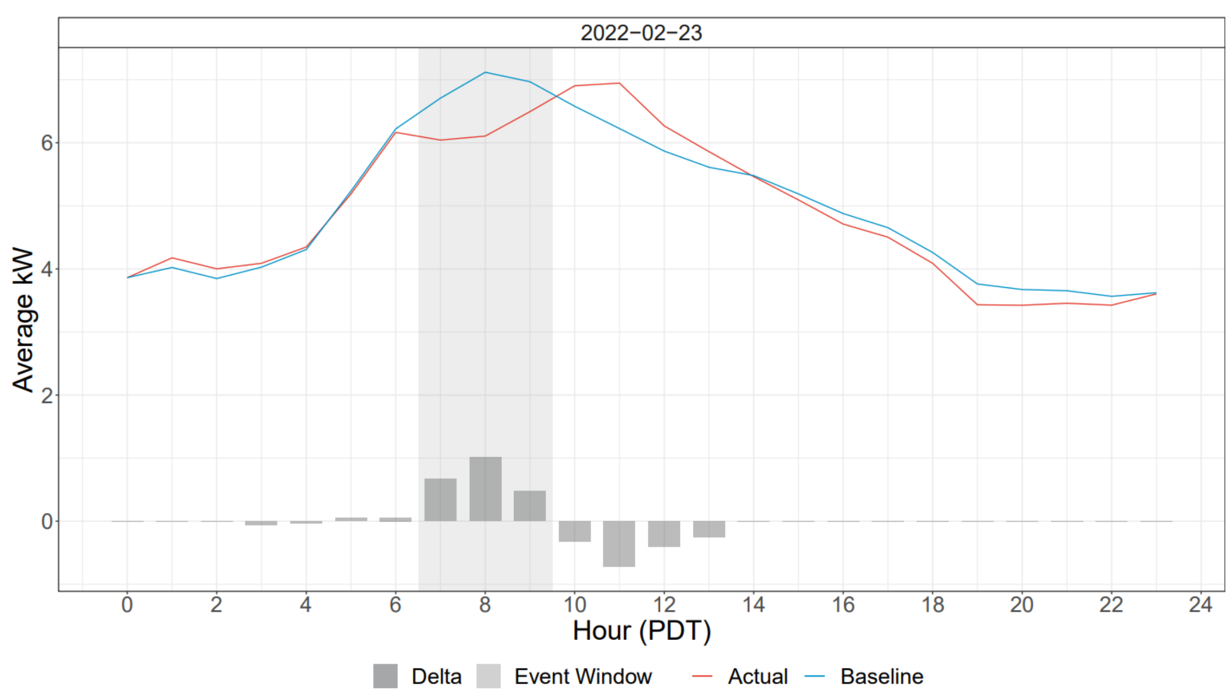


Figure 2 Winter Event Day Average Demand



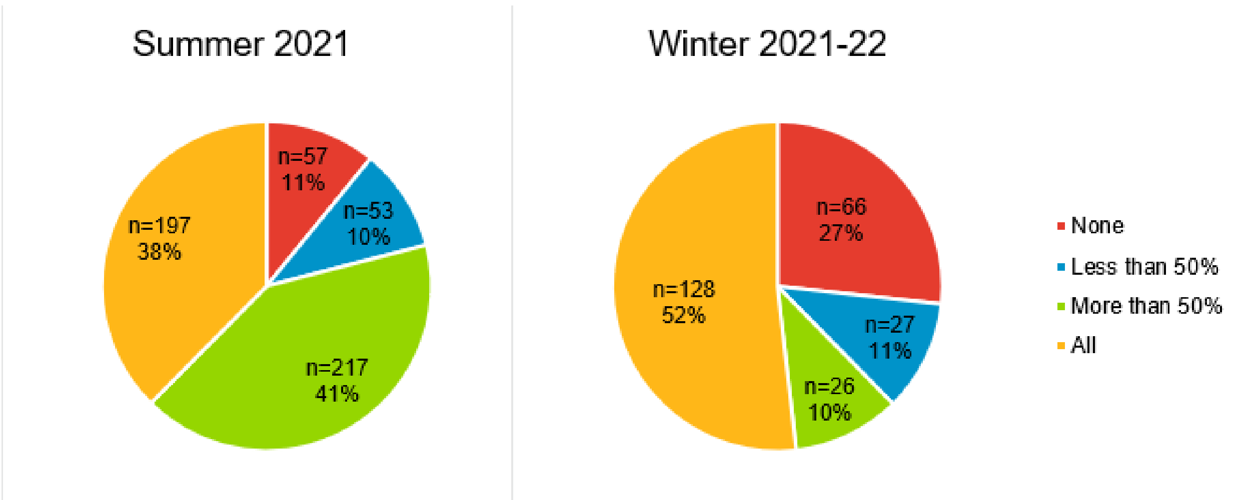
Guidehouse observed that the model results appeared to be understating baseline demand during non-event hours (and therefore, overstating impacts during event hours) for the events on June 28th, 2021 and February 23rd, 2022[5]. To ensure a more accurate estimate of impacts, Guidehouse applied an additive

[5] Plots above show the final baseline, which includes the day-of load adjustment.

day-of load adjustment and calculated ex-post impacts for these events as the difference between that adjusted baseline and actually observed demands, discussed more in Appendix A: Technical Approach.

Total event demand reduction is driven by the number of Participating Thermostats and the reduction achieved by those thermostats. Participating Thermostat is defined as a thermostat that participated in at least one hour of the event. Out of the 524 summer participants analyzed, there were 57 customers who had enabled thermostats but did not participate in any event hours, 414 customers who participated in the at least half of the event hours, and 197 customers who participated in every event hour.

Figure 3 Customer Percent Participation Across Summer 2021 Event Hours



The Winter 2021-22 season had a higher percentage of customers who participated in every event hour (51% versus 38%), but also had a higher percentage of customers who participated in no event hours (25% versus 11%). Out of the 247 winter participants analyzed, there were 66 customers who had enabled thermostats but did not participate in any event hours, 154 customers who participated in the at least half of the event hours, and 128 customers who participated in every event hour.

Table 2 shows number of participating thermostats by event and opt-out rates. This table highlights that:

- Opt-Out Rate Prior to Event has been increasing over the last few seasons.
    - The Summer 2021 Opt-Out Rate Prior to Event was 20-29%, which is about 10 percentage points higher than the Summer 2020 Opt-Out Rate Prior to Event.
    - The Opt-Out Rate Prior to Event was 33% during the Winter 2021-22 season, which is about 5-10 percentage points higher than the Summer 2021 Opt-Out Rate Prior to Event and almost 20 percentage points higher than the Summer 2020 rates.
- The Opt-Out Rate During Event stayed relatively consistent with prior years seasons. The Summer 2021 was between 2-4%, which is slightly lower than Summer 2020. The Winter Opt-Out Rate During Event stayed consistent with prior winter seasons at 6%.

Table 2: Participating Thermostats by Event

Event	Count of Non-Enabled Thermostats	Number of Enabled Thermostats				Opt-Out Rate Prior to Event	Opt-Out Rate During Event	Total Opt-Out Rate
		Did Not Participate	Partially Participated	Fully Participated	Total			
			Summer 2021					
2021-06-01	158	454	40	1,066	1,560	29%	2%	**31%**
2021-06-21	113	354	45	1,167	1,566	23%	3%	**25%**
2021-06-28	109	346	59	1,161	1,566	22%	4%	**26%**
2021-07-29	105	336	50	1,180	1,566	21%	3%	**25%**

2021-07-30	101	330	34	1,202	1,566	21%	2%	**23%**
2021-08-04	94	320	59	1,187	1,566	20%	4%	**24%**
2021-08-11	94	399	50	1,116	1,565	25%	3%	**29%**
2021-08-13	74	309	50	1,207	1,566	20%	3%	**23%**
2021-09-09	74	452	33	1,081	1,566	29%	2%	**31%**
Average[6]	**102**	**367**	**47**	**1,152**	**1,565**	**23%**	**3%**	**26%**
				Winter 2021-22				
2022-02-23	0	214	41	385	640	33%	6%	**40%**
Average	**0**	**214**	**41**	**385**	**640**	**33%**	**6%**	**40%**

The impacts of all events that occurred during the Summer 2021 and Winter 2021-22 seasons are summarized below in Table 3, along with the number of participating customers, number of participating thermostats, number of enabled thermostats, average impact per customer, average impact per thermostat, and relative precision at 90% confidence interval. The program total impact denotes the sum of the average impact per event for all customers that demonstrated a reduction. Each customer's average impact per event is the average demand curtailed across each hour of the event.

Table 3 Event Impact Summary

Event Date	Program Total Impact (kW)	Number of Customers	Number of Participating Thermostats	Number of Installed Thermostats[7]	Average Impact per Participating Customer (kW)	Average Impact per Participating Thermostat (kW)	Average Impact per Installed Thermostat (kW)	Relative Precision at 90% CI
				Summer 2021				
2021-06-01	373	330	1,081	1,402	1.13	0.34	0.27	3%
2021-06-21	382	337	1,187	1,453	1.13	0.32	0.26	4%
2021-06-28	461	319	1,188	1,457	1.45	0.39	0.32	4%
2021-07-29	394	328	1,206	1,461	1.20	0.33	0.27	4%
2021-07-30	467	333	1,219	1,465	1.40	0.38	0.32	3%
2021-08-04	330	345	1,219	1,472	0.96	0.27	0.22	4%
2021-08-11	336	299	1,137	1,472	1.13	0.30	0.23	5%
2021-08-13	502	332	1,228	1,492	1.51	0.41	0.34	3%
2021-09-09	267	280	1,096	1,492	0.95	0.24	0.18	5%
Average[8]	**390**	**323**	**1,173**	**1,463**	**1.21**	**0.33**	**0.27**	**1%**
				Winter 2021-22				
2022-02-23	219	139	401	640	1.58	0.55	0.34	6%
Average	**219**	**139**	**401**	**640**	**1.58**	**0.55**	**0.34**	**6%**

Some insights about Summer 2021 from Table 3 above include the following:

- The average impact per participating thermostat is 0.33 kW and the average impact per installed thermostat is 0.27 kW. The average impact per participating customer is 1.21 kW.
- The average impact per participating thermostat is around 50% lower compared with the Summer 2020 analysis, due to the increase in smaller sized customers.

[6] Simple average across events

[7] The number of installed thermostats was calculated using the enablement dates provided to Guidehouse by PGE. This was done in place of actual installation date information which was unavailable.

[8] Simple average across events

- The relative precisions are lower compared with the Summer 2020 analysis, due to the large increase in customers enrolled in the program.
- The event with the highest impact (on August 13) corresponded to the highest number of installed thermostats in an event and the highest impact per installed thermostat.
- The event with the highest event temperature (June 28) still had a participation rate consistent with other events, and the second highest impact per installed thermostat.

Some insights about Winter 2021-22 from Table 3 above include the following:

- The average impact per participating thermostat is 0.55 kW and the average impact per installed thermostat is 0.34 kW. The average impact per participating customer is 1.58 kW.
- The average impact per participating thermostat is around 90% higher compared with the Winter 2020-21 analysis.

Additionally, in Summer 2021 forty-six of the customers enrolled in the program are located within the PGE DR testbed. On average, they delivered 0.39 kW per installed thermostat which is slightly more than the overall group average. Due to the small sample size of the testbed population within the wider group, this number is subject to differences between the individuals such as conditioned square footage, business type, selection biases, and random error. The sample size of the testbed population for the Winter 2021-22 evaluation was too small to draw meaningful insights.

It should be noted that many small commercial customers' business operations were likely affected by the COVID-19 pandemic during both seasons. The loadshapes from these seasons do not exhibit behavior atypical of small commercial customers and Guidehouse did not identify any obvious effect of COVID-19 on participant impacts; however, since the vast majority of customers have been evaluated during COVID-19 affected seasons, it is difficult to say with certainty that the participants' impacts were not affected by COVID-19 in either season.

Table 4 below summarizes the average impacts based on HVAC cooling capacity (Summer 2021). This table highlights that the majority of customers have less than 10 tons of cooling capacity and deliver less DR per customer. At the same time, these customers generally have a higher average impact per installed thermostat relative to customers with greater cooling capacity.

Table 4 Summer 2021 Event Impacts by Cooling Capacity[9]

HVAC Cooling Capacity (tons)	Program Total Impact (kW)	Number of Customers	Number of Installed Thermostats	Average Impact per Customer (kW)	Average Impact per Installed Thermostat (kW)
0 - <10	243.5	364	685	0.67	0.36
10 - <20	84.7	92	301	0.92	0.28
20 - <30	34.5	29	168	1.19	0.21
30 - <40	18.5	12	96	1.54	0.19
40 - <50	17.0	9	89	1.89	0.19
50 - <60	8.8	3	26	2.92	0.34
60 - <70	6.4	3	33	2.14	0.19
70 - <80	0.9	1	13	0.89	0.07
80 - <90	4.7	1	11	4.70	0.43
90 - <100	3.7	1	25	3.66	0.15
100 - <110	39.7	1	7	39.69	5.67
110 - <120	7.9	1	12	7.91	0.66
120 - <130	7.0	1	23	7.04	0.31
130 - <140	9.1	1	9	9.11	1.01
140 - <150	19.7	2	22	9.83	0.89
150 - <160	0.0	0	0	N/A	N/A
160 - <170	0.0	0	0	N/A	N/A
170 - <180	0.0	0	0	N/A	N/A
180 - <190	13.7	1	15	13.67	0.91
190 - <200	0.0	0	0	N/A	N/A
200 - <210	0.0	0	0	N/A	N/A
210 - <220	0.0	0	0	N/A	N/A
220 - <230	25.4	2	31	12.71	0.82

Table 5 below summarizes the average impacts based on HVAC heating capacity (Winter 2021-22). This table highlights that the majority of customers have unknown heating capacity. Out of those with known heating capacity, most had heating capacity between 10 and 20 tons, and these customers delivered the most DR. Customers with smaller heating capacity delivered more DR per thermostat than larger customers, which is consistent with previous evaluations.

[9] HVAC cooling capacity represents the total cooling capacity controlled by thermostats for a given customer.

Table 5 Winter 2021-22 Event Impacts by Heating Capacity[10]

HVAC Heating Capacity (tons)	Program Total Impact (kW)	Number of Customers	Number of Installed Thermostats	Average Impact per Customer (kW)	Average Impact per Installed Thermostat (kW)
Unknown	95.9	107	221	0.90	0.43
0 - <5	27.7	43	43	0.65	0.65
5 - <10	5.0	16	19	0.31	0.27
10 - <20	49.5	44	96	1.13	0.52
20 - <30	8.0	8	19	0.99	0.42
30 - <40	0.9	2	7	0.44	0.13
40 - <50	4.3	3	17	1.42	0.25
50 - <60	3.4	4	16	0.85	0.21
60 - <70	2.9	4	18	0.73	0.16
70 - <80	0.0	1	5	0.00	0.00
80 - <90	0.0	0	0	-	-
90 - <100	0.0	0	0	-	-
100 - <110	0.0	1	5	0.00	0.00
110 - <120	0.7	2	12	0.35	0.06
120 - <130	0.0	0	0	-	-
130 - <140	1.5	1	9	1.49	0.17
140 - <150	0.0	0	0	-	-
150 - <160	0.0	1	7	0.00	0.00
160 - <170	0.7	1	8	0.72	0.09
170 - <180	0.0	0	0	-	-
180 - <190	0.0	0	0	-	-
190 - <200	0.0	0	0	-	-
>200	18.5	9	138	2.06	0.13

For Winter 2021-22, Guidehouse conducted an analysis by business type. Table 6 below summarizes the average impacts based on business type. The majority of thermostats and impacts are designated as schools. The highest average per thermostat impacts are the Unknown category or groups with very small sample sizes.

[10] HVAC heating capacity represents the total heating capacity controlled by thermostats for a given customer.

Table 6 Winter 2021-22 Event Impacts by Business Type

Business Type	Program Total Impact (kW)	Number of Participating Thermostats	Number of Installed Thermostats	Average Impact per Participating Thermostat (kW)	Average Impact per Installed Thermostat (kW)
24 Hr/Hotel	-	2	3	-	-
Food Service	15.3	18	23	0.87	0.67
Grocery (not c-store)	4.2	2	2	2.08	2.08
Hospitality	5.1	12	16	0.43	0.32
Logistics	-	-	2	-	-
Medium Office	16.8	51	134	0.33	0.13
Medium Retail	0.0	2	10	0.01	0.00
Municipality/Civic	1.5	1	1	1.46	1.46
School	87.0	163	232	0.53	0.38
Small Office	26.9	36	50	0.75	0.54
Small Retail	13.8	22	36	0.63	0.38
Other	21.2	80	109	0.27	0.19
Unknown	27.2	13	22	2.14	1.23

Process Evaluation

As Schedule 25 has been undergoing a pilot redesign, Guidehouse's process evalution activities for the Winter 2021-22 season consisted of interviewing the PGE program manager on recent pilot activities and anticipated changes through the redesign[11].

Overall, after significant discussion about whether to continue or cancel Schedule 25, the OPUC approved a redesign including a number of changes to help the pilot reach a more cost-effective state. As of June 1, the program has been extended for 3 years (until 2025) and is approved to enroll and call up to 7,000 thermostats. As part of this redesign, PGE also renegotiated the contract for CLEAResult.

The program redesign included a significant shift in the incentive structure – from offering to $60 per thermostat, to now offering $60 per site. This change has impacted large sites up to thousands of dollars, requiring direct outreach by the PGE program manager and CLEAResult to share with customers and understand reactions. As of the time of this writing, none of the participants have indicated that they plan to unenroll in the program based on the changes.

The recruitment process for Schedule 25 was also paused while the PGE team conducted internal research on how to identify the "ideal customer" and streamline the costs of marketing and recruitment. Going forward, the pilot will focus on targeted outreach through PGE's marketing manager and Energy Efficiency Outreach team. CLEAResult has the option to supplement these efforts if PGE's team falls below targets. Additionally, PGE is adding a trade ally referral channel incrementally to PGE's Energy Efficiency Outreach team, in which trade allies are paid an incentive for referring customers to the pilot.

One ongoing challenge is the transition from the Apricity notification system to Enbala's Concerto Notification System (CNS). There were issues with the system over the Winter 2021-22 season related to the 4G to 5G transition. Early indicators from the Summer 2022 season are that these challenges persist and will need to be addressed as a key technology-related pilot focus.

Looking forward, the pilot team will be focused on testing the new pilot design and its cost effectiveness and expanding to new customers, while also exploring adding Honeywell thermostats to the enabled

[11] Guidehouse did not conduct any process evaluation for the Summer 2021 season.

device list, continuing to refine its partnerships with trade allies, and addressing challenges with the CNS notification system.

Conclusions and Recommendations

As PGE moves forward with the redesigned pilot, PGE will need to assess the actual cost effectiveness of Schedule 25 relative to expected cost effectiveness and continue refining understanding of the pilot's impacts. Based on the results of the impact evaluations, Guidehouse recommends the following for PGE's and CLEAResult's consideration:

- Summer 2021 impacts for 79 customers could not be calculated due to missing interval data, and over half of these customers qualified for the program incentive based on event participation. Guidehouse recommends ensuring adequate interval data availability for all customers enrolled in the pilot, especially those who qualified for incentives.
- The percentage of thermostats opting out prior to events has been increasing over the last several seasons. The Winter 2021-22 season showed an all time high of around 30%. Guidehouse recommends further exploration into chronically inactive participants to re-evaluate their participation status and understand factors driving chronic opt-outs. Understanding why customers opt-out could help focus program recruitment efforts on sites more likely to have high participation rates or inform adjustments to program characteristics to minimize opt-outs.
- Guidehouse recommends tracking enrollment and installation dates in addition to enablement dates, as well as incorporating thermostat dispatch and telemetry data to be able to better analyze opt-out rates and device responsiveness.
- While the Summer 2021 evaluation suggests that customers with greater HVAC cooling capacity deliver less DR per thermostat, these customers can deliver more DR per customer and may have a lower installation cost per thermostat, if economies of scale are possible when installing multiple thermostats on a single customer site. That said, customers with lower HVAC cooling capacity have comprised a larger portion of newly enrolled customers over the past year. These customers tend to deliver more DR per thermostat but less DR per customer. As PGE considers the cost effectiveness of the pilot, Guidehouse recommends considering these dynamics in the pilot's customer targeting and incentive design efforts.
- The Winter 2021-22 analysis broke down impacts by HVAC heating capacity and business type, however a majority of customers did not have this data. Guidehouse recommends PGE collect more complete customer information on enrolled customers. Additional information such as business type and heating capacity will provide a clearer picture of how these metrics relate to impacts, and this information can be helpful in managing the program as a whole.
- Finally, while this analysis did not identify obvious effects of COVID-19 on participant impacts as discussed in Approach and Data Sources, Guidehouse recommends revisiting the impact results in comparison to future seasons not affected by the COVID-19 pandemic.

Additionally, Guidehouse notes the following process-related findings for PGE's and CLEAResult's consideration:

- Work with Generac to address the challenges with CNS for customer notifications.
- PGE has not seen impacts on pilot participation due to the new incentive structure at the time of this report. Guidehouse recommends monitoring for possible impacts through future evaluation activities, including surveying existing customers about their satisfaction with the pilot's new incentives, monitoring participation and overrides, and monitoring customer recruitment efficacy, including gathering feedback from the Customer Business Outreach Team.
- Work with the PGE internal teams and CLEAResult to optimize exchange of up-to-date data on customer characteristics and status to facilitate outreach to ideal customers for participant recruitment.
- Continue to have open and proactive conversations with the OPUC as the pilot continues to refine its impact models and overall cost-effectiveness.

Appendix A: Technical Approach

This section describes the five main steps in Guidehouse's approach for impact evaluation of PGE's Energy Partner Smart Thermostat Program.

1. Non-Event Days Selection
2. Regression Model Specification
3. Unadjusted Baseline Prediction
4. Day-of Load Adjustment Calculation
5. Estimation of Impacts and Uncertainty

1. Non-Event Days Selection

The goal of selecting matched non-event days for within-subjects regression is to improve the accuracy of the counterfactual (baseline) by feeding the model information about usage on similar days. The relationship between usage and weather varies widely, especially for medium and small businesses. Consequently, it is often necessary to adjust aspects of weather incorporation to best suit the situation. One adjustment we make is to the criteria used to select the matched non-event days. Below are some common non-event selection criteria.

- **Whole day:** Find non-event days with smallest differences in hourly usage across the entire day.
- **Weighted whole day:** Find non-event days with smallest differences in hourly usage across the entire day, giving event hours additional weight in the calculation.
- **Partial day:** Find non-event day with smallest differences in hourly usage across a subset of hours, usually event periods.

For each event day, three non-event days were selected based on the proximity of hourly temperature observations to the event day's hourly temperature observations. In previous evaluation seasons and the Summer 2021 evaluation, event hours were given three-times the weight of non-event hours in selecting the closest match. For the Winter 2021-22 season, match comparisons showed larger differences than usual in usage and temperature during event period. This prompted an exploration of the relative performance of the alternative approaches for this program evaluation[12].

Three selection approaches based on the above descriptions were compared in several ways. First, Guidehouse compared hourly temperature and usage between event days and selected non-event days. Then, to assess baseline prediction accuracy, predicted usage on non-event days from the regression model output was compared to actual usage on non-event days. Attachment 3 contains the comparisons discussed below.

Based on analysis results, Guidehouse implemented a partial day approach using the event period and surrounding hours (5AM to 11AM). The partial day approach showed smaller differences in hourly temperature during the event period, and larger differences during the afternoon peak period. The partial day approach also resulted in non-event day hourly demand more consistent with event day demand, both in demand curve shape and overall difference in usage. Additionally, there was significant variation in the non-event day demand curves when using the weighted whole day approach. Finally, when comparing the predicted non-event day usage from the model to actual non-event day usage, the partial day approach resulted in smaller differences, especially during event hours

The decrease in performance of the previous methodology as compared to the partial day approach makes sense when contextualized with temperature to usage relationships. The findings are consistent

[12] Exploratory analysis was only conducted for Winter 2021-22. A discussion of why Summer 2021 was not revisited can be found in subsequent paragraphs.

with the idea that post-event temperature is less important than lagged or same hour temperature in predicting usage. In the Winter 2021-22 season, there was only one event, which occurred from 7am to 10am, and the majority of event day hours occur after the event has concluded. Temperature during these later hours a less important predictor of usage hourly compared to temperature during or directly before the event. This is especially significant when compared to Summer events, where including all hours preceding the event helps account for factors such as heat build up.

Holidays and weekends were excluded from the pool of non-event days from which the event-like non-event days were selected. Table 5 shows the list of Oregon statutory holidays excluded for the non-event day selection.

Table 7 Oregon Statutory Holidays in 2021-22 Season

Day	Holiday Date	Holiday
Monday	2021-05-31	Memorial Day
Monday	2021-07-05	Independence Day
Monday	2021-09-06	Labor Day
Thursday	2021-11-25	Thanksgiving
Friday	2021-11-26	Day after Thanksgiving
Friday	2021-12-24	Christmas Day
Friday	2021-12-31	New Years Eve

Across the ten events, unique non-event days were selected for each weather station included in the regression. Attachment 1 (Tabs: Summer Non-Event Days and Winter Non-Event Days) contains a detailed table summarizing the temperatures of selected non-event days and their rank for each weather station. Attachment 2c and Attachment 3c contain temperature comparisons between each event day, their 5 closest matched weather days, and the hottest matched weather day for Summer 2021 and Winter 2021-22 respectively.

2. <u>Regression Model Specification</u>

Guidehouse estimated baselines using an individual regression analysis applied to AMI data for each service point. This is refered to as a “within subject” approach, as opposed to matching program participants to non-participants with similar loadshapes. Using a within subject regression is recommended for small business customers due to the highly variable loadshapes from customer to customer. Matching program participants to non-participants is ill-suited for customers with unique loadshapes and behavior, and introduces selection biases. Upon examining the customer baseline graphs, Guidehouse determined that the within subject approach performed well for this program.

The regression controlled for the following variables:

1) **Weather Effects:** These capture the effect of temperature on the estimated baseline.
2) **Calendar Effects:** These account for the hour of the day.
3) **Program Effects:** These include the demand response impact of curtailment during the event, and increased demand after the event, referred to as snapback.

Equation 1 below shows the regression equation estimated separately for each service point (meter).

Equation 1.

$$y_t = \sum_{h=1}^{H=24} \beta_h hour_{h,t} + \sum_{h=1}^{H=24} \beta_h hour_{h,t} ema4\_cdh_t + \sum_{c=1}^{C=6} \gamma_c c_{c,t} + \sum_{s=1}^{S=16} \gamma_s sb_{s,t} + \varepsilon_t$$

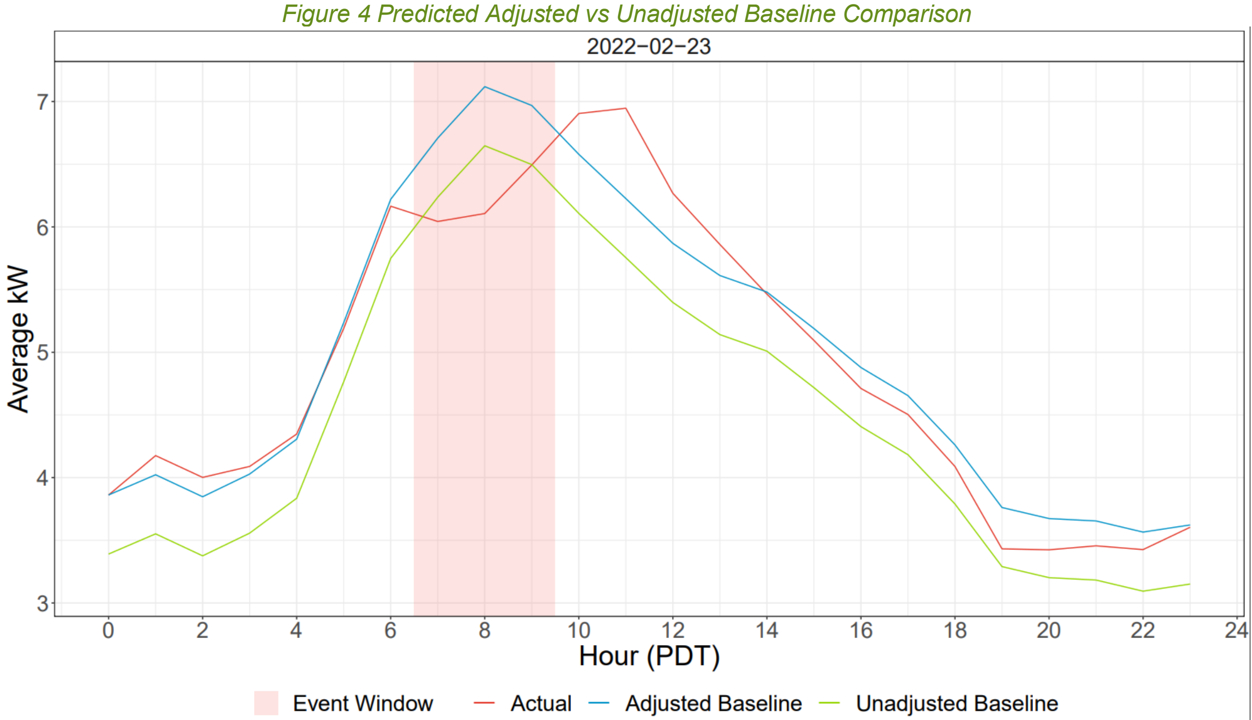
Definition of variables:

1. y_t = Is the dependent variable estimating impact by meter at period *t*.
2. $hour_{h,t}$ = Is a set of 24 dummy variables flagging each hour of the day. Each one is equal to one when hour *t* is in the *h*-th hour of the day, and zero otherwise.
3. $ema4\_cdh_t$ = Is the four-hour exponential moving average of cooling degree hours observed at period *t*. An exponential moving average is used instead of a simple contemporaneous observation of temperature to allow for the fact that sudden drops in temperature (due to, e.g., a thunderstorm) do not have an immediate effect on building thermal load.
4. $c_{c,t}$ = A set of dummy variables to capture the DR event hourly periods. Each variable is equal to one when hour *t* is the *c*-th DR hour observed in the period.
5. $sb_{s,t}$ = A set of dummy variables to capture the snapback impacts in the four-hour period immediately following the end of each event. Each variable is equal to one when hour *t* is the *s*-th hour of snapback assumed in the period.
6. ε_t = Errors.

Important note: the estimated parameters associated with the program effects dummy variables deliver an estimated impact equivalent to the difference between the unadjusted baseline and actual demand. These values are not directly used in the estimation of the impacts (estimated as the difference between the adjusted baseline and the actual demand) but are estimated in order to deliver the standard errors which (when appropriately adjusted using the day-of adjustment) are used to provide the estimated uncertainty associated with the impacts.

For most events, Guidehouse's used the estimated program effects parameters resulting from the regression analysis to calculate estimated impacts directly. However, upon examining the preliminary results derived directly from the program effect dummy variable parameter estimates, Guidehouse observed that the model results appeared to be understating baseline demand during non-event hours (and therefore, overstating impacts) for two event days, June 28th, 2021 and February 23rd, 2022. To ensure a more accurate estimate of impacts, Guidehouse applied an additive day-of load adjustment and calculated ex-post impacts as the difference between that adjusted baseline and actually observed demand. Figure 4 demonstrates how the day-of adjustment changes the baseline, by comparison of actual usage, the unadjusted baseline, and the adjusted baseline on the February 23rd.

Figure 4 Predicted Adjusted vs Unadjusted Baseline Comparison



Standard errors were estimated using the coefficient covariance matrix, as discussed in Estimation of Impacts and Uncertainty.

3. <u>Unadjusted Baseline Prediction</u>

To estimate the unadjusted baseline, Guidehouse used predicted values, actual demand, and residuals and curtailment and snapback estimated impact parameters from the regression analysis (Equation 2 and Equation 3).

Equation 2.

$$\hat{y}_{i,t} = Actual\ Demand_{i,t} - e_{i,t}$$

Where "$\hat{y}_{i,t}$" is the predicted value and $e_{i,t}$ is the residual.

Equation 3.

$$Unadjusted\ Baseline\ _{i,t} = \hat{y}_{i,t} - (estimated\ impact\ parameters)_{i,t}$$

4. <u>Day-of Load Adjustment Calculation</u>

Guidehouse applied a day-of load adjustment to fine-tune program impacts and address effects that are not other wholly captures by the regression analysis. An additive adjustment comparing the unadjusted baseline to actual demand during the 4-hour interval preceding the start of the event was calculated as per Equation 4 and Equation 5

Equation 4.

$$Day - of\ Load\ Additive\ Adjustment = Unadjusted\ Baseline\ - Actual\ Demand$$

The day-of load adjustment was applied to the hourly baseline estimation resulting from the regression model as per Equation 5.

Equation 5.

$$Adjusted\ Baseline = Unadjusted\ Baseline + Day - of\ Load\ Additive\ Adjustment$$

The day-of load adjustment can increase or decrease the estimated program impact estimation on the load profiles in the hours preceding the event. Attachment 1 contains details on the additive adjustments applied to the unadjusted baseline and impacts for each event by customer.

5. Estimation of Impacts and Uncertainty

Using a day-of load adjustment means that the estimated impact resulting from the regression analysis cannot be used. Guidehouse calculated the adjusted impacts by taking the difference between the adjusted baseline and the actual demand (Equation 6).

Equation 6.

$$Adjusted\ Impact\ = Adjusted\ Baseline - Actual\ Demand$$

The regression-estimated standard errors are on a per service point (meter) basis. Guidehouse used the estimated treatment dummy parameter standard errors from the regression analysis to estimate the standard errors associated with the impact on a per customer and per event basis. When doing this calculation, each customer’s meters were assumed to be independent of one another. The day-ofload adjustment was treated as a constant for the purposes of estimating standard errors.