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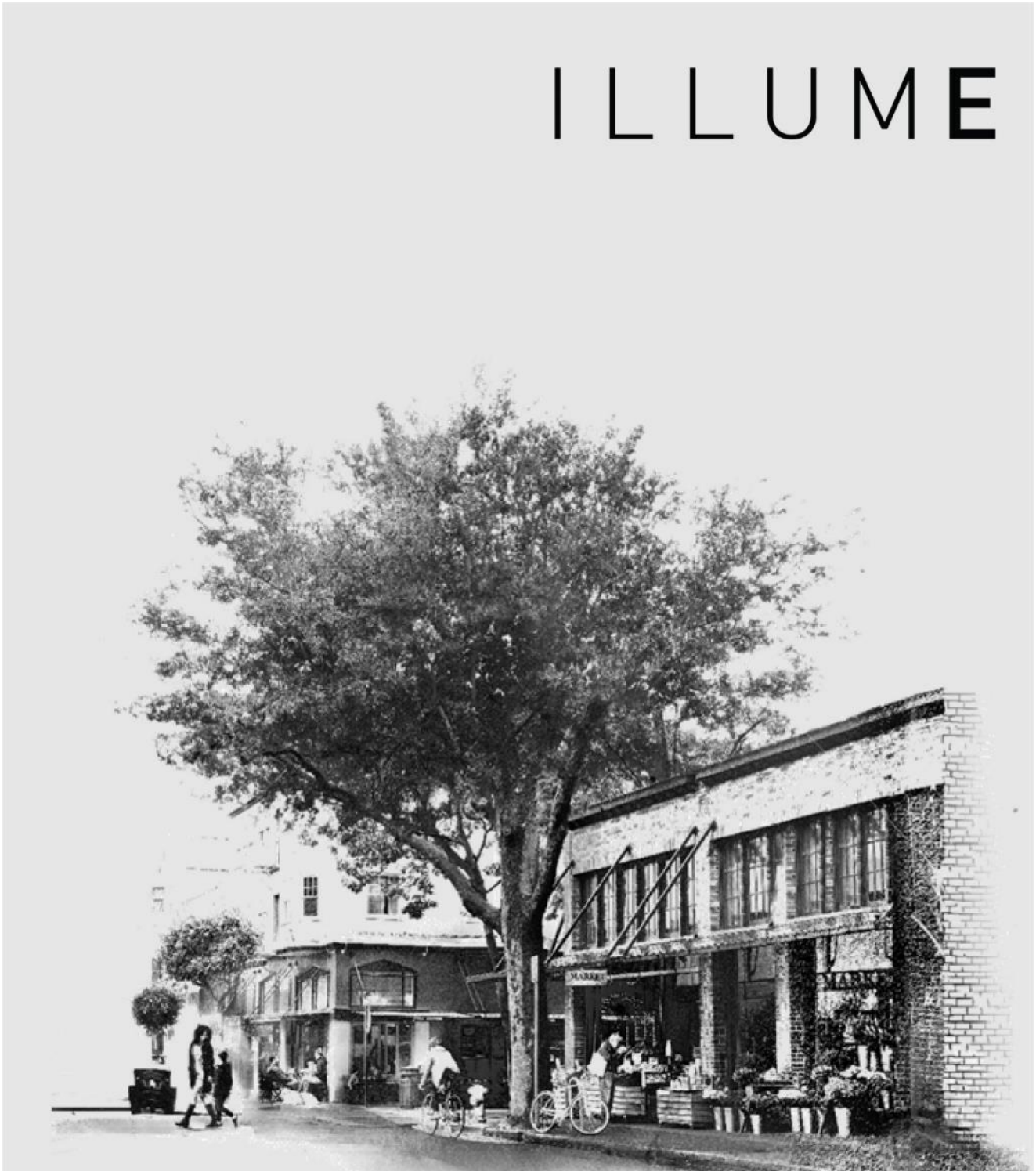

PROJECT:

Water Heater Demand Response Pilot

Final Evaluation Report

PROJECT SPONSOR:

Georgia Power Company

ACKNOWLEDGMENTS

ILLUME Advising, LLC is a forward-thinking consulting company at the rare intersection of insight and execution. Founded in 2013, the company has quickly grown to include a deep bench of quantitative and qualitative research experts. ILLUME uses cutting edge research strategies to help build a resilient energy ecosystem to enrich lives, improve global health, and ensure a more secure and sustainable future.

For this effort, we would like to acknowledge, first and foremost, Jeff Smith and Eric Arnold. We would also like to acknowledge the Water Heater Demand Pilot program manager, Audrey Ewen, and the ILLUME team members Shannon Kahl, Pace Goodman, Jes Rivas, and Eileen Hannigan.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION

In 2018, Georgia Power launched the Grid-Interactive Water Heater Demand Response (WHDR) Pilot to assess the magnitude of demand impacts and energy savings from a water heater-based demand response (DR) program. The pilot tested DR events in both winter and summer.

Georgia Power contracted with ILLUME Advising, LLC (henceforth, "ILLUME", "we" or "our team") to provide evaluation, measurement, and verification (EM&V) of the pilot. ILLUME also evaluated program processes and gathered customer feedback on experiences and satisfaction with the pilot. We present our findings from the evaluation in this report.

PILOT OBJECTIVES

Georgia Power recruited 100 residential customers[1] into its WHDR Pilot. The pilot installed 70 heat pump water heaters (HPWHs) and 30 electric resistance water heaters in the homes of participants.

The overall objectives of the pilot were to (1) quantify demand (kW) and energy (kWh) impacts attributable to water heater DR events (a minimum of eight, four in winter and four in summer); (2) estimate energy savings achieved by new water heaters; (3) assess customer experiences with water heater DR events; (4) understand customers' experiences with HPWHs; and (5) identify recommended approaches for recruitment , program delivery, metrics, and data tracking for future water heater DR program evaluability.

RESEARCH QUESTIONS

The evaluation team developed a list of key research questions with input from Georgia Power and Public Service Commission staff. Table 1 summarizes these questions by research topic area. The full list of research questions can be found in *Section 2.1 Research Questions*.

[1] 83 of the customers are Georgia Power employees and the remaining 17 are friends and family of Georgia Power employees.

TABLE 1. RESEARCH TOPICS AND EXAMPLE QUESTIONS

RESEARCH TOPIC	RESEARCH QUESTIONS
Impacts	• What are the demand and energy impacts of water heater DR events? • Do the energy impacts and demand vary by the types of water heater installed? • When preheating is used to load shift, what is net effect on energy savings?
Customer Experience, Interest and Motivation	• What is the customer's experience of the installation process? • What did customers experience during the DR events? • What motivated customers to participate in the pilot?
Pilot Design and Evaluability	• Did the pilot meet the recruiting and participation goals? • Are the methods for tracking participation and energy use scalable? • What other metrics should a program track to assess success?

EVALUATION APPROACH

The evaluation team identified and conducted a set of data collection and evaluation activities designed to address the research objectives and questions specified above. Table 2 summarizes these activities, and we provide the details of each activity in *Section 2.2 Evaluation* Activities.

TABLE 2. SUMMARY OF EVALUATION ACTIVITIES

TASK	DESCRIPTION
Interviews	• Interviewed the pilot program manager
Surveys	• Surveyed participants within two weeks of water heater installation • Surveyed participants after 9 of the 10 DR events, one day after each event
Impact Analysis	• Estimated demand reduction and energy savings for each DR event • Analyzed data collected from Rheem for additional insight into estimated demand reduction and energy savings • Reviewed The Energy Detective (TED) monitoring device data to confirm events occurred[2] • Checked for cross-participation in other Georgia Power programs to reduce double-counted savings • Reviewed number and frequency of opt-outs

[2] TED monitoring devices were installed in the homes of 15 pilot participants to log kW draw of the water heater and other large electric appliances in the home like the dryer, AC, and oven.

FINDINGS AND RECOMMENDATIONS

IMPACTS

Key Finding. The WHDR Pilot achieved an average demand reduction of 0.20 kW per household during winter load shed events and an average of 0.11 kW per household during summer load shed events. As expected, there was a slight increase in demand during the load shift period when Georgia Power preheated some of the water heaters in both winter and summer. During the post-event period, there was an increase in demand across winter events as water heaters returned to their original setpoints, but across summer events, the demand reduction continued into the post-event period.

Key Finding. Across all participants and events, the pilot achieved energy savings of 39 kWh for the summer DR events while energy usage increased 45 kWh for the winter DR events.[3] While energy use decreased during the load shed phase, it was not enough to offset the increased energy use in the pre-and post-event phases during winter. This resulted in an overall increase in energy use during event days. During summer event days, the decreased energy use during the load shed and post-event phases was enough to offset the increased energy use during the pre-event phase resulting in energy savings. In both winter and summer, the statistical uncertainty around the energy savings per household means it is reasonable to conclude Georgia Power achieved no kWh savings per household on average across events.

Key Finding. The program achieved greater demand reduction during the load shed event among water heaters that were preheated through the load shift event. ILLUME found evidence that Georgia Power can expect DR impacts to vary by program delivery (e.g., whether load shift is implemented prior to load shed and how long beforehand), and for different customer characteristics (e.g., water heater type). Water heaters that received the load shift event had about one-third greater demand reduction, on average, than water heaters that did not receive the load shift event. In addition, the program achieved larger demand reductions with electric resistance water heaters.

> ***Recommendation:*** *For a future program offering, consider implementing load shifting for all participants. Additionally, Georgia Power can better ensure reliable savings by enrolling more electric resistance than HPWHs.*

Key Finding. Water heater connectivity issues negatively affected demand reduction achieved by the program and the customer experience. Through examining the number of water heaters connected during each DR event, ILLUME estimates that connectivity issues may have diminished load shed kW impacts by as much as 25% during the winter and 10% during the summer. Moreover, the most commonly reported issue respondents reported having with their water heaters was connecting them to Wi-Fi. This was primarily due to issues with the Wi-Fi network, not the water heater itself.

[3] ILLUME estimated total energy savings achieved across the summer events by taking the average summer demand impacts as shown in Section 3.1.A Summary Results and multiplying it by the total number of event hours, sites and summer events. We repeated this process to estimate the total energy savings achieved across the winter events. These results correspond to 0.08 kWh/site/event (+-280%) energy savings for summer events and 0.10 kWh/site/event (+-217%) energy increase for winter events.

Recommendation: *Assume connectivity issues will diminish impacts from future events by 10%, based on the improved delivery of load shift and load shed signals between the winter and summer DR events.*

Recommendation: *Evaluate future DR programs and update the connectivity assumption as warranted.*

Recommendation: *Monitor water heater connectivity status through DR vendor platform and send alerts to participants when water heaters are offline extended periods of time.*

CUSTOMER EXPERIENCE, INTEREST, AND MOTIVATION

Key Finding. Respondents were highly satisfied with their water heater, the WHDR Pilot, and Georgia Power throughout their participation in the pilot.[4] The majority (89%) of respondents to the post-installation survey rated their initial satisfaction with their water heater a five on a 5-point scale. The initial level of satisfaction did not change as the pilot continued, with 84% of respondents to the first post-event survey and 92% of respondents to the last post-event survey rating their water heater a 5 on a 5-point scale. Similarly, respondent ratings of the WHDR Pilot overall ranged from a low of 4.4 to a high of 4.8 across events with an average satisfaction rating of 4.7. Furthermore, respondents, who were primarily Georgia Power employees, consistently gave Georgia Power high satisfaction ratings as their utility service provider.[5]

Key Finding. The water heater DR events did not cause concern among participants and led to few disruptions to routines, negative effects, or issues with hot water in either season. When the water heater was installed, very few respondents (16%) expressed any questions or concerns about the upcoming water heater DR events. Additionally, the majority (89%) of post-event survey respondents were not bothered by Georgia Power adjusting their water heater setpoint during DR events. Also, very few respondents reported issues with their hot water, disruptions to routines, or negative effects due to the DR events. Notably, there were three DR events where no respondents reported any event-related issues through the post-event surveys.

Recommendation: *When recruiting new participants, consider including pilot participant testimonials to highlight the fact that the program is relatively low impact and that when issues arise, it is easy to override an event.*

Key Finding. Neither advance notice of the DR events nor preheating the water heaters affected the customer experience with the DR events. The ILLUME team examined responses to key survey questions that may have been affected by providing participants with notification of events or preheating and found no evidence of a positive or negative effect on the customer experience caused by notifying participants of

[4] Survey respondents varied across surveys, while there is some overlap, the same set of respondents did not complete each survey.

[5] The ILLUME team also found that Bring Your Own Thermostat Pilot participants, who were not Georgia Power employees, rated their satisfaction with the pilot program and Georgia Power highly throughout their participation.

the DR events or preheating their water heaters directly prior to the DR events. Furthermore, respondents that received the advance notice of events did not opt-out of any DR events prior to the event start.

> ***Recommendation:*** *To ensure customer service and transparency, notify customers of upcoming DR events one to three days in advance and include a way for participants to opt-out of the DR event before it begins.*

Key Finding. Most survey respondents (75%) would participate in a future water heater DR program. The final five post-event surveys (conducted in the summer) asked respondents if they would participate if Georgia Powered offered another water heater DR program, and on average, 75% of respondents indicated they would.

> ***Recommendation:*** *Target pilot participants with a special offer to enroll in a future DR program.*

Key Finding. Event opt-outs may have an unacceptable delay. During summer DR events, where the implementer leveraged an improved platform, three customers opted out of events. Rheem data indicated that two of the three opt-outs remained in load shed active status for almost the entirety of the event, and the other customer who opted out remained in load shed active status for almost 60% of the event. While it is unclear if this is due to a delay in the water heater responding to the change in setpoint to override the load shed signal or the participant not changing their setpoint until much of the event period had passed, it is important to ensure participants have a means to return their water heater to its normal temperature.

> ***Recommendation:*** *Georgia Power should track the responsiveness of water heaters to opt-out as it considers future Water Heater DR programs—customer control is an important component for participant retention.*

Key Finding. WHDR Pilot participants were less motivated by technology than other pilots. Unlike other smart technology pilots like Georgia Power's Bring Your Own Thermostat Pilot, where participants often identify as early technology adopters and are motivated to participate by new technology, respondents to the post-installation survey cited wanting to support Georgia Power in its research and taking advantage of the opportunity to replace their old, inefficient water heaters for free. Furthermore, the largest proportion of respondents said they purchase new technology in the middle of the group, rather than trying new technology as soon as possible or even before most of their friends when asked about when they typically buy new technologies.

PILOT DESIGN AND EVALUABILITY

Key Finding. Having decimals available in the interval meter data was critical to detect program impacts. For this pilot, Georgia Power reprogramed participant meters to provide interval meter data as decimal values rather than integer values. Integer values in hourly intervals can obscure changes in energy demand and use because residential customers frequently use less than 1 kWh per hour.

> ***Recommendation:*** *Provide decimal reads in 15-minute intervals to better detect program impacts for future program participants.*

Key Finding. A small portion of respondents took additional energy-saving actions during DR events, even though the pilot did not actively encourage this behavior. We asked respondents who received pre-event notification if they avoided using hot water or took any additional energy-saving actions, like turning off lights or avoiding cooking, during DR events. On average, 14% of respondents who were notified of the DR

event took additional actions, primarily related to avoiding hot water use, during the event. This behavior was more common in winter, when between 7% and 29% of respondents who received a pre-event notification reported taking additional action. During summer events, between 11% and 13% of respondents reported taking additional actions during DR events.

> *Recommendation: Provide educational messaging to encourage additional actions participants can take to reduce energy use in general and during DR events.*

Key Finding. In addition to the cost of the water heaters, Georgia Power invested significant time and resources screening prospective pilot participants and installing water heaters in their homes. Additionally, over two-thirds converted to electric water heat to participate. To vet participants, Georgia Power used a screening survey and required participants to provide photos of their current water heater. Installation was also labor intensive, with most installations (64%) taking at least two visits to complete, with one visit for the electrical work and one for the water heater installation. The majority of respondents (86%) reported installation visits took between two and six hours to complete.

> *Recommendation: Due to the modest demand savings and retail cost of new water heaters, ILLUME recommends investigating cost effectiveness for various water heater demand response program designs, including that of the pilot, paying for a HP/DR-ready water heater through energy efficiency, or installing retrofit DR components to existing water heaters.*

> *Recommendation: To expand the number of DR-enabled water heaters in the service territory, Georgia Power could work directly with distributors to assort, stock, and supply DR enabled water heaters.*

Key Finding. Not all events may have occurred as scheduled. Data about whether or not the February 26 event took place as scheduled is inconclusive and contradictory. Analysis of AMI data shows a very small, not statistically significant, kW impact for the February 26 event. Rheem data show no water heaters in "*Load shed active*" or "*Load shift active*" status during the DR event timeframe, suggesting that no DR event took place on February 26, 2019. On the other hand, one TED-monitored participant was assigned to the load shift group for this DR event, and the data show that the water heater ran as expected during load shift and was shut off during the load shed, consistent with a DR event running successfully. Similarly, the largest number of survey respondents reported issues after the February 26 event which took place from 6 a.m. to 8 a.m., a time of day when more people may be showering before work. Respondents reported that the water was not hot enough (n = 5), they ran out of hot water (n = 2), and the water took too long to heat (n = 3).

> *Recommendation: Consider ways to monitor event delivery, such as installing TED data monitoring devices on a higher percentage of units, in a future program.*

1. PILOT OVERVIEW

1.1 RECRUITMENT AND INSTALLATION

Georgia Power recruited employees to participate in the pilot via email, sending invitation emails in June 2018. Recruitment emails highlighted the offer of a free electric resistance or HPWH for participating in the pilot. They also briefly explained how the pilot would help Georgia Power test the amount of demand shift possible with water heaters, gauge customer satisfaction with the water heater and DR events, and assess the energy efficiency aspect of the heat pump water heaters. The emails also included a link to a short qualifying survey and program frequently asked questions (FAQs) that provided detailed information about the water heater and installation process, and what to expect from the DR events. To be eligible for this pilot, participants had to:

- Own their single-family home and not have plans to move within the year,
- Have an active account with Georgia Power with a standard electric residential rate,
- Have electric water heat or the ability to convert to electric water heat,
- Have an existing water heater that is at least five years old,
- Have Wi-Fi in their home, and
- Not be participating in Power Credit, Georgia Power's AC switch DR program or any other Georgia Power pilots.

After reviewing the survey results, Georgia Power contacted eligible employees to have them provide a photograph of their existing water heater showing the space around it. If their current water heater was gas, eligible employees had to provide a photograph of their breaker box. Georgia Power used these photographs to determine if there was adequate space to meet the ventilation requirements of the HPWHs and/or space in the breaker box to add a circuit for the water heaters converted from natural gas. Many otherwise eligible employees were not able to participate in the pilot because there was not enough space around their water heater to install a HPWH. Because of these difficulties, Georgia Power opened recruitment to friends and family of employees in October 2018 to meet their target of 100 participants.

Water heater installations began in late September 2018 and concluded the first week of January 2019. Installations started with an appointment to add a breaker for the water heater (where necessary) and to install a TED monitoring device (in the homes of 15 participants). After any necessary electrical work, a plumber installed the new HPWH or electric resistance water heater and connected it to the Rheem EcoNet mobile app. The pilot aimed to provide water heaters equal to or one size larger than the existing water heater.

Table 3 displays the number of water heaters installed by type and tank size.

TABLE 3. SUMMARY OF WATER HEATERS INSTALLED

TANK SIZE	HPWH	ELECTRIC RESISTANCE
50-gallon	25	30
66-gallon	25	-
80-gallon	20	-
Total	**70**	**30**

Note: One pilot participant with an electric resistance water heater moved after the winter DR events; we removed that site from the summer analysis.

1.2 IMPLEMENTATION

AutoGrid provided the DR services for the pilot. Because the AutoGrid FLEX platform was not yet fully functional during winter 2019, Georgia Power notified AutoGrid of event dates and times, and AutoGrid manually sent signals to the water heaters to change setpoints during the winter DR events. During summer 2019, Georgia Power scheduled DR events through AutoGrid FLEX.

Each DR event consisted of two components: a load shift event during which the water was preheated by raising the setpoint to 140 degrees F, and a load shed event during which the water heaters' setpoints were reduced. During the load shed event, Georgia Power lowered the water heaters' setpoints to 110 degrees F until the end of the event, at which point they raised it back to the customers' selected pre-event setpoints.

The timing of the load shift events varied throughout the pilot as Georgia Power became aware of issues with the water heaters receiving the signal and AutoGrid made improvements to the FLEX platform and API call to water heaters.[6] During the first two DR events, Georgia Power scheduled the load shift for one hour prior to the load shed event. However, not all devices received the signal to switch from the load shift event to the load shed event. Per AutoGrid's recommendation, Georgia Power began scheduling the load shift events to begin 1.5 hours prior to the event. This created a 30-minute gap between the end of the load shift event and the beginning of the load shed event during which the water heaters could receive the signal. Georgia Power scheduled the load shift events to begin 1.25 hours prior to the last two load shed events after AutoGrid made improvements to the API, which left a 15-minute gap between the end of the load shift event and the beginning of the load shed event.

Georgia Power held a total of 10 DR events throughout the winter and summer of 2019.

[6] The API is the software through which the AutoGrid Flex platform sent signals to the water heaters.

Table 4 displays the dates and times of these DR events.

TABLE 4. DR EVENT DATES AND TIMES

EVENT DATE	LOAD SHIFT	LOAD SHED
Friday, January 18	7:00 a.m. to 8:00 a.m.	8:00 a.m. to 10:00 a.m.
Thursday, February 7	6:00 a.m. to 7:00 a.m.	7:00 a.m. to 9:00 a.m.
Monday, February 18	5:30 a.m. to 6:30 a.m.	7:00 a.m. to 9:00 a.m.
Tuesday, February 26	4:30 a.m. to 5:30 a.m.	6:00 a.m. to 8:00 a.m.
Wednesday, March 6	4:30 a.m. to 5:30 a.m.	6:00 a.m. to 8:00 a.m.
Friday, June 21	1:30 p.m. to 2:30 p.m.	3:00 p.m. to 5:00 p.m.
Tuesday, June 25	2:30 p.m. to 3:30 p.m.	4:00 p.m. to 6:00 p.m.
Tuesday, July 2	2:30 p.m. to 3:30 p.m.	4:00 p.m. to 6:00 p.m.
Wednesday, July 10	1:45 p.m. to 2:45 p.m.	3:00 p.m. to 5:00 p.m.
Monday, July 29	2:45 p.m. to 3:45 p.m.	4:00 p.m. to 6:00 p.m.

1.3 DESIGN

The pilot design tested how two variables may affect demand impacts and customer experience: (1) pre-notification of DR events and (2) preheating (through load shift event) of water heaters. Future program design could offer either or both of these elements, as some control systems allow for these features to be toggled on and off.

To facilitate this testing, we divided the 100 participants equally into 4 different treatment groups and developed a plan for rotating each group through all 4 different possible combinations of receiving notification and/or pre heat twice—once during winter events and once during summer events. As shown in Table 5, for each event, Georgia Power notified half of the participants via email two to three days in advance of the event and implemented a load shift event to preheat half of the water heaters. Because of the small pilot size, the analysis of this sample design could only detect very large differences in survey responses between the different groups at statistically significant levels. *Appendix C. Sampling Memo* contains the full detail of this sampling plan.

TABLE 5. NOTIFICATION AND LOAD SHIFTING STRATEGY*

	Event 1		Event 2		Event 3		Event 4		Event 5
	Notification								
Load Shift	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Yes	Group 1	Group 2	Group 3	Group 4	Group 2	Group 1	Group 4	Group 3	ALL
No	Group 3	Group 4	Group 1	Group 2	Group 4	Group 3	Group 2	Group 1	

*Notification and load shift strategy repeated for the five summer DR events.

As noted above, Georgia Power held five winter DR events and five summer DR events for this pilot. The first four events during each season followed the previously described sample design with half of the water heaters preheated and half of the participants notified of the event. For the fifth DR event of each season,

Georgia Power notified all participants in advance of the event and preheated all water heaters. For the fifth summer DR event, Georgia Power also incorporated text notification which became available when the AutoGrid platform was fully implemented for summer.

2. EVALUATION OBJECTIVES AND APPROACH

This section describes the objectives and activities conducted for the evaluation of the WHDR Pilot.

2.1 RESEARCH QUESTIONS

The evaluation team developed the following list of key research questions with input from Georgia Power and Public Service Commission staff.

A. IMPACT QUESTIONS

1. What are the demand and energy impacts of water heater DR events? Are the impacts different on different days, times of day, or seasons? This includes impacts before, during, and after the event.
2. How does the installation of new water heaters and fuel switching affect energy use of participating customers?
3. Do the energy impacts and demand vary by the type of water heater installed? What is the demand value difference between HPWH and electric resistance water heaters?
4. How does fuel-switching affect energy use of participating customers? Are customers more or less satisfied with electric water heating, are there other benefits to electric water heating that can be documented or quantified—e.g., grid value, "free" cooling of garage spaces with HPWHs, etc.
5. Does control of the HPWH mode (heat pump only or hybrid) provide improved snap back control without sacrificing comfort?
6. Do the energy and demand impacts vary by other measurable participant characteristics (such as occupancy, schedules, etc.)?
7. Are the energy and demand impacts affected by participation in other Georgia Power energy efficiency programs?
8. What data should the program collect to effectively measure program impacts?
9. When preheating is used to load shift, what is the net effect on energy savings?
10. How much preheating is required to ensure the water heater maintains a comfortable temperature throughout an event?
11. Are energy and demand impacts affected by notifying participants of an upcoming event (compared to not providing notice of events)?

B. PROCESS QUESTIONS

CUSTOMER EXPERIENCE QUESTIONS

1. How do customers evaluate the installation process? What are the customers' experiences of the installation process?
2. Are customers satisfied with their new water heater? Does it provide enough hot water?
3. What did customers experience during the DR events? Did they notice any changes? Did they change their behavior before, during, or after the event? Did the event affect their satisfaction with their water heater or Georgia Power?
4. [For HPWH] Do customers understand the technology? The different modes? Does the water heater need to switch modes to keep up with customer demand for hot water?

CUSTOMER INTEREST AND MOTIVATION QUESTIONS

1. What motivated customers to participate in the pilot?
2. What do customers see as the benefits of their new water heater and the DR events? What are the barriers?
3. What messaging around water heaters and DR resonates most with customers?
4. What are the levels of incentives that are required to get customers to participate?

PILOT METRICS

1. Did the pilot meet the recruiting and participation goals?
2. Are the methods for tracking participation and impacts scalable? Are different approaches needed for a pilot versus a full-scale program?
3. What other metrics should a program track to assess program success?

2.2 EVALUATION ACTIVITIES

This section describes the set of data collection and evaluation activities ILLUME conducted to address the research objectives and questions listed above. We provide a detailed methodology in *Section 4 Methodology*.

STAFF INTERVIEWS

ILLUME and Georgia Power staff met weekly throughout the duration of pilot. During these meetings, the ILLUME team gathered insight into the history of the pilot, recruitment efforts, pilot goals and objectives, and barriers for meeting those goals.

IMPACT ANALYSIS

The ILLUME team estimated demand reduction and energy savings achieved during the DR events by using hourly AMI data for participating homes, an estimate of double-counted savings (through an examination of pilot participant involvement in other Georgia Power energy efficiency programs), and an analysis of

device-level event participation using Rheem water heater data. See *Section 3.3 Design & Evaluability Considerations* for a more detailed impact analysis methodology.

DOUBLE-COUNTED IMPACTS

Double-counted impacts (demand reductions or energy savings) can occur if customers participated in other energy efficiency programs and impacts from those actions are claimed by the energy efficiency program and captured in the analysis of AMI data for the WHDR Pilot. We assessed the risk of double-counted impacts by cross-referencing the HPWH participants with program tracking data from the following Georgia Power energy efficiency programs:

- Home Energy Improvement Program
- Refrigerator Recycling Program
- HVAC Service
- Marketplace

Ultimately, we found very little participation in other energy efficiency programs during the time periods used for baseline day selection and, as such, minimal risk of double-counted impacts. If we had found a greater likelihood of double-counted impacts, we would have subtracted the claimed impacts of the energy efficiency program measures from the estimated WHDR Pilot event impacts.

RHEEM WATER HEATER DATA ANALYSIS

The ILLUME team used interval data from the Rheem water heaters to provide insight into the estimated demand reduction and energy savings. Rheem data, stored in 5-minute intervals, included information on the operating mode, load shed and load shift status, setpoint, water heater use, kW draw, schedule modifications, and connectivity. Data was available for four winter DR events and all of the summer DR events.

TED DATA REVIEW

We reviewed this data for confirmation that load shift and load shed events occurred as scheduled when other data indicated uncertainty. We looked for kW draw during the load shift, or preheating, time frame and no kW draw during the load shed time frame which is consistent with a DR event running successfully.

PARTICIPANT SURVEYS

The ILLUME team used three types of online surveys to understand the customer experience:

- Post-installation survey. We used this short survey to gather initial feedback on the water heater, program enrollment, and installation experience. The team sent participants email invitations to complete the survey within two weeks of their water heater installation.
- In-depth customer experience survey. This survey assessed motivations for participation, user experience with the pilot, customer satisfaction, and demographics. The team sent email invitations for the customer experience survey to all 100 unique participant emails after the January 18, 2019 event. Participants who had not yet responded to the customer experience survey continued to receive invitations to this survey after subsequent events.
- Short follow-up surveys. The team used a shorter follow up survey to provide a longitudinal perspective on the customer experience with DR events. Once a participant completed the

customer experience survey, the team invited them to take this shorter follow-up survey after every remaining DR event.

We invited all pilot participants to complete a survey (either customer experience or follow up, depending on previous survey completion) the day after 9 of the 10 DR events as listed in Table 6. In total, 75% of participants completed the post-installation survey and 70% of participants completed the full customer experience survey. As shown, the proportion of participants completing post-event surveys dropped from over two-thirds after the first DR event to less than half after the last DR event. Few participants (15%) completed all 9 post-event surveys, but 92% completed multiple surveys.

TABLE 6. SURVEY RESPONSES

	POST-INSTALL	JAN 18	FEB 7	FEB 18	FEB 26	MAR 6	JUNE 21	JUNE 25	JULY 2	JULY 10	JULY 29
Number of Respondents	75	70	57	60	62	n/a	38	45	53	49	42

* Because post-Installation and winter survey response rates are based on 100 participants and summer survey response rates are based on 99 participants, response rate to each survey is the same as the number of respondents.

3. FINDINGS

This section provides detailed findings from the WHDR Pilot evaluation. We present these findings by research topic: impact findings, process findings, and design and evaluability considerations.

3.1 IMPACT EVALUATION FINDINGS

In this section, we provide estimated demand impacts and energy savings achieved during the DR events. We also present findings regarding the impact that load shift, water heater type, connectivity, and opt-outs may have on demand and energy savings.

It is important to note that we include all pilot participants, even those with connectivity issues, in the summary results to estimate the impacts the program achieved per *enrolled* water heater. For the event-level and customer-specific characteristics results that follow, we constrained our analysis to only the water heaters we could verify were connected and active during events to provide insight into the potential savings per *connected* water heater.

These analyses use hourly AMI data for participating homes, weather data, implementation tracking data, and Rheem device data. As described in *Section 2.2 Evaluation Activities*, we also assessed the likelihood of double-counted savings through participation in other Georgia Power energy efficiency programs.

A. SUMMARY RESULTS

The results we present in the following subsections reflect impacts across all pilot participants, even those with connectivity issues. This approach better aligns with typical load management evaluation practices, in part because it avoids overreliance on connectivity data.

WINTER DR EVENTS

During winter DR events, Georgia Power achieved an average load shift demand increase of 0.18 kW, average load shed savings of 0.20 kW, and a post-event demand increase of 0.21 kW. These impacts apply to an average of 89.4 sites across 5 winter events. This corresponds to total program impacts per event of 16.1 kW pre-heat load increase, 17.9 kW load shed savings, and 18.8 kW of post-event load increase. Table 7 shows the average estimated household-level demand reduction achieved across all five winter DR events, as well as the average demand impact in pre- and post-event periods. We define the pre-event period as the load shift event held one to two hours prior to the load shed event and the post-event period as the one hour following the event.

TABLE 7. ESTIMATED HOUSEHOLD-LEVEL AVERAGE DEMAND REDUCTION FOR WINTER DR EVENTS

SEASON	PERIOD	AVERAGE TREATED SITES PER EVENT	AVERAGE NUMBER OF SITES PER EVENT IN ANALYSIS	% TREATMENT DELIVERED (ESTIMATED)	NUMBER OF IMPACTED HOURS	HOUSEHOLD KW IMPACT	HOUSEHOLD CONFIDENCE INTERVAL (HIGH/LOW)
Winter	Load Shift	89.4	88.4	42%	1.6[a]	-0.18	-0.11/-0.25
Winter	Load Shed	89.4	88.4	94%, 75%[b]	2	0.20	0.28/0.13
Winter	Post-Event	89.4	88.4	-	1	-0.21	-0.11/-0.31

[a] Pre-event periods occurred for an hour in duration. However, with hourly usage data, the pre-event period may have spanned multiple hours (e.g., occurring from 5:30 a.m. to 6:30 a.m.). As a result, the modeling yields an estimate of the impacted kW over the impacted hours, which would be two hours for a pre-event occurring from 5:30a.m. to 6:30 a.m.

[b] The Rheem data indicates that shed load action was not delivered February 26, 2019. Outside of that event and where Rheem data exists (events 1-3), connectivity issues affected 6% of sites; including that event and the available data for event 5, connectivity issues affected 25% of sites.

Across the winter, the model estimates that water heater demand response caused an energy increase of 0.10 kWh (+-217%) per household on average across events, or -45 kWh/yr. savings for the pilot during the winter in total. Given the statistical uncertainty on this estimate, it is reasonable to conclude Georgia Power achieved approximately 0 kWh of energy savings for winter water heater demand response events. It should be noted that this is savings associated with DR events and does not include the energy savings seen by installing new electrotechnology, specifically heat pump water heaters.

Please note that the summary results presented here are different than those presented previously in the Preliminary Evaluation Results Memo[7] and the Winter Demand Response Event Impact Results Memo[8]. The results presented previously only include water heaters that were enrolled and connected during DR events. Additionally, we used increasingly rigorous analysis methods in each report. Section 4.1 Impact Analysis Methodology provides additional detail.

CONNECTIVITY

Connectivity issues may have diminished realized shed savings by approximately 6% or 25%. Rheem's connectivity data indicates that shed was not delivered for event four. If that data is accurate, connectivity issues diminished Georgia Power's winter shed savings by approximately 25%. If that data is not accurate, connectivity issues diminished Georgia Power's winter shed savings by approximately 6%. ILLUME's regression modeling indicates that the diminishing effect of connectivity issues on shed savings during winter events was closer to 25% than 6%.

LOAD SHIFTING

As discussed in Section C Results for Customer-Specific Characteristics below, households with load shifting through preheating had greater demand reductions during the load shed period. Implementing the load

[7] ILLUME Advising, Water Heater Demand Response Pilot: Preliminary Evaluation Results, 3/19/2019.

[8] ILLUME Advising, Water Heater Demand Response Pilot: Winter Demand Response Event Impact Evaluation Results. 8/9/2019.

shift event increased the load shed impacts by roughly one-third. By design, the pilot attempted to load shift for 60% of participants on average across the 5 winter events. After accounting for connectivity issues, only 42% of sites across 5 winter events successfully received the load shift event. The combination of the pilot design and connectivity diminished the realized load shift impacts for the population of participants by approximately 58%.

SUMMER DR EVENTS

During summer DR events, Georgia Power achieved an average load shift demand increase of 0.09 kW, average load shed demand reduction of 0.11 kW, and post-event savings of 0.05 kW. These impacts apply to an average of 97 sites across 5 summer DR events. This corresponds to total program impacts per event of 8.7 kW load shift load increase, 10.7 kW load shed savings, and 4.9 kW of post-event savings. While the post-event impacts are not statistically significant at the industry-standard 90% confidence level, ILLUME's robustness checks of the results provide some evidence to the reliability of this approximate estimate[9]. Table 8 shows the average estimated household-level demand reduction achieved across all five summer DR events, as well as the average demand impact in pre- and post-event periods.

TABLE 8. ESTIMATED HOUSEHOLD-LEVEL AVERAGE DEMAND REDUCTION FOR SUMMER DR EVENTS

SEASON	PERIOD	AVERAGE TREATED SITES PER EVENT	AVERAGE NUMBER OF SITES PER EVENT IN ANALYSIS	% TREATMENT DELIVERED (ESTIMATED)	NUMBER OF IMPACTED HOURS[A]	HOUSEHOLD KW IMPACT	HOUSEHOLD CONFIDENCE INTERVAL (HIGH/LOW)
Summer	Load Shift	97	94.0	54%	2	-0.09	-0.01/-0.18
Summer	Load Shed	97	91.6	90%	2	0.11	0.18/0.04
Summer	Post-Event	97	93.6	-	1	0.05	0.15/-0.04

[a] Pre-event periods occurred for an hour in duration. However, with hourly usage data, the pre-event period may have spanned multiple hours (e.g., occurring from 5:30 a.m. to 6:30 a.m.). As a result, the modeling yields an estimate of the impacted kW over the impacted hours, which would be two hours for a pre-event occurring from 5:30a.m. to 6:30 a.m.

[b] The Rheem data indicates that shed load action was not delivered February 26, 2019. Outside of that event and where Rheem data exists (events 1-3), connectivity issues affected 6% of sites; including that event and the available data for event 5, connectivity issues affected 25% of sites.

Across the summer, the model estimates that water heater demand response caused an energy impact of 0.08 kWh savings (+-280%) per household on average across events, or 39 kWh/yr. savings for the pilot during the summer in total. Given the statistical uncertainty on this estimate, it is reasonable to conclude Georgia Power's demand response pilot achieved approximately 0 kWh of energy savings for summer water

[9] Robustness checks support an overall estimate of 0.05 kW savings during the summer post-shed hour and some of the variance is likely due to load shifting, which was only intended to be applied to 60% of sites on average across the events. The difference in post-shed impacts between sites who did (0.23 kW) and did not (-0.14 kW) receive load shift event likely contributes to the large error band, and for an example of the robustness of this estimate, the average post-shed savings for customers who did and did not receive load shift is 0.05 kW.

heater demand response events. It should be noted that this is savings associated with DR events and does not include the energy savings seen by installing new electrotechnology, specifically heat pump water heaters.

CONNECTIVITY

Connectivity issues may have diminished realized summer shed savings by approximately 10%. Rheem's connectivity data indicates that load shed was not delivered for 10% of participants on average across summer events.

LOAD SHIFTING

Like the winter DR events, households with load shifting through preheating during summer DR events had greater demand reductions during the load shed period. Implementing the load shift event increased the load shed impacts by roughly one-third for summer DR events as well. Section C Results for Customer-Specific Characteristics below provides additional detail

The pilot intended to load shift for 60% of participants on average across the 5 summer events. Implementing the load shift event increased the load shed impacts by roughly one-third. When also incorporating connectivity issues, the pilot successfully delivered load shift to 54% of sites across 5 summer events. The combination of study design and connectivity diminished the realized load shift impacts for the population of participants by approximately 46% for summer events.

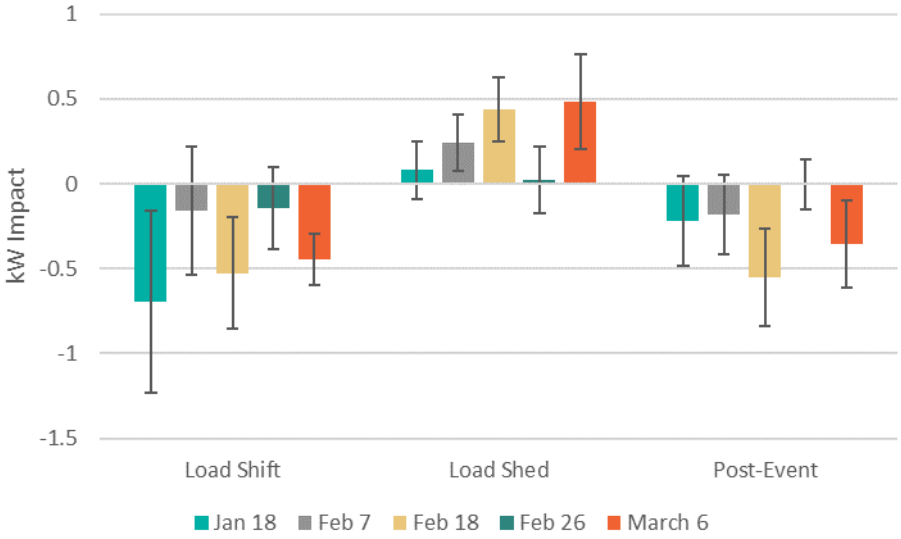
B. EVENT-LEVEL RESULTS

In this section, ILLUME presents event-level results. As noted previously, these results represent demand impacts only for those water heaters that we could verify were both connected and active during the DR events.

WINTER DR EVENTS

As shown in Figure 1 and Table 9, event-level results for winter were variable, ranging from a minimum load shed demand reduction of 0.02 kW (on February 26) to a maximum 0.49 kW reduction (on March 6). As expected, there was a slight increase in demand during the load shift period and during the post-event period, when water heaters returned to their original setpoints.

FIGURE 1. WINTER IMPACTS BY EVENT



Events typically led to increased energy use, although the change in absolute terms is minor. Table 9 displays the event-level regression results for demand and energy impacts in detail.

TABLE 9. AVERAGE HOUSEHOLD-LEVEL HOURLY IMPACTS FOR CONNECTED WATER HEATERS: WINTER

WINTER DEMAND IMPACT	LOAD SHIFT (1-2 HOURS[a])		LOAD SHED (2 HOURS)		POST-EVENT (1 HOUR)		ALL EVENT RELATED (6-7 HOURS)
	KW	90% CI (HIGH/LOW)	KW	90% CI (HIGH/LOW)	KW	90% CI (HIGH/LOW)	KWH/DAY
FRIDAY, 1/18/2019	-0.70	-0.16/-1.23	0.08	0.25/-0.09	-0.22	0.04/-0.49	-0.76
THURSDAY, 2/7/2019	-0.16	0.22/-0.53	0.24	0.41/0.08	-0.18	0.05/-0.41	0.15
MONDAY, 2/18/2019[b]	-0.53	-0.20/-0.85	0.44	0.63/0.25	-0.55	-0.27/-0.84	-0.73
TUESDAY, 2/26/2019[b]	-0.14	0.10/-0.39	0.02	0.22/-0.17	-0.00	0.15/-0.15	-0.24
WEDNESDAY, 3/6/2019[b]	-0.45	-0.30/-0.59	0.49	0.77/0.21	-0.36	-0.10/-0.61	-0.27
EVENT AVERAGE[c]	**-0.39**	**-0.07/-0.72**	**0.25**	**0.45/0.05**	**-0.26**	**-0.02/-0.50**	**-0.37**

[a] Because AMI data is recorded on the hour, for load shift events that crossed hours we measured the impact across the two hours in which load shift took place.

[b] There was a 30-minute gap between load shift and the load shed event for these events.

[c] These event average results differ from summary results because the impacts in this table represent only the sites where load shift was delivered, as opposed to the population on average.

In Table 10 we present the unique characteristics for each event, including information about the event day as well as characteristics from the Rheem water heater data. While other factors may influence results, the Rheem data and regression analysis results indicate reasons for variation in winter event-level impacts may include the following:

- **Shed signal delivered late.** Events One (1/18) and Two (2/7): Rheem data indicates that the pilot delivered the shed signal late. The delay is the result of no gap between load shift and shed periods for these events.
- **Load shift signal delivered early.** Event Two (2/7): It appears that the pilot delivered the load shift signal beginning shortly after midnight for about 25 water heaters. All 50 water heaters included in the load shifting group for this event indicated that the load shift signal was active at some point prior to scheduled delivery.
- **Signals not delivered.**
    - Event Four (2/26): Load shift and load shed may not have been delivered as Rheem data show no water heaters in load shift active or load shed active status. Very small kW impacts derived from the analysis of AMI data also seem to indicate the event was not delivered.
    - Event One (1/18): At the time of the first DR event, AutoGrid had not yet fully enrolled 15% of the water and therefore they did not receive DR event signals.

TABLE 10. WINTER DR EVENT CHARACTERISTICS

EVENT DATE	EVENT TIME	AVG. HDH[b]	% ENROLLED	% WITH SHED CONNECTIVITY ISSUES[C]	LOAD SHIFT & SHED DELAYS
FRIDAY, 1/18/2019	**Load shift:** 7:00 – 8:00 a.m. **Load Shed:** 8:00 – 10:00 a.m.	17	85%	3%	Load shed fully delivered ~25% into the event
THURSDAY, 2/7/2019	**Load shift:** 6:00 – 7:00 a.m. **Load Shed:** 7:00 – 9:00 a.m.	2	96%	9%	Load shift largely delivered starting at midnight Load shed fully delivered ~50% into the event
MONDAY, 2/18/2019	**Load shift:** 5:30 – 6:30 a.m. **Load shed:** 7:00 – 9:00 a.m.	18	96%	1%	Load shift and shed delivered roughly on time.
TUESDAY, 2/26/2019	**Load shift:** 4:30 – 5:30 a.m. **Load shed:** 6:00 – 8:00 a.m.	19	97%	100%	No devices showing load shift (preheat) or load shed active
WEDNESDAY, 3/6/2019	**Load shift:** 4:30 – 5:30 a.m.	38	97%	10%[a]	

EVENT DATE	EVENT TIME	AVG. HDH[b]	% ENROLLED	% WITH SHED CONNECTIVITY ISSUES[c]	LOAD SHIFT & SHED DELAYS
	Load shed: 6:00 – 8:00 a.m.				

[a] ILLUME used previous data from AutoGrid on connectivity for event 5. Rheem device interval data was not available for event 5.
[b] Heating degree hours base 65.
[c] Percent of sites where Rheem data indicates that the water heater was not connected and/or that load shed was delivered for less than 60% of the load shed event period.

SUMMER DR EVENTS

As shown in Figure 2 and Table 11, event-level load shed impacts for summer were lower than winter impacts and also somewhat variable. Load shed impact ranged from a demand increase of 0.10 kW (on June 21) to maximum demand reduction of 0.29 (on June 26). As expected, there was a slight increase in demand during the load shift period. However, with the exception of the July 10 DR event, demand reduction continued into the post-event period during the summer events.

FIGURE 2. SUMMER IMPACTS BY EVENT

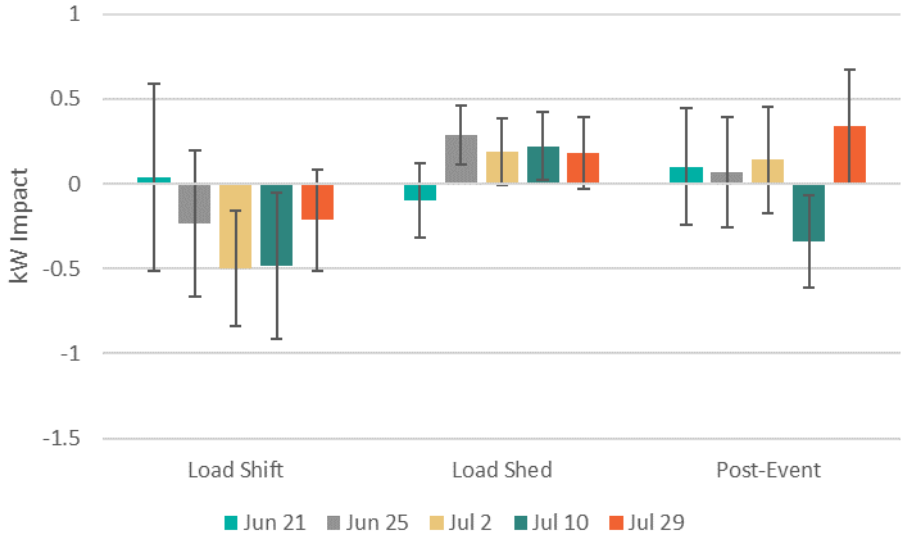


Table 11 displays the event level regression results in more detail. Events typically lead to increased energy use, although the change in absolute terms is minor, and lower than in winter.

TABLE 11. AVERAGE HOUSEHOLD-LEVEL HOURLY IMPACTS FOR CONNECTED WATER HEATERS: SUMMER

SUMMER DEMAND IMPACT	LOAD SHIFT (2 HOURS[a])		LOAD SHED (2 HOURS)		POST-EVENT (1 HOUR)		ALL EVENT RELATED (7 HOURS)
	KW	90% CI (HIGH/LOW)	KW	90% CI (HIGH/LOW)	KW	90% CI (HIGH/LOW)	KWH/DAY
FRIDAY, 6/21/2019	0.04	0.59/-0.51	-0.10	0.12/-0.32	0.10	0.45/-0.24	-0.01
TUESDAY, 6/25/2019	-0.24	0.19/-0.67	0.29	0.46/0.11	0.07	0.39/-0.26	0.06
TUESDAY, 7/2/2019	-0.50	-0.16/-0.84	0.19	0.39/-0.01	0.14	0.45/-0.17	-0.16
WEDNESDAY, 7/10/2019	-0.48	-0.05/-0.91	0.22	0.42/0.02	-0.34	-0.07/-0.61	-0.29
MONDAY, 7/29/2019	-0.21	0.08/-0.51	0.18	0.39/-0.03	0.34	0.67/-0.00	0.09
EVENT AVERAGE[c]	**-0.28**	**0.13/-0.69**	**0.16**	**0.36/-0.04**	**0.06**	**0.38/-0.26**	**-0.06**

[a] Because AMI data is recorded on the hour, for load shift events that crossed hours we measured the impact across the two hours in which load shift took place.

[c]The event average results differ from summary results. Load shift impacts in this table represent sites where load shift was delivered, as opposed to the population on average.

Table 12 displays unique characteristics for each summer event, including information about the event day as well as characteristics from Rheem water heater data. However, the available data for summer does not provide a clear explanation for variability across summer events. With the available data on event-level characteristics, the variation across summer event impacts is mostly unexplained. ILLUME highlights key DR event characteristics below, although these characteristics do not clearly align with regression results. Reasons for the variation in summer event-level impacts could include:

- Connectivity issues. Event One (6/21) and Five (7/29): Relatively high degrees of connectivity issues as indicated in the Rheem data.
- Timing of signals delivered. Events Four (7/10) and Five (7/29): Load shed delivered with only a 15-minute gap after load shift whereas other summer DR events had a gap of 30-minutes between load shift and load shed.
- Warm weather. Event Three (7/2): Warmest event period.

TABLE 12. SUMMER DR EVENT CHARACTERISTICS

EVENT DATE	EVENT TIME	AVG. CDH[b]	% ENROLLED	% WITH SHED CONNECTIVITY ISSUES	LOAD SHIFT & SHED DELAYS
FRIDAY, 6/21/2019	**Load shift:** 1:30 – 2:30pm **Load shed:** 3 – 5pm	18	100%	14%	Load shift and shed delivered roughly as expected.
TUESDAY, 6/25/2019	**Load shift:** 2:30 – 3:30pm **Load shed:** 4 – 6pm	15	100%	4%	Load shift and shed delivered roughly as expected.
TUESDAY, 7/2/2019	**Load shift:** 2:30 – 3:30pm **Load shed:** 4:00 – 6:00pm	24	100%	1%	Load shift and shed delivered roughly as expected.
WEDNESDAY, 7/10/2019	**Load shift:** 1:45 – 2:45pm **Load shed:** 3:00 – 5:00pm	19	100%	1%	Load shift and shed delivered roughly as expected.
MONDAY, 7/29/2019	**Load shift:** 2:45 – 3:45pm **Load shed:** 4:00 – 6:00pm	17	100%	30%	Load shift and shed delivered roughly as expected.

[b] Cooling degree hours base 70.

C. RESULTS FOR CUSTOMER-SPECIFIC CHARACTERISTICS

To better understand the demand impacts of the DR events, ILLUME investigated the effect of connectivity, water heater type, preheating, and event participation to determine which factors affect the overall demand impact.

The results of this section represent participants where load shed could be verified as delivered using the site-level Rheem water heater data. As such, impacts per site are higher than for the population of participants presented in the Summary Results section above. *Appendix A. Supplementary Findings, Tables, and Figures* provides additional analysis on the effects of tank size, notification, and water heater location on demand impacts.

CONNECTIVITY

The success of a water heater DR program depends on the devices being consistently connected to the internet. ILLUME estimated household connectivity status two ways: (1) using Rheem's connectivity data and (2) through regression modeling. Using Rheem data, we defined connected participants (successfully

received load shed signals) based on the percent of time participants' water heaters were connected to the cloud and the proportion of the event for which Rheem data indicated that load shed was active.[10]

We corroborated our definition of connected participants by comparing demand impacts from regression modeling applied to the whole population to just the subset of connected participants. When load shed impact is smaller for the whole population compared to connected participants, it is likely that connectivity issues contributed to diminished overall load shed impact. However, additional factors such as proportion of customers who received preheating may also affect savings, so we only use the results of the regression models to corroborate the Rheem connectivity data. We use the Rheem connectivity data as our primary flag for when devices are connected.

Rheem's water heater data did not show any water heaters in load shift active or load shed active status on February 26, indicating that the pilot may not have delivered load shift and load shed for event four during winter. If that is correct, then connectivity issues diminished Georgia Power's overall winter load shed savings by approximately 25%. If the status of event four is unknown and we look only at events one through three, then connectivity issues diminished Georgia Power's winter load shed savings by approximately 6%. Our analysis that compared impact results for all participants to those who were verified as connected indicated that the diminishing effect of connectivity issues on load shed savings during winter events was closer to 25% than 6%.

The delivery of load shift and load shed delivery improved substantially between winter and summer DR events. Rheem's data indicated that connectivity issues diminished summer load shed savings by approximately 10%. ILLUME's analysis that compared impact results for all participants to those who were verified as connected corroborated that estimate.

TABLE 13. EFFECT OF CONNECTIVITY ON DEMAND IMPACTS

SEASON	METRIC	AVERAGE NUMBER OF SITES PER EVENT	LOAD SHED SAVINGS ESTIMATE
Winter	Population (where data exists)	76.5	0.20 kW
Winter	Participants where shed verified as delivered	71.8, 57.4[a]	0.34 kW
Winter	**Percent impact from connectivity**	**6%, 25%**	**41%**
Summer	Population (where data exists)	68.6	0.11 kW
Summer	Participants where shed verified as delivered	61.6	0.13 kW
Summer	**Percent impact from connectivity**	**10%**	**20%**

[a] The Rheem data indicates that load shed was not delivered February 26, 2019. Outside of that event and where Rheem data exists for other winter DR events (events 1-3), connectivity issues affected 6% of sites; including that event and the available data for event 5, connectivity issues affected 25% of sites during winter DR events.

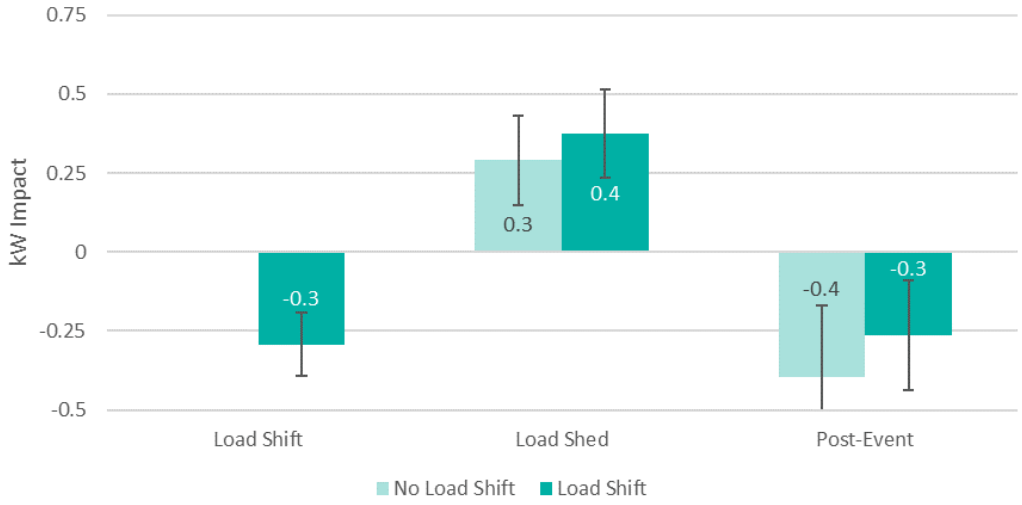
[10] ILLUME defined connectivity issues as water heaters that connected to the cloud for less than 60% of the event period or where the pilot successfully delivered the relevant load action to the water heater for less than 60% of the event period. This definition is roughly corroborated by the impact estimates for the population as compared to sites where connectivity was not an issue.

EFFECT OF LOAD SHIFT ON LOAD SHED AND POST-EVENT DEMAND REDUCTION

As shown in Figure 3 and Figure 4, households that had load shift through preheating had greater demand reductions during the load shed period, suggesting that implementing a load shift may increase impacts during the load shed period. Winter and summer events show a similar trend, with load shift increasing load shed impacts by approximately one-third in each season. In addition, in winter, households that had load shift had lower snapback effects in the post-event period.[11] In summer, households that had load shift showed demand savings during the post-event period. This may be partially driven by the load shift period: the water heaters may be maintaining temperature through the load shed period and beyond.

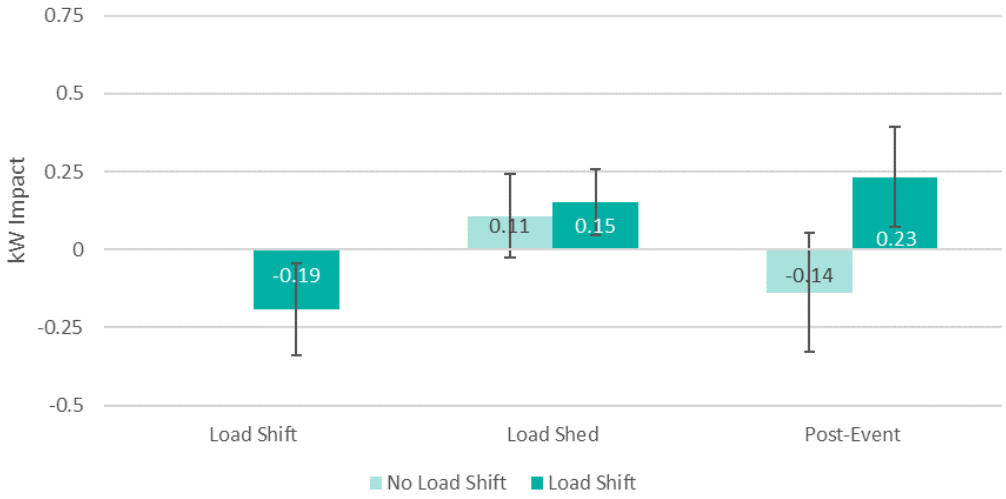
Although the impact evaluation results have relatively large error bands due to sample size, this finding aligns with expectations. Water heaters are more likely to stay above their setpoint with load shift. In semi- or unconditioned spaces during hot summer afternoons, some water heaters may be able to stay above their setpoints beyond the two-hour shed event. In conditioned spaces during winter, some water heaters may be able to stay above setpoints beyond the two-hour shed event, thus diminishing the snapback load increase in the hour after the event.

FIGURE 3. AVERAGE HOUSEHOLD DEMAND IMPACT BY LOAD SHIFT: WINTER DR EVENTS



[11] Snapback is the increase in energy use or demand after a DR event due to the water heater returning to its previous setpoint.

FIGURE 4. AVERAGE HOUSEHOLD DEMAND IMPACT BY LOAD SHIFT: SUMMER DR EVENTS



LOAD SHIFT AND LOAD SHED DELIVERY AND WINTER EVENTS

Internet connectivity is necessary for water heaters to receive load shift and load shed signals, but being connected is not a guarantee that the signal will be sent and received at the scheduled times. Based on analysis of the Rheem data, it appears that load action delivery improved substantially between the winter and summer DR events. During winter DR events AutoGrid manually sent signals to water heaters to change setpoints. During summer DR events the AutoGrid Flex platform was fully functional. As shown in Figure 5 and Figure 6, load shift and load shed were active outside of scheduled event times during winter DR events, but this occurred less frequently during summer DR events.

This variability in load action delivery during winter may have contributed to the variable impact estimates across winter events. Most specifically, for the February 26, 2019 DR event, AMI data indicated mild, non-statically significant impacts and the Rheem data indicated that no load action was successfully delivered for that event. Rheem water heater data was not available for the March 6 R event.

FIGURE 5. LOAD SHIFT AND LOAD SHED ACTIVE DURING WINTER DR EVENTS

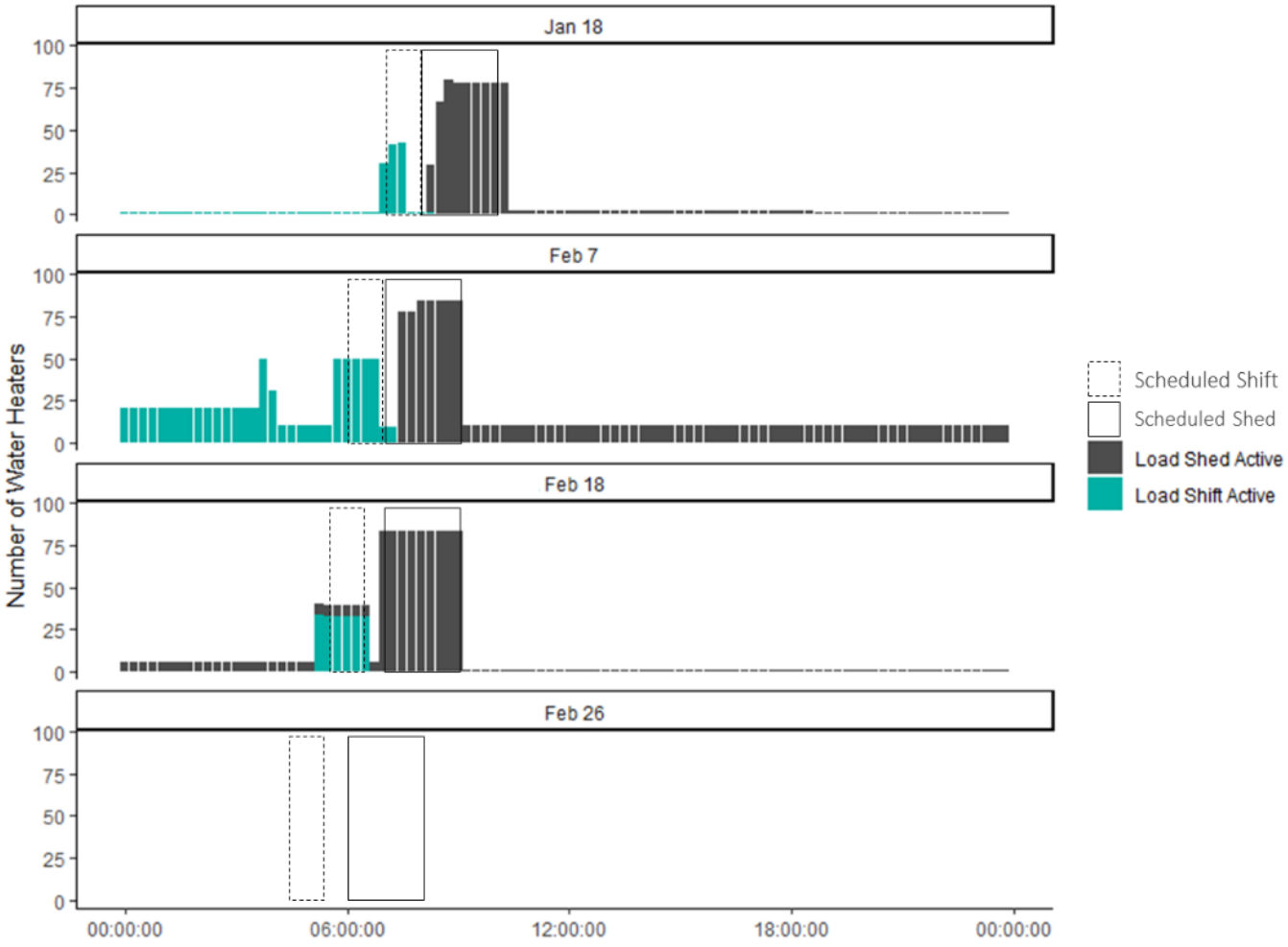


FIGURE 6. LOAD SHIFT AND LOAD SHED ACTIVE DURING SUMMER DR EVENTS

Table 14 displays the number of water heaters affected by the delayed starts or ends illustrated in the previous figures.

TABLE 14. NUMBER OF AFFECTED WATER HEATERS[a]

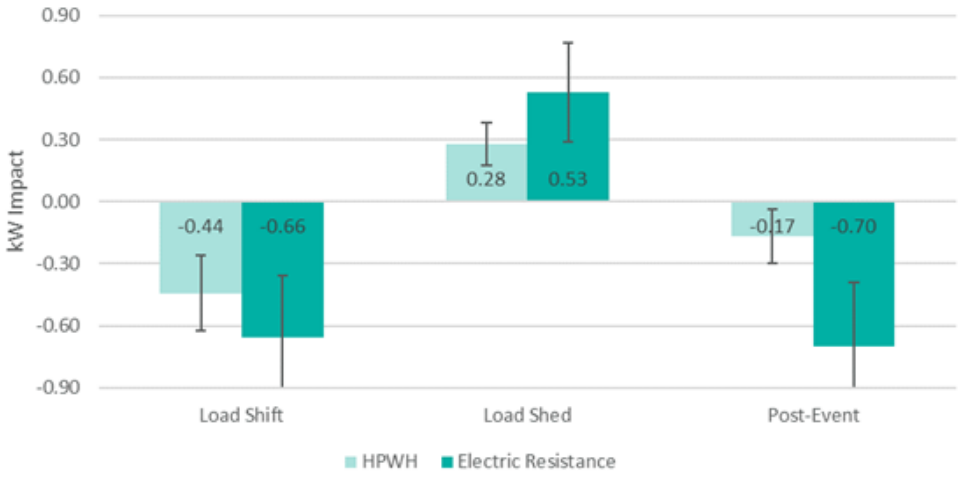
EVENT DAY	START SHIFT EARLY	END SHIFT LATE	START SHED EARLY	END SHED LATE
Jan 18	1	1	1	78
Feb 7	50	9	0	1
Feb 18	34	34	6	12
Jun 21	0	0	0	6
Jun 25	0	0	0	14
Jul 2	0	0	0	12
Jul 10	0	0	0	20
Jul 29	0	0	0	0

[a]Rheem water heater data was not available for the March 6 event.

WATER HEATER TYPE

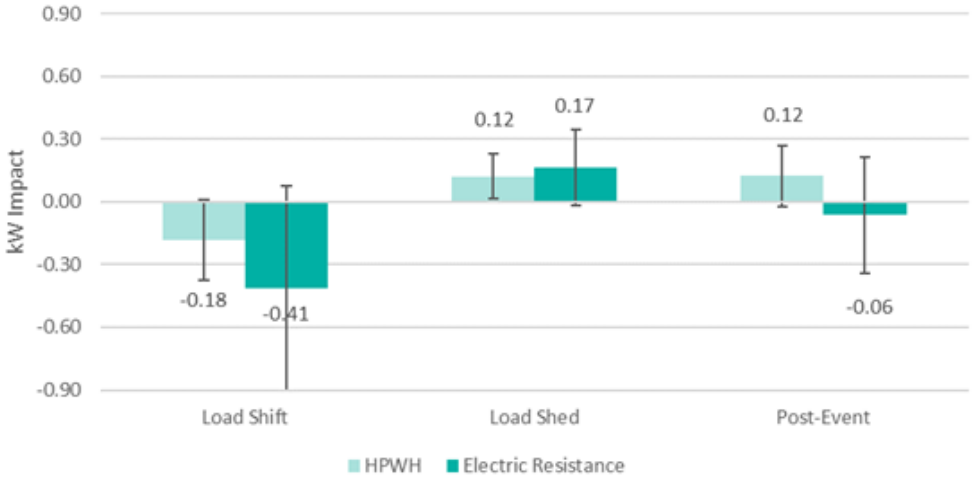
Results from both summer and winter show more pronounced impacts for preheat and load shed for electric resistance water heaters than for HPWHs. The HPWH mode did not affect the impacts. Although these results have relatively large error bands due to sample size, this finding aligns with expectations for HPWHs. Because HPWHs typically have lower power demand than electric resistance water heaters, they have a lower potential for demand reduction.[12]

FIGURE 7. WINTER EVENT IMPACTS BY WATER HEATER TYPE



[12] HPWHs typically have two heating mechanisms: heat pump heating and electric resistance. Heat pump heating has lower demand than electric resistance and the HPWHs in this pilot predominantly operated in modes that maximize heat pump heating.

FIGURE 8. SUMMER EVENT IMPACTS BY WATER HEATER TYPE



As seen in Figure 7 and Figure 8, winter results have greater post-event impacts for electric resistance water heaters. This is likely because water heaters are able to maintain the water temperature longer in the summer due to warmer ambient air temperatures.

EVENT OVERRIDES OR OPT-OUTS

No participants opted out in advance and very few participants opted out during DR events. Fewer participants opted out of the summer DR events than winter DR events.

Summer results indicate that customers opting out of events had little effect on load impacts. Less than 1% of participants opted out of summer events on average. Even customers who opted out received the load shed signal for 83% of the event. Based on available data, we cannot determine if participants did not change their setpoint to override an event until much of the event period has passed or if there was a delay in the water heater responding to the change in setpoint to override the load shed signal.

TABLE 15. OPT-OUT RATES

EVENT DATE	NUMBER OF TREATED SITES	NUMBER OPT OUTS	PERCENT OF SHED EVENT WHERE SHED ACTION DELIVERED
JUN 21	97	0	-
JUN 25	97	2	58%, 96%
JUL 02	97	0	-
JUL 10	97	0	-
JUL 29	97	1	96%
Average per Event	**97**	**0.6**	**83%**

*Per the sample design, Georgia Power notified half the participants in advance of events one through four and six through nine and notified all participants of event five (3/6/2019) and event ten (7/29/19). Both customers who overrode the 6/25 event received advance notice.

3.2 PROCESS EVALUATION FINDINGS

In this section, we report findings from the post-installation and post-event participant surveys conducted after the first four winter DR events and all five summer DR events. *Section 2.2 Evaluation Activities* provides more detail about these surveys.

A. INSTALLATION EXPERIENCE

ILLUME conducted a short post-installation survey to assess the customer experience during the water heater installation, early experience with the water heater, and motivations for participation. We sent a link to a web-based survey via email to each participant within approximately two weeks of installation. Of participants, 75 of 100 completed this survey.

As noted, pilot eligibility required participants to have electric water heat or to convert to electric water heat. As shown in Table 16, just over two-thirds of survey respondents converted to electric water heat from natural gas or propane to participate in the pilot. Ten respondents were unsure of their water heater type.

TABLE 16: SURVEY RESPONDENT FUEL CONVERSION BY WATER HEATER TYPE

	HPWH (n=56)	ELECTRIC RESISTANCE (n=10)	NOT SURE (n=9)	TOTAL (n=75)
Switched from natural gas or propane	68%	70%	67%	**68%**
Did not switch fuel type	30%	30%	33%	**31%**
Not sure	2%	-	-	**1%**

Source: Installation survey question A1. "What type of water heater was installed in your home?" and question A2. "Did you switch from a natural gas or propane water heater to an electric water heater?"

The following subsections address the research questions related to the installation experience.

REASONS FOR PARTICIPATING

Respondents primarily enrolled in the pilot to support Georgia Power and to take advantage of the opportunity to replace old, inefficient water heaters for free. Several respondents mentioned that they viewed the pilot as a win-win situation where they could help Georgia Power and benefit by replacing their existing water heaters which were nearing the end of their useful life. For a few respondents, the pilot coincided with the homeowner's planned replacement timelines. For others, the pilot served as a cue that brought their aging water heater to mind, and they decided to take advantage of the opportunity to replace an aging unit before it became inoperative. Some respondents were interested in having a technology upgrade; motivated by both curiosity and energy conservation. Nearly 70%, switched from natural gas or propane water heaters to an electric water heater and were excited to make the switch and test out the new technology.

INSTALLATION PROCESS

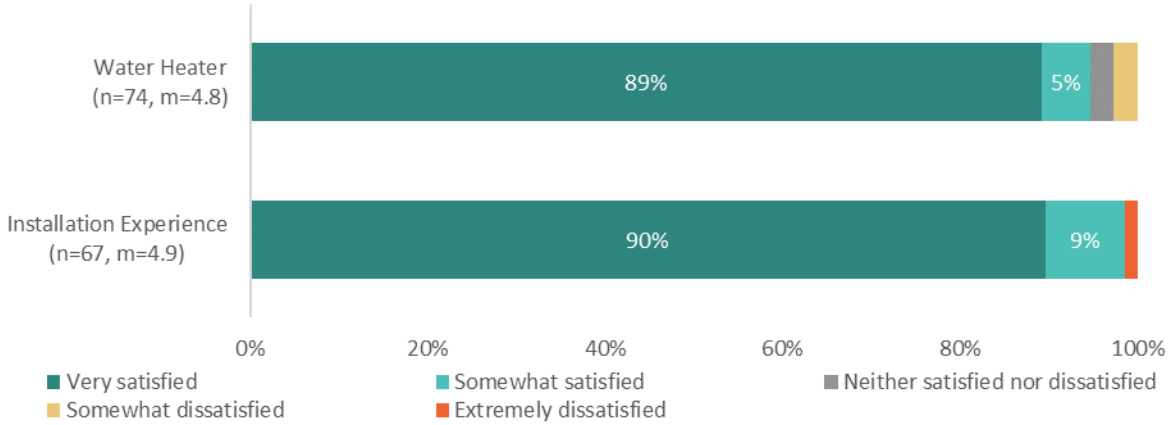
Most respondents (89%) were present for and very satisfied with the installation process (90%) (Figure 9). All respondents who were present during the installation process reported that the installers were professional and courteous during their visits. Only one respondent answered that an installer failed to clean up after completing their work, with the respondent reporting, *"Electrician did not clean up. Plumbers were awesome. Process was good overall; the installers just need a little more experience with the characteristics of the Rheem water heaters."* Many respondents expressed praise for the program manager and the installers, as one stated, *"[The program manager] has been extremely helpful. The electrician and plumbing installers arrived on time and completed the job as they said they would. I've been satisfied with the whole process so far."*

Most installations (64%) required at least two visits and took 2 – 6 hours (86%) to complete. Only 3 installations (4%) needed 3 or more visits. About 13% of appointments required more than 6 hours for completion. Almost all customers present for the installation found a convenient time for the appointments with only one respondent reporting that their installation appointment was at an inconvenient time.

INITIAL WATER HEATER SATISFACTION

Shortly after installation, the majority of respondents were very satisfied with their new water heaters (89%) and rated the new water heaters highly; the average rating was 4.8 on a 5-point scale. Almost all respondents (95%) said the new water heaters met their expectations. Reasons for satisfied ratings included: not noticing any changes in water temperature, water pressure, or overall experience using water in their home; the added features and information provided through the Rheem EcoNet app; and the long-term energy efficiency benefits they expect to experience over time. The most common complaint from respondents who were not satisfied with their water heaters was low water temperature (n=4). It should be noted, respondents provided these ratings before any DR events had taken place.

FIGURE 9. SATISFACTION WITH INSTALLATION AND NEW WATER HEATER



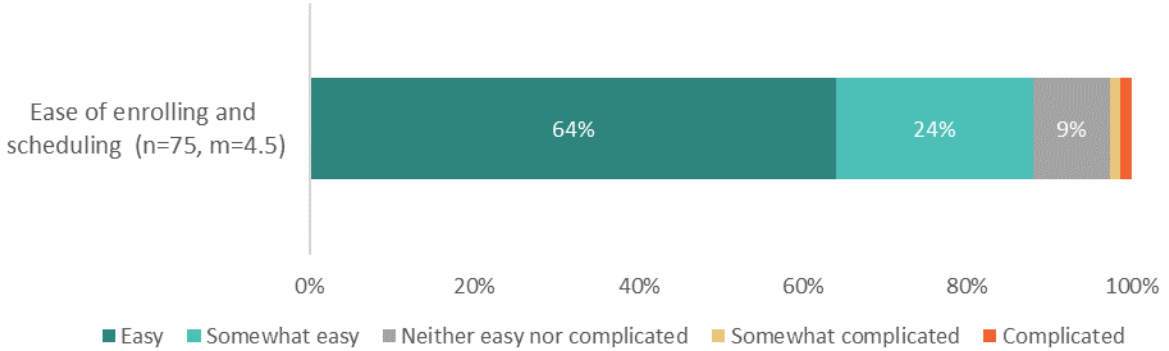
Source: Installation survey question B8. "How would you rate your satisfaction with the new water heater so far?" and question A10. "How would you rate your satisfaction with the installation experience overall?"

At the time of the post-installation survey, very few respondents (19%) had questions or concerns about the water heater that was installed. Respondents with questions or concerns most frequently noted concerns about hardware installations such as leaks, insulation or water pressure adjustments. Four respondents complained that their water did not get as hot as desired. Three respondents had questions about how to connect their unit to the Wi-Fi or were curious and seeking instructions about how to do that after installing the Rheem EcoNet app on their mobile devices. Of the 14 respondents who had questions following the installation, five reached out to an installer with these concerns, and two of the five found resolution. Three of the five had not found resolution at the time of the survey. The other nine respondents did not communicate with the installers about their concerns and three indicated that they would appreciate having someone follow up with them. ILLUME provided these questions and concerns to Georgia Power during survey fielding.

SATISFACTION WITH PROGRAM ENROLLMENT AND WATER HEATER INSTALLATION

Most respondents (64%) believed that their participation in the pilot at that point had been "*easy*." When asked to think about their experience with the WHDR Pilot so far and rate their experience enrolling in the program and scheduling their water heater installation, most respondents (64%) found the sign-up process to be easy, rating ease of the process an average of 4.5 on the 5-point scale where 1 meant "complicated" and 5 meant "easy." Only two customers rated the processes as somewhat complicated or complicated (Figure 10).

FIGURE 10. EASE OF PROGRAM ENROLLMENT AND SCHEDULING INSTALLATION



Source: Installation survey question C2. "Thinking about your experience with signing up for the program and scheduling installation, how would you rate your overall experience with the WHDR Pilot so far?"

INITIAL QUESTIONS AND CONCERNS ABOUT DR EVENTS

Very few respondents (16%) had any questions or concerns about the upcoming DR events when their water heater was installed. In general, these questions were related to how the DR signal would work. For example, one respondent asked, *"I'm unclear how Georgia Power is able to exercise the control. I didn't set anything up in the Rheem app to allow this. I am wondering if I missed a step? Also, I'm curious if I can see when those events are sent from within the app."*

Respondents were also concerned that changes they made to their devices would affect the DR events. One respondent said, *"I would like to know more about how it is supposed to be saving the company energy when there are demand peaks. I mean substantial savings. Also, would like to know when I should expect to be told that a signal will be sent to my water heater."* Another respondent asked, *"Is it possible to adjust the temp on water heater without affecting the pilot (study)."* An additional concern about pairing the water heater with other smart home devices was raise by a respondent who asked, *"I linked the water heater to my nest thermostat. Do I need to do this or does it create an issue if Nest is managing my "response" rather than GPC?"*

Some respondents who had experienced failure to connect their devices to the Wi-Fi were concerned that the program would not work at all. Others were concerned about experiencing disruptions in their household routines as a result of the events.

B. DR EVENT EXPERIENCE

ILLUME also conducted participant surveys after 9 of the 10 DR events (described in *Section 2.2 Evaluation Activities*) to provide further insight into customer experience with the DR events and the pilot over time. The remaining sections present findings from these surveys.

It is important to note that—because so few respondents completed all nine post-event surveys—we could not conduct a longitudinal analysis to claim statistical findings across time. Instead, we report event-specific findings for the majority of questions. For some questions, we report the mean frequency or rating, or comparison of proportions across events, to provide a "bellwether" or general indicator of customer response to the question. This mean cannot be read as statistically valid, but it can provide qualitative insight into trends. Finally, respondents varied across surveys, so while there is some overlap, the same set of respondents did not complete each of the surveys.

The following subsections address the research questions related to the DR event experience through the post-event surveys conducted after the first four winter DR events and all five summer DR events.

EVENT NOTIFICATION

As noted in *Section 1.3* Design, Georgia Power was interested in testing the effects of pre-event notification on the customer experience. Together with ILLUME, Georgia Power designed and implemented a strategy to randomly assign groups to receive pre-event notification. Each post-event survey then asked all respondents, regardless of their pre-event notification group, if they recalled receiving an email notifying them of the upcoming DR event. Most respondents that were in the notification group remembered this notification, however, fewer respondents recalled the notice after the February 18 and February 26 DR events (Table 17). The percentage of respondents who recalled the email ranged from 29% after the February 26 DR event to 100% after the February 7 event.

TABLE 17. RECOLLECTION OF PRE-EVENT NOTIFICATION BY EVENT

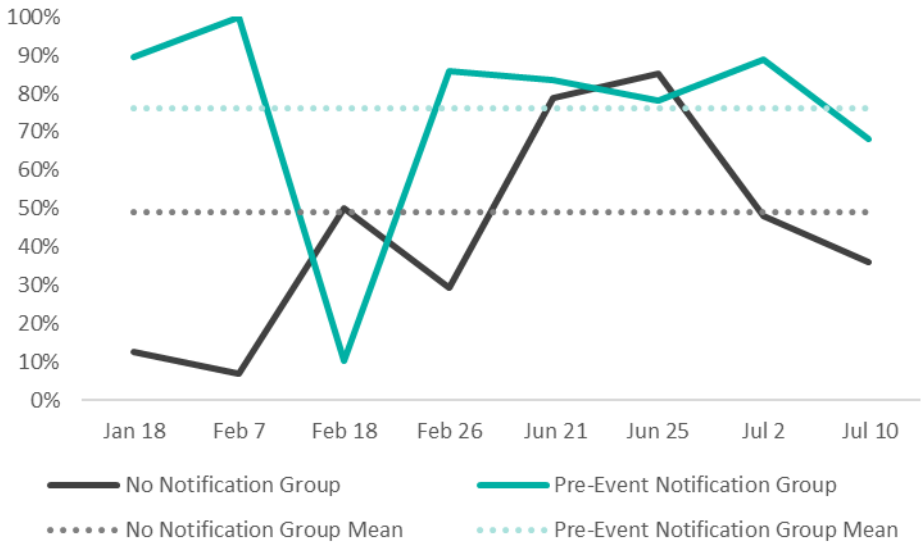
	JAN 18 (n=34)	FEB 7 (n=28)	FEB 18 (n=30)	FEB 26 (n=34)	JUN 21 (n=19)	JUN 25 (n=23)	JUL 2 (n=27)	JUL 10 (n=22)	JUL 29[a] (n=41)
Remember receiving event notification	89%	100%	50%	29%	79%	78%	89%	68%	88%
Does not remember receiving event notification	11%	0%	50%	71%	21%	22%	11%	32%	12%

Source: Survey Question C1. "Do you remember getting notified of a demand response event scheduled for EVENT TIME?" Base = respondents who were notified.

[a] All participants were notified in advance of July 29 DR event.

Interestingly, some respondents who were not in the pre-event notification group said they remembered being notified of the DR events. In three of the post-event surveys, at least 50% of those who were not in the pre-event notification group indicated that they received notification (February 18, June 21, and June 25). On average, 49% of non-pre-event notification respondents and 76% of those in the pre-notification group recalled receiving the notification (Figure 11).

FIGURE 11. RESPONDENTS WHO RECALLED PRE-EVENT NOTIFICATION BY NOTIFICATION GROUP



Source: Survey Question C1. "Do you remember getting notified of a demand response event scheduled for EVENT TIME?" Base = all respondents.

In addition to emailing participants, Georgia Power also texted participants to notify them of the final DR event (July 29). Of the 20 respondents who expressed preferences for how they receive DR event notification, 14 preferred email notification, 3 preferred receiving both the text and email, and 2 preferred the text notification.

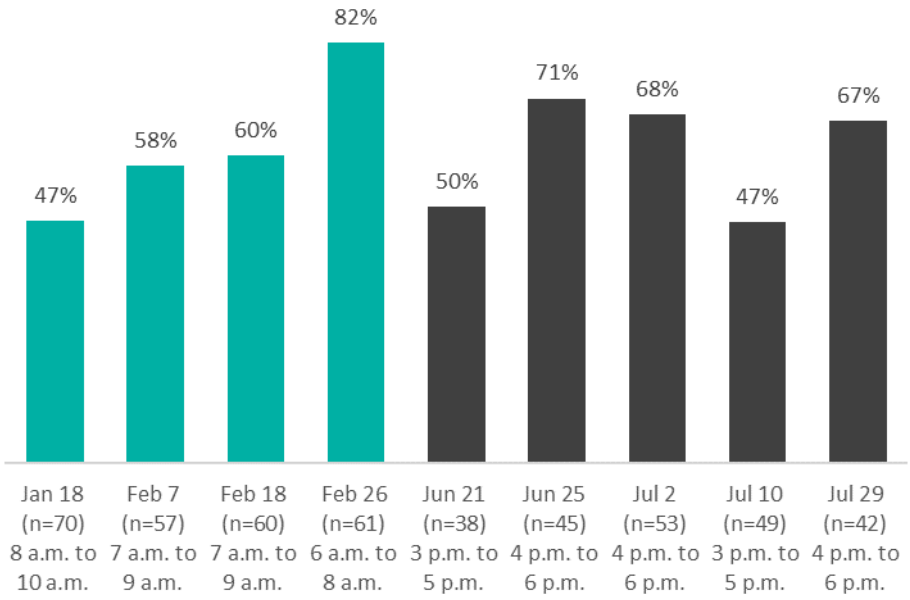
OPT OUTS

Participants who received advance notice of events were able to opt-out of an event through the email notification. All participants were able to opt out of the DR events by manually or remotely changing the water heater setpoint during a DR event. Notification of the event did not make a significant difference in whether the respondent was home during the DR event or opted out of the DR event. In fact, no participants opted out of any DR events in advance and self-reported participation aligned with that provided through the program with very few respondents overriding the setpoint during events.

EVENT EXPERIENCE

Respondents were most likely to be home during DR events held in the early morning before people typically leave for work and in the early evening when they return home. In winter, respondents were significantly more likely to be home during the 6:00 a.m. to 8:00 a.m. DR event (February 26) than they were during the other winter DR events held later in the morning. In summer, respondents were more likely to be home during the 4:00 p.m. to 6:00 p.m. DR events than the 3:00 p.m. to 5:00 p.m. DR events. Figure 12 provides additional detail on the percentage of respondents who were at home during part or all of each surveyed DR event.

FIGURE 12. PERCENTAGE OF RESPONDENTS HOME DURING PART OF ALL OF DR EVENT



Source: Survey Question C4. "Were you at home EVENT TIME?" Base = all respondents.

Generally, respondents experienced few issues with their hot water, disruptions to routines, or negative effects due to any changes made to their water heater during the DR events. In fact, respondents reported no related issues during three DR events (1/18, 6/21, and 7/10). The largest number of respondents reported issues after the February 26 event, the event for which the most participants were home. This event took place from 6:00 a.m. to 8:00 a.m., a time of day when it is likely that more people are showering before work (Figure 13). Additionally, neither pre-event notification nor preheating appeared to impact the number of respondents who reported any issues with hot water, disruptions to routines, or other negative effect from the DR event. The following subsections provide additional details.

HOT WATER

The survey asked respondents if anyone in their home experienced any of the following issues with their water heater: water temperature would not get hot enough, ran out of hot water, water took too long to heat, or water was too hot. The highest rate of issues related to water temperature was on February 26, when 10 respondents reported experiencing problems, most often that the water would not get hot enough.

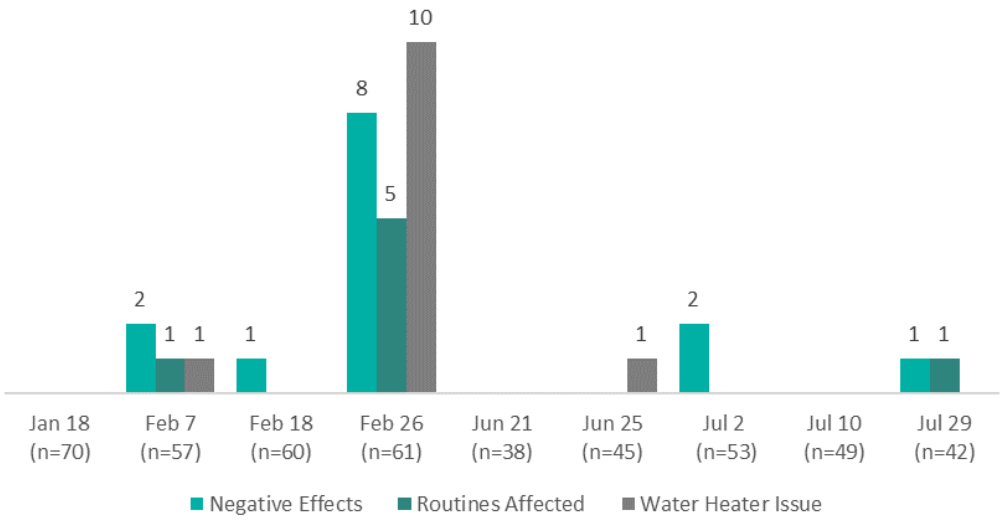
IMPACT TO ROUTINE

Very few respondents reported that the DR events affected their routines. In fact, respondents noted disruption to their routines after only three of the nine surveyed events (Figure 13). The largest proportion of respondents reported disruption to their routines after the February 26 event, when 8% said their routines were affected. As noted previously, this event took place between 6:00 a.m. and 8:00 a.m. when more people may have been getting ready for work or school. In general, respondents who reported that their routines were affected noted that getting ready for work or school was an issue and that the water not reheating in between showers affected their routines.

OTHER NEGATIVE EFFECTS

The survey also asked respondents if they experienced any other negative effects as a result of the DR events or if letting Georgia Power adjust their water heater bothered them. Very few respondents experienced any other negative effects and the majority (89%) were not bothered by the adjustments to their water heater setpoint. On average across events, 2.7% of respondents reported experiencing negative effects as a result of having their water heater setting changed. The February 26 event had the highest number of respondents facing negative effects (8); this was the outlier among events. Other events ranged from no respondents reporting negative effects to 2 respondents reporting negative effects (February 7 and July 2). The only negative effects respondents mentioned when asked to describe their negative experience were that the event itself lasted too long and that the water was too cold.

FIGURE 13. EVENT EFFECTS ON RESPONDENTS



Source: Survey Questions C5, C7, and C9. C5. "Did you or anyone in your home experience any of the following during that time frame? Response option: 1. Water temperature would not get hot enough; 2. Ran out of hot water; 3. Water took too long to heat; 4. Water was too hot; 5. None of the above" Base = respondents who reported being home during some or all of the event; C7. "Were any routines in your home affected by this demand response event?" Base = all respondents; "Did you or others in your home experience any negative effects as a result of having your water heater's setting changed through the demand response event?" Base = all respondents.

EFFECT OF PRE-EVENT NOTIFICATION AND PREHEATING ON EVENT EXPERIENCE

As stated above, the number of survey respondents was too low to conduct statistical tests on the embedded pre-notification and preheat participants. Instead, we conducted a pattern analysis across multiple survey questions and events to understand the difference between these groups and the effect of pre-notification and preheating on customer experience. Based on this analysis, we found very little difference in the customer experience of those who received pre-notification and those who did not, and those who received preheating and those who did not across the following topics:

- Whether or not respondents recalled receiving email notifications
- Likelihood to be home during an event

- Event opt-out rates
- Rate of reporting any issues with their water temperature, routines, or any other negative effect
- Satisfaction with the pilot overall and Georgia Power
- Willingness to participate in a future water heater DR program

ADDITIONAL ACTIONS TAKEN DURING EVENTS

While the pilot communications did not specifically ask participants to take additional actions during times of high energy use, we asked respondents who received pre-event notification if they avoided using hot water or took any additional energy-saving actions, like turning off lights or avoiding cooking, during the event. Overall, few respondents took additional action during the DR events, but more respondents reported taking actions in the winter when DR events were in the morning than in the summer when DR events were in the late afternoon/early evening. On average, only 14% of respondents who were notified of the DR event took additional actions, primarily related to avoiding hot water use, during the event. During winter events, between 7 and 29% of respondents who received a pre-event notification reported taking additional action; during summer events, between 11 and 13% of respondents reported taking additional actions.

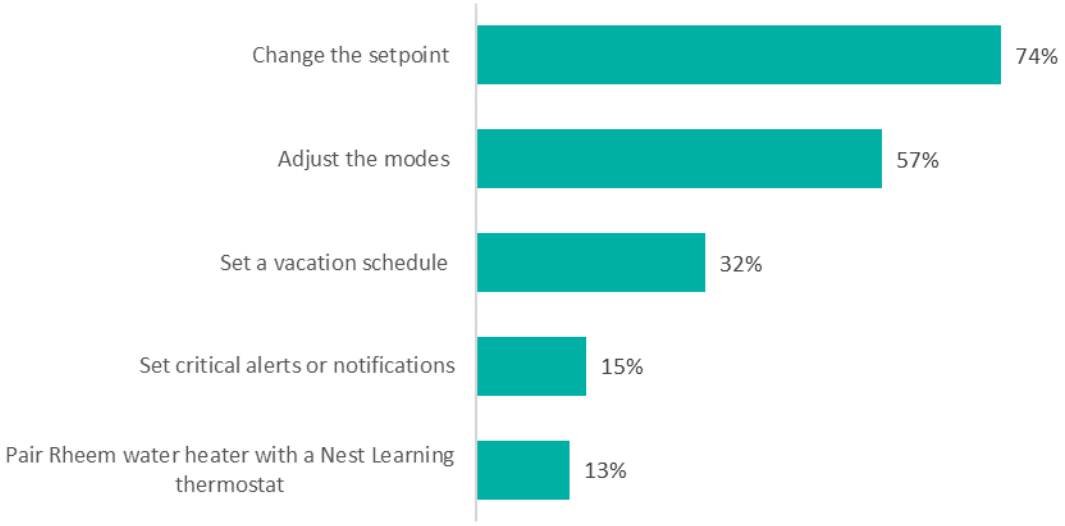
C. WATER HEATER EXPERIENCE

Almost all respondents (99%) moderately or completely agreed with the statement that they are satisfied with their water heater. We asked this question of all respondents after the first and final surveyed DR events. After the first DR event 84% agreed completely that they were satisfied with their water heater; in the final event, 92% of respondents agreed completely. While we cannot test for statistically significant difference in the increase due to the small sample size, it is promising that satisfaction with the water heater remained high in the final surveyed event.

Overall, respondents did not report having many issues with their Rheem water heater. The most commonly reported issue was connecting the water heater to Wi-Fi, with 15% (n = 12) reporting this issue. Of those with trouble connecting, five had issues with the Wi-Fi network itself. People described having low or spotty Wi-Fi signal which affected their water heater staying connected. For example, one respondent said, “Had poor wifi signal in basement. Once the wifi signal issue was corrected installation of app was fairly simple.” Ten of these 12 reported that the issues were resolved.

Every respondent said they installed the Rheem EcoNet mobile app and the majority agreed that the app was easy to use (84%). Respondents most frequently used the app to adjust the setpoint of their water heater (74%) and adjust the mode of the water heater (57%). Figure 14 describes the other ways respondents used the mobile app. Across all surveys, 14 unique respondents in total experienced problems with the Rheem EcoNet mobile app. Respondents most commonly reported having issues with the app because their water heater disconnected from wifi occasionally. Respondents would also like to receive more information through the app such as event notifications and “sensor readings, time of day peaks, time between run cycles, etc.”.

FIGURE 14: WAYS RESPONDENTS USED THE RHEEM ECONET MOBILE APP



Source: Survey Question D4. "Have you used the Rheem EcoNet mobile app to….? (select all that apply)"

D. SATISFACTION WITH THE PILOT AND GEORGIA POWER

PROGRAM SATISFACTION

Respondents were satisfied with the WHDR Pilot and its components. For overall pilot satisfaction, respondents gave mean ratings between 4.4 and 4.8 (on a scale of 1 to 5 where 1 is *very dissatisfied* and 5 is *very satisfied*). Almost all pilot components received mean ratings of 4.0 or higher. The only component that received any mean ratings lower than a 4.0 was the amount of notice before a DR event; these lower responses were after the February 7 and February 18 events. Respondents generally gave some of the highest component satisfaction ratings after the first event and some of the lowest after the second event, but then gave higher ratings again for subsequent events. Table 18 shows the mean ratings for each of the various pilot components after each event.[13]

[13] Survey respondents varied across surveys, while there is some overlap, the same set of respondents did not complete each survey.

TABLE 18. MEAN SATISFACTION WITH PILOT COMPONENTS BY EVENT

	JAN 18	FEB 7	FEB 18	FEB 26	JUN 21	JUN 25	JUL 2	JUL 10	JUL 29
Number of DR events	4.9 (n = 55)	4.2 (n = 51)	4.5 (n = 50)	4.6 (n = 60)	4.2 (n = 38)	4.4 (n = 42)	4.3 (n = 53)	4.4 (n = 49)	4.4 (n = 42)
How water heater settings adjust during DR events	4.7 (n = 47)	4.0 (n = 43)	4.5 (n = 43)	4.3 (n = 56)	4.3 (n = 38)	4.6 (n = 40)	4.5 (n = 51)	4.5 (n = 46)	4.7 (n = 40)
How water heater responds after DR events[a]	NA	NA	NA	NA	4.5 (n = 38)	4.6 (n = 41)	4.5 (n = 49)	4.7 (n = 48)	4.7 (n = 40)
Ease of opting out	5.0 (n = 42)	4.1 (n = 41)	4.3 (n = 43)	4.5 (n = 58)	4.7 (n = 36)	4.8 (n = 41)	4.6 (n = 47)	4.7 (n = 44)	4.7 (n = 37)
Amount of notice before DR event	4.7 (n = 50)	3.9 (n = 49)	3.7 (n = 47)	4.4 (n = 58)	4.6 (n = 38)	4.7 (n = 40)	4.5 (n = 52)	4.6 (n = 48)	4.8 (n = 39)
Availability of hot water during DR events	4.8 (n = 41)	4.4 (n = 42)	4.5 (n = 46)	4.4 (n = 54)	4.7 (n = 34)	4.7 (n = 38)	4.6 (n = 49)	4.7 (n = 46)	4.7 (n = 39)
Availability of hot water after DR event[a]	NA	NA	NA	NA	4.6 (n = 36)	4.6 (n = 41)	4.6 (n = 52)	4.7 (n = 48)	4.6 (n = 39)
WHDR Pilot overall	4.8 (n = 64)	4.4 (n = 53)	4.6 (n = 55)	4.7 (n = 60)	4.8 (n = 38)	4.8 (n = 43)	4.6 (n = 52)	4.8 (n = 49)	4.8 (n = 41)

Source: Survey Question E1. "Please rate your satisfaction with each of the following aspects of the Water Heater Demand Response Pilot" Base = all respondents.

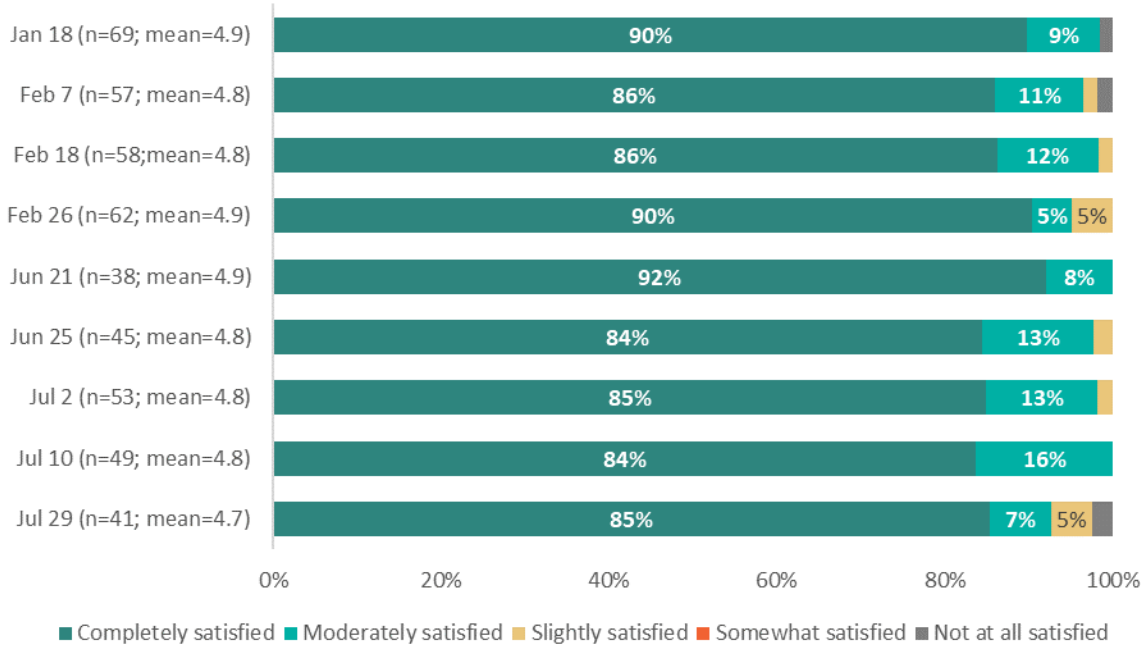
Note: Variation in *n* for each event date is due to large numbers of "Don't know" responses to some questions.

[a]This question was only asked in summer event follow up surveys.

OVERALL SATISFACTION WITH GEORGIA POWER COMPANY

WHDR Pilot participants, who were primarily Georgia Power employees, rated their overall satisfaction with Georgia Power as their utility service provider after each event highly (Figure 15). The majority (ranging from 93 to 100%) of respondents were either *completely* or *moderately satisfied* with Georgia Power after each event. The mean satisfaction ratings ranged from a 4.7 (July 29 event) to a 4.9 (two winter events and one summer event).

FIGURE 15. GEORGIA POWER SATISFACTION BY EVENT



Source: Survey Question E2. "Taking into consideration all aspects of your utility service experience, please rate your current satisfaction with Georgia Power overall as your electric service provider?" Base = all respondents

INTEREST IN PARTICIPATING IN FUTURE WATER HEATER DR PROGRAM

The majority of respondents (average of 75% across events) said they would participate in a future water heater DR program. The summer post-event surveys asked respondents if they would be interested in participating if Georgia Power offered another water heater DR program to customers with eligible water heaters. The responses ranged from 72% (July 2 and July 29 events) to 82% (June 21 event).

When asked what type of incentive they would like to receive for participating in a future program, the respondents most frequently suggested a bill credit (n=14 unique suggestions across events) or rate reduction (n=8 unique suggestions across events). Respondents also made more interesting incentive suggestions, including preferential treatment in other Georgia Power programs like the solar credit program (n=4 unique suggestions across events)[14], additional technology—like additional water heaters or smart technology for their homes (n=2 across events), and gift cards to the Georgia Power Marketplace (n=2 unique suggestions across events).

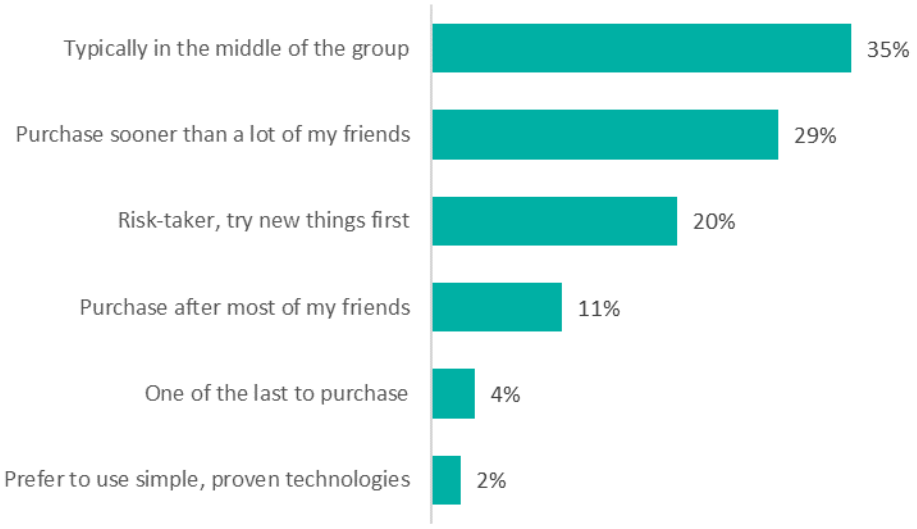
[14] Quote from survey, "Free enrollment in the Simple Solar program."

E. PARTICIPANT DEMOGRAPHICS

CUSTOMER ATTITUDES & BEHAVIORS

The majority of respondents said they purchased new technology in the 'middle of the group' (35%) or before their friends (29%) (Figure 16). Only 20% of respondents considered themselves to be risk-takers when it came to technology adoption. Unlike other smart technology pilots where participants often claim they are seeking new technology which leads them to participate, such as Georgia Power's BYOT Pilot, these respondents said they needed a new water heater (38%) and wanted to help Georgia Power in a pilot (13%). It should be noted that participants did receive a new water heater at no cost through the program which may explain the motivations for participating.

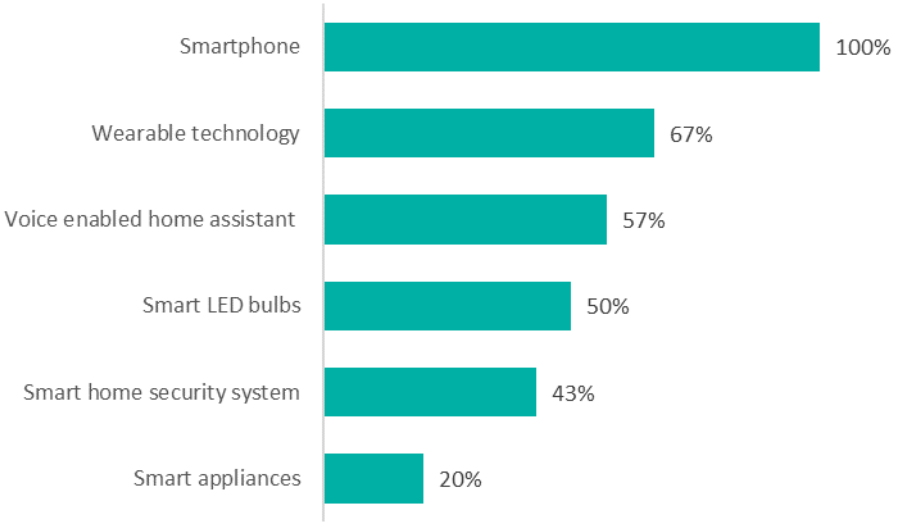
FIGURE 16. TECHNOLOGY ADOPTION PREFERENCE (n = 84)



Source: Survey Question F2. "Some people like to be the first people to try out a new product while others like to wait and see what works well or what becomes popular before making a purchase. Thinking about how soon you buy new technologies, which of the following best describes you? (You can think of things like electronics or appliances)"

Despite not classifying themselves as being early adopters or being motivated to participate in the pilot because of the technology, all respondents reported having a smartphone, just over two-thirds (67%) said they had wearable technology, and over half (57%) had voice enabled home assistants (Figure 17).

FIGURE 17. SMART TECHNOLOGY ADOPTION (n = 84)



Source: Survey Question F1. "Do you or any member of your household own any of the following? (select all that apply)"

DEMOGRAPHICS

Nearly half of the participants live in newer homes (built in 2000 or later, 46%). Additionally, most of the participants own their homes (98%) and have lived in their current house for at least 6 years (57%). Nearly two-thirds have two or three person households (61%).

Program participants are generally between 25 and 44 years old, well-educated, and affluent; 59% are between 25 and 44 years old, and 86% have four year or advanced degree. Most participants are employees of Georgia Power.

Participant Characteristics

TABLE 30 and Table 31 provide additional detail on the demographic and household characteristics of pilot participants.

Table 30 and Table 31 in *Appendix A. Supplementary Findings, Tables, and Figures* provide additional detail on the demographic and household characteristics of participants.

3.3 DESIGN & EVALUABILITY CONSIDERATIONS

In this section, we present findings and recommendations for the design and evaluation of a future Water Heater DR pilot or program, as well as potential additional research opportunities.

A. DESIGN AND EVALUATION CONSIDERATIONS

For future Water Heater DR pilots or programs, the team provides the following program design, data needs, and metrics considerations.

DESIGN CONSIDERATIONS

Experimental designs are feasible to implement for cloud-based DR programs and enable evaluators to provide more accurate estimate of impacts at lower costs.

The WH DR Pilot used a *within subject baseline* approach to establish the counterfactual — an estimate of what participants' energy demand would have been during the event period in the absence of the event. With this approach the pilot could include all participants in every event and hold events on all eligible days. Given the small size of the pilot, including all participants was important for statistical power.

If future pilots or programs include more participants, a power analysis using results from this pilot (treatment effects, variability, participation rates) can suggest appropriate treatment and control group sizes needed for an experimental design. Below we summarize the advantages and considerations for two approaches to an experimental design:

(1) Participant experimental design splits participants into treatment and control groups for each event and uses the control group demand and energy use as the counterfactual.

Advantages: The experimental design (assuming groups are balanced) enables simpler modeling and more confidence in the baseline since the baseline is the event day.

Considerations: Since some customers will be part of the control group, the program will not be using all available resources on days when they may be most needed. The random assignment should take into consideration factors that may affect impacts such as water heater type, geography, and average energy use to ensure the treatment and control groups are balanced.

(2) Control day approach identifies days that are eligible for events and then randomly assigns a subset as control days. These control days are leveraged for establishing the baseline possibly with other non-eligible, non-event days.

Advantages: The control days will have similar extreme weather to the event days, providing a baseline of like days to leverage as a counterfactual. All customers participate on event days.

Considerations: This approach is only possible if the demand response resources are not needed on some extreme weather days

METRICS

Below we list several metrics that, if collected, will aid in assessing a Water Heater DR program from the utility and customer perspective.

- Recruitment: Number of customers signing up for program and number who un-enroll
- Demand reductions per household and per event
- Energy use over entire event (pre, event, post) compared to baseline
- Device participation and reasons for not participating (connection issue, voluntary opt-out, etc.)
- Customer satisfaction with the program (satisfaction with the enrollment process, incentive, number of events, ease of overriding events, amount of notice before events, how the program adjusts water heater set points)

DATA AND ANALYSIS CONSIDERATIONS

Different types of data will facilitate impact and process evaluations, depending on the goals and needs of those evaluations. Below we outline the uses of different types of data to support the evaluation of Water Heater DR programs.

Interval meter data are needed to calculate demand reductions. Because interval meter data captures all energy use in the home, higher resolution data captured at shorter time-intervals improve the ability to detect the impact of Water Heater DR programs. Hourly data is often insufficient when analyzing impacts of programs with small effects or that start/end on the quarter or half hour. In these instances, shorter interval data (e.g. 15-minute) may be needed to detect impacts. Additionally, because residential customers frequently use less than 1 kWh per hour, integer values for interval meter data will obscure small changes in energy demand and use. Decimal reads for interval data enable greater accuracy in determining changes in energy use. Georgia Power was able to reprogram WHDR pilot participant meters to include decimals in hourly intervals.

B. FUTURE RESEARCH OPPORTUNITIES

In this section, ILLUME highlights research opportunities for Georgia Power to consider, whether they be for program planning or as a part of a future pilot or program.

ADDITIONAL ANALYSIS

With the data that is already available from this evaluation, Georgia Power could pursue additional research to better inform future program planning. We provide some opportunities below.

DR Savings Forecast: Georgia Power could provide a better estimate of forecasted DR savings by using Rheem data to understand water heater load shapes, incorporating the load shapes in the AMI analysis directly and testing the accuracy of the forecasted savings. Georgia Power could then use those results to design a program to meet various needs, e.g. to identify savings for critical hours during different weather conditions and at different times of the day or year and for different customers.

Length of Post-Event Impacts: During Summer events where load shift was implemented before load shed, savings lingered for the hour after shed. Georgia Power could consider conducting research to determine if those savings drift toward zero over time or if a snapback eventually occurs.

Length of Load-Building events: Georgia Power could consider analyzing tank temperatures (as collected by the WH manufacturer) to assess the temporal impact of load-building (or Renewable Energy) events by gaining an understanding of how long a water heater can maintain usable tank temperatures post a load-building event. This would allow Georgia Power to identify optimal load building strategies that can be used for seasonal intermittent renewable events.

ADDITIONAL DATA COLLECTION

Device level demand data could provide insight into the proportion of heat pump water heaters that are operating in heat pump vs. electric resistance heating mode during typical peak periods. This information could better inform our understanding of savings for heat pump water heaters, as those modes correlate to different levels of demand reduction. To collect this data, Georgia Power could use TED monitoring devices for a larger sample of customers. If installing TED devices for a very large sample of customers is not possible, Georgia Power could consider installing them for a representative sample of participants at 30 participants or 15% of participants, whichever is higher.

4. METHODOLOGY

4.1 IMPACT ANALYSIS METHODOLOGY

ILLUME estimated the demand reduction achieved during the DR events using hourly AMI data for participating homes. ILLUME conducted the impact analysis through data cleaning and preparation, identifying baseline or counterfactual days, and regression modeling. We describe each activity in detail below.

In addition to estimated peak demand reduction during the event period, the team also estimated the overall "event-related" impact on energy use, defined as the overall energy impact in the load shift, load shed, and post-event periods taken together.

DATA CLEANING AND PREPARATION

Georgia Power provided our team AMI data as hourly, cumulative values. We converted cumulative values to hourly interval power draw and removed hours with duplicate-yet-conflicting readings. We compared regression results with minimum filtering to those with additional cleaning, which corroborated the findings presented in this report.

ILLUME then removed invalid sites (e.g., sites with AMI data stored as integers, sites with connectivity issues during the event). Table 19 shows the final sample sizes that remained for each event.

TABLE 19. FINAL SAMPLE SIZES FOR WINTER DR EVENTS

EVENT DATE	LOAD SHED EVENT SAMPLE SIZE	% WITH SHED CONNECTIVITY ISSUES[a]	LOAD SHED SAMPLE SIZE	% WITH SHIFT CONNECTIVITY ISSUES[a]
Friday, 1/18/2019	80	3%	40	10%
Thursday, 2/7/2019	90	9%	40	28%
Monday, 2/18/2019	90	1%	41	5%
Tuesday, 2/26/2019	91	100%	41	100%
Wednesday, 3/6/2019	91	10%[b]	91	10%[b]

[a] Percent of sites where Rheem data indicates that the water heater was not connected and/or that load shift or shed was delivered for less than 60% or more of the event period.

TABLE 20. FINAL SAMPLE SIZES FOR SUMMER DR EVENTS

EVENT DATE	LOAD SHED EVENT SAMPLE SIZE	% WITH SHED CONNECTIVITY ISSUES[a]	LOAD SHED SAMPLE SIZE	% WITH SHIFT CONNECTIVITY ISSUES[a]
Friday 6/21/2019	94	14%	49	0%
Tuesday 6/25/2019	95	4%	43	10%
Tuesday 7/2/2019	93	1%	48	0%
Wednesday 7/10/2019	94	1%	44	6%
Monday 7/29/2019	94	30%	49	31%[a]

[a] Percent of sites where Rheem data indicates that the water heater was not connected and/or that load shift or shed was delivered for less than 60% or more of the event period.

SITE ACCOUNTING

To enable the largest sample size available for the evaluation analysis, ILLUME included sites that we could verify met the following criteria:

- Had no energy efficiency measures installed
- Were enrolled
- Had available AMI data

In the following two tables, we present the total and average number of sites per event across these criteria. For winter events, connectivity and enrollment caused high degrees of site attrition. For summer events, merging between AMI data, data on shift assignment, and Rheem data caused the highest degree of site attrition.

TABLE 21. WINTER SITE ACCOUNTING

ANALYSIS STEP	AVERAGE NUMBER OF SITES PER EVENT	NUMBER OF DROPPED SITES	% DROPPED
Treatment Delivered	97	-	-
Enrolled	89.4	7.6	8%
No Energy Efficiency Measures Installed	88.4	1	1%
Removed for Modeling Data Requirements (e.g., Hourly AMI, data on load shift assignment and enrollment, device data on treatment delivery)	76.5	11.9	13%
Shed Treatment Delivered for 60% or More of the Event Period	71.8, 57.4 [a]	4.7, 19.1 [a]	6%, 25%[a]
AMI Data Filter	71.8, 57.4	4.7, 19.1	0%

[a] The Rheem data indicates that shed load action was not delivered February 26, 2019. Outside of that event and where Rheem data exists (events 1-3), connectivity issues affected 6% of sites; including that event and the available data for event 5, connectivity issues affected 25% of sites. Without the February 26 event, the average number of sites per event is 71.8, including that event it is 57.4.

TABLE 22. SUMMER SITE ACCOUNTING

ANALYSIS STEP	AVERAGE NUMBER OF SITES PER EVENT	NUMBER OF DROPPED SITES	% DROPPED
Treatment Delivered	97	-	-
Enrolled	97	0	0%
No Energy Efficiency Measures Installed	97	0	0%
Removed for Modeling Data Requirements (e.g., Hourly AMI, data on load shift assignment and enrollment, device data on treatment delivery)	68.6	28.4	29%
Shed Treatment Delivered for 60% or More of the Event Period	61.6	7	10%
AMI Data Filter	51.2	10.4	17%

For exploratory analysis (i.e., for all other analyses), ILLUME used only sites for which all relevant data was available including Rheem data on connectivity.

DOUBLE-COUNTED SAVINGS

Double-counted impacts (demand reductions or energy savings) can occur if customers participated in other energy efficiency programs and impacts from those actions are claimed by the energy efficiency program and are captured in the analysis of AMI data for the DR evaluation. We assessed the risk of double-counted impacts by cross-referencing the DR participants with program tracking data from the following Georgia Power energy efficiency programs:

- Home Energy Improvement program
- Refrigerator Recycling program
- HVAC Service

- Marketplace

We flagged any participation that occurred during the periods of time from which we selected baseline days. As described in the section below, the impact analysis used non-event baseline days from the event seasons to establish the counterfactuals—what would participants' energy use have been in absence of the events. Any participation in other energy efficiency programs that took place prior to the time period used for baseline day selection becomes part of the baseline. For example, if a customer installed a high efficiency air conditioner in June, then that device affects energy use on both the baseline days and the event days (as the first date for baseline day selection is August 1) and thus is netted out of impact calculations. Only participation in other energy efficiency programs that occurs in-between selected baseline days can affect DR impacts.

Ultimately, we found very little participation in other energy efficiency programs during the time periods used for baseline day selection and, as such, minimal risk of double-counted impacts. As shown in Table 23, ILLUME removed from the analysis one site that purchased a Nest thermostat through the Georgia Power Marketplace in close proximity to the winter events.

TABLE 23. CROSS-PARTICIPATION WITH OTHER GEORGIA POWER PROGRAMS

PROGRAM NAME	NUMBER OF CROSS PARTICIPANTS – WINTER EVENTS	NUMBER OF CROSS PARTICIPANTS – SUMMER EVENTS
Home Energy Improvement Program	0	0
HVAC Service	0	0
Refrigerator Recycling Program	0	0
Marketplace – Lighting	0	0
Marketplace – Nest Products	1	0
Marketplace – Other thermostats	0	0
Total count of cross participants	1	0

BASELINE OR COUNTERFACTUAL DAYS

Since the pilot does not have a control group, the team estimated a baseline for each event based on participants' energy use during non-event days. This method is often called a "within subject baseline" approach. We selected three non-event days from those that closely matched each event day based on the following criteria:

1. Within two weeks of the matching event day;
2. Not a holiday or weekend day;
3. Must not be another DR event day or test event day; and
4. Three days with the smallest temperature difference between the non-event day and event day prior to one-hour after the shed event.

REGRESSION SPECIFICATION

ILLUME used data from the selected non-event days and event days in a linear fixed effects regression model to estimate a treatment effect for each event period. The final model specification included terms that account for weather (as heating degree hours with a base temperature of 65°F and cooling degree hours with a base of 70°F), time of day, and interactions between weather and time of day. The team estimated peak demand reduction and energy savings during an event day by including variables in the model to identify treatment (i.e., taking the value of 1 for days, hours, and sites where treatment occurred and 0 otherwise). ILLUME validated the modeling using five variations of the regression model specification, which all yielded similar results, as well as reviewing the average impacts from the event level results.

ILLUME implemented multiple regression analyses for this work:

- **Evaluation:** a regression that best aligns with typical evaluation analysis.
- **Robustness Checks:** multiple regressions with minor changes to the model specification to provide an indication as to the sensitivity of the results.
- **Exploratory Analysis:** multiple regressions where impacts are separated by various characteristics (e.g., event-level results and results by water heater type).

ILLUME provides the evaluation regression specification below, where our team implemented separate models for winter and summer. ILLUME specified models for robustness checks and exploratory analyses based on the evaluation regression specification.

$$kW_{i,h,d} = \alpha_i + \sum \beta_{1,h} * Hr_h + \sum \beta_{2,d} * Event_d + \beta_3 * HDH.65_{i,h,d} + \beta_4 * CDH.70_{i,h,d} + \sum \beta_{5,d} * Event_d * HDH.65_{i,h,d} + \sum \beta_{6,d} * Event_d * CDH.70_{i,h,d} + \beta_7 * Trt.Day_d + \beta_8 * Shift.Hr_h + \beta_9 * Trt.Shift_{h,d} + \beta_{10} * Trt.Shed_{h,d} + \beta_{11} * Trt.Post_{h,d} + \varepsilon$$

kW_{avg}	Hourly average demand for site *i* at hour *h* during day *d*.
α_i	Site fixed effect for site *i*. This field captures site specific conditions that do not vary over time.
Hr_h	Hourly dummy variables for hours 1-24, where Hr_1 takes a value of 1 for observations where the hour is 1 and 0 otherwise.
$Event_d$	Event dummy variables, where $Event_1$ takes a value of 1 for the day of event 1 and its counterfactual days and 0 otherwise.
$HDH.65$	Heating degree hours at base 65°F for site *i* at hour *h* during day *d*.
$CDH.70$	Cooling degree hours at base 70°F for site *i* at hour *h* during day *d*.
$Trt.Day_d$	Dummy variable for days where load shift and/or load shed was delivered, where this field takes a value of 1 during days where load shed was sent and 0 otherwise.
$Shift.Hr_h$	Load shift dummy variable, where this field takes a value of 1 during hours where shift was delivered and 0 otherwise. This field captures unique characters of the hours for which Shift was delivered based on the counterfactual days. ILLUME adds this additional field to better control for unobservable factors that could influence

	Shift savings. ILLUME only adds this control for Shift treatment because the program is designed to only deliver shift for 50% of participants for most events.
$Trt.Shift_{h,d}$	Load shift treatment dummy variable, where this field takes a value of 1 during days and hours where shift was delivered and 0 otherwise. This field captures shift impacts.
$Trt.Shed_{h,d}$	Load shed treatment dummy variable, where this field takes a value of 1 during days and hours where load shed was intended to be delivered and 0 otherwise. This field captures shed impacts.
$Trt.Post_{h,d}$	Post-shed treatment dummy variable, where this field takes a value of 1 for the hour after shed was intended to be delivered and 0 otherwise. This field captures post-shed snapback.

DIFFERENCES FROM PREVIOUSLY REPORTED RESULTS

ILLUME reported results for the winter DR results in two previous memos, an interim memo after the first two winter DR events to provide initial savings estimates quickly and a second winter results memo after completing all five winter DR events[15]. We used increasingly rigorous methods in each report. We leveraged additional data (e.g., Rheem data) for this analysis, mirrored the exploratory analysis from previous work, and conducted an analysis aligned with typical program DR evaluations. While the results vary between the methods, the outcomes do not. For example, the results for the second event on February 7, 2019 are similar in this report (0.24 kW) to the winter report (0.25 kW) and the winter memo (0.26 kW). For the first winter event, where results varied between the winter report (0.03 kW) and memo (0.12 kW), the results in this report are 0.08 kW.

4.2 SURVEY METHODOLOGY

Because of the small pilot size, the analysis of the sample design described in *Section 1.3 Design* would have only detected very large differences (of about 30 % or more) between the different groups (load shift through preheating and pre-notification) at statistically significant levels if all 100 participants responded to each survey. With such small numbers of survey respondents, we were unable to perform statistical calculations to identify significant differences between groups. However, we focused our analysis on looking for patterns across multiple events using survey response frequencies and a qualitative review of t-test results to determine if the preheating or pre-notification seemed to influence the participant

[15] ILLUME Advising, Water Heater Demand Response Pilot: Preliminary Evaluation Results, 3/19/2019.
ILLUME Advising, Water Heater Demand Response Pilot: Winter Demand Response Event Impact Evaluation Results. 8/9/2019.

experience. For example, we compared respondents who received pre-notifications during an event to those who did not to see if they consistently responded in a certain way. Additionally, for some questions, we report the mean frequency or rating to provide a "bellwether" or general indicator of customer response to the question. This mean cannot be read as statistically valid but can provide qualitative insight into trends. The following survey questions were included in this analysis: C1, C2, C3, C5, C7, C9, D6c, E1i, and E2.

APPENDIX A. SUPPLEMENTARY FINDINGS, TABLES, AND FIGURES

This appendix outlines additional results from ILLUME's investigation into impacts and includes several supplementary tables and figures on pilot participant demographic characteristics.

WATER HEATER TANK SIZE

After leveraging Rheem data, the effect of tank size on event impacts is not clear. Some of the variability and unexpected findings may be the result of collinearity, where tank size correlates to other influential variables, such as occupancy schedule. For example, the proportion of 50-gallon water heaters in Atlanta is higher than for 66 and 80-gallon water heaters. In other words, the effect of tank size on water heater impacts may have more to do with the associated effect of occupancy schedules on impacts rather than the effects associated with the physics of thermal storage between larger and smaller tanks.

TABLE 24. WATER HEATER TANK SIZES IN ATLANTA

Water Heater Tank Size	Water Heater Type	City	Number of Sites	Percent
50 GAL.	Electric Resistance	Atlanta	8	27%
50 GAL.	HPWH	Atlanta	12	44%
66 GAL.	HPWH	Atlanta	4	17%
80 GAL.	HPWH	Atlanta	1	5%

FIGURE 25. WINTER RESULTS BY WATER HEATER TANK SIZE

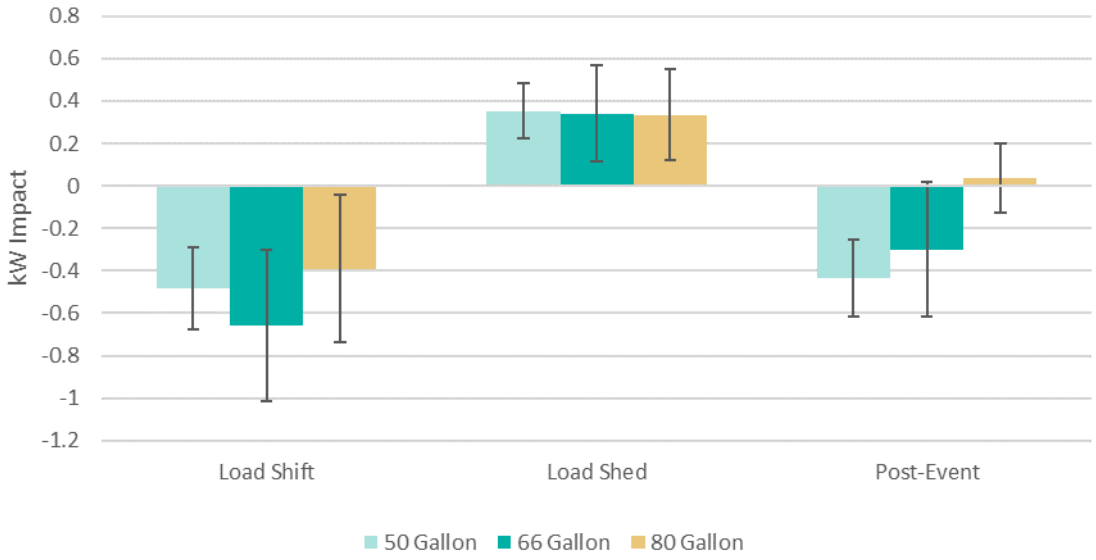
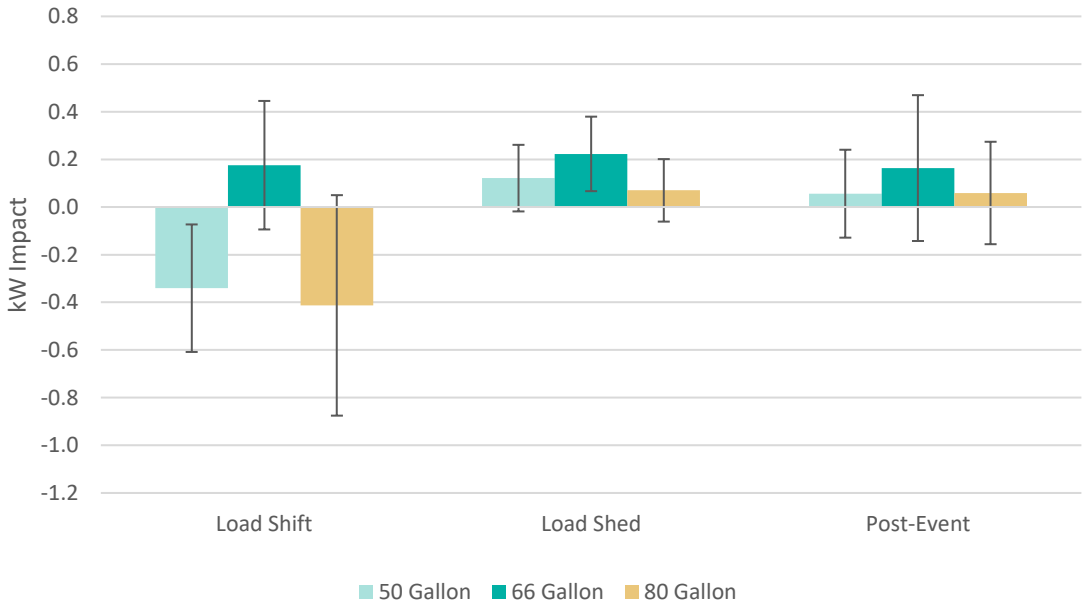


FIGURE 26. SUMMER RESULTS BY WATER HEATER TANK SIZE



NOTIFICATION

ILLUME investigated the effects of notifications on event impacts. Given the variability of results, ILLUME cannot make any determinations about whether the notification affected impacts.

FIGURE 27. WINTER RESULTS BY NOTIFICATION STATUS

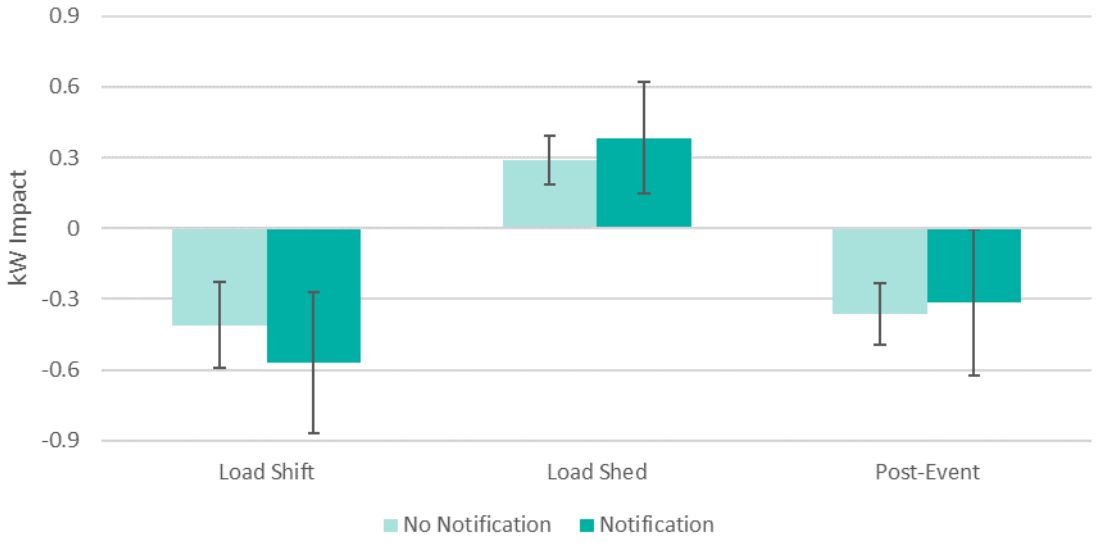
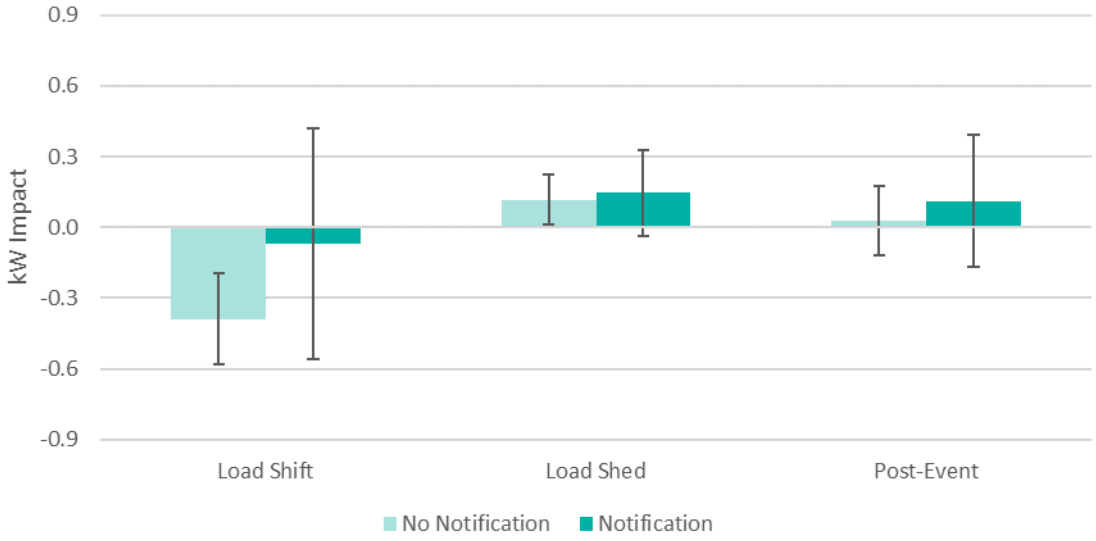


FIGURE 28. SUMMER RESULTS BY NOTIFICATION STATUS



WATER HEATER LOCATION

ILLUME investigated the impact of water heater location on shift and shed impacts. However, there are no meaningful conclusions given the sample size and available data. There are too few water heaters that are clearly in conditioned space and too many water heaters that may or may not be in conditioned space: 6% are in conditioned space; 38% are in semi-conditioned space, and 56% cannot be clearly determined.

ILLUME ran a simple regression to determine shed impacts where sample size is highest (i.e., for water heaters in basements and garages). ILLUME expects higher shed impacts in basements than in garages

during summer. Shed events save demand by lowering the water heater setpoint, and thus reducing the temperature differential between the water heater and surrounding ambient temperature, the lower the difference between the water heater and ambient temperature, the less energy the water heater requires to maintain water at the setpoint temperature. Because basements are typically cooler than garages on hot summer afternoons, ILLUME expects the opportunity for shed savings to be higher in basements than in garages. While the simple regression results support this notion, there is considerable uncertainty due to the variability in the estimate, the small sample size, and the lack of clarity around space conditioning.

TABLE 29. WATER HEATER LOCATION

WATER HEATER LOCATION	NUMBER OF SITES	NUMBER OF EVENTS	PERCENT OF SITES	SIMPLE REGRESSION SAVINGS (Summer)	SIMPLE REGRESSION P-VALUE (Summer)
BASEMENT *UNKNOWN CONDITIONING*	29	5	41%	131 W	0.09
GARAGE *SEMI-CONDITIONED*	24	5	34%	104 W	0.30
UTILITY ROOM *UNKNOWN CONDITIONING*	9	5	13%		
CONDITIONED	4	4	6%		
CRAWL SPACE *SEMI-CONDITIONED*	3	5	4%		
NOT SPECIFIED *UNKNOWN CONDITIONING*	2	5	3%		

PARTICIPANT CHARACTERISTICS

TABLE 30 and Table 31 provide additional detail on the demographic and household characteristics of pilot participants.

TABLE 30: HOUSEHOLD CHARACTERISTICS

HOME OWNERSHIP (n = 84)	PERCENT
Own	98%
Rent	2%
TENURE IN CURRENT HOME (n = 84)	
One year or less	13%
2-3 years	20%
4-5 years	10%
6-10 years	25%
More than 10 years	32%
HOME VINTAGE (n = 84)	
1900 to 1939	2%
1940 to 1959	10%
1960 to 1979	21%
1980 to 1989	8%
1990 to 1999	12%
2000 to 2004	15%
2005 or later	31%
PEOPLE LIVING IN HOME (n = 82)	
1	2%
2	29%
3	32%
4	29%
5 or more	6%

TABLE 31: PARTICIPANT DEMOGRAPHICS

AGE (N = 83)	PERCENT
25-44	59%
45-64	40%
65 and older	1%
EDUCATIONAL ATTAINMENT (n = 83)	
Some college, no degree	8%
Two-year college degree	2%
Technical college degree or certificate	4%
Four-year college degree	58%
Graduate or professional degree	28%
RACE AND ETHNICITY (n = 79)	
Asian	8%
Black or African American	32%
White	60%

APPENDIX B. POST-INSTALLATION SURVEY

This appendix contains the survey, email and landing page content the ILLUME team used to collect post-installation satisfaction information from Georgia Power customers participating in the Water Heater DR pilot. The goal of this survey was to assess the customer experience during the water heater installation, early experience with the water heater, and motivations for participation. ILLUME provided a link to a web-based version of this survey in an email to each participating customer roughly two weeks after installation.

SURVEY GUIDE

A. WATER HEATER INSTALLATION

A1. What type of water heater was installed in your home?

1. Heat Pump Water Heater
2. Electric Resistance
98. Not Sure

A2. Did you switch from a natural gas or propane water heater to an electric water heater?

1. Yes
2. No
98. Not Sure

A3. Were you present during any portion of the water heater installation?

1. Yes
2. No
98. Not Sure

[IF A3 <> 1, THEN SKIP TO B1]

A4. Was the date and time of your installation convenient for you?

1. Yes
2. No
98. Not Sure

A5. How many times did contractors/installers have to visit your home to complete the installation of your water heater? (Please include the number of visits necessary to convert to an electric water heater if applicable)

1. 1
2. 2
3. 3 or more
98. Not sure

A6. In total, how long did the installation take? (Please include the time for all visits included in the previous question)

1. < 2 hours
2. 2-4 hours
3. 4-6 hours
4. 6+ hours
98. Not sure

A7. Was the installer(s) professional and courteous?

1. Yes
2. No
98. Not Sure

A8. Did the installer(s) clean up before leaving?

1. Yes
2. No
98. Not Sure

[IF A4, A7, or A8=2, THEN A9]

A9. Please share more about how the installation process did not meet your expectations. [OPEN END]

A10. How would you rate your satisfaction with the installation experience overall?

1. Very dissatisfied
2. Somewhat dissatisfied
3. Neither satisfied nor dissatisfied
4. Somewhat satisfied
5. Very Satisfied
98. Not Sure

[IF A10 = 1 or 2, THEN A11]

A11. Why did you rate your satisfaction with the installation this way? [OPEN END]

B. WATER HEATER SATISFACTION

B1. Did you have, or do you still have, any questions or concerns about the water heater that was installed?

1. Yes
2. No
98. Not Sure

[IF B1 = 1, THEN B2]

B2. What are or were your questions or concerns? [OPEN END]

[IF B1= 1, THEN B3]

B3. Did you communicate with your installer about your concerns or questions?

1. Yes
2. No
98. Not Sure

[IF B3 = 1, THEN B4]

B4. Have your questions or concerns been resolved?

1. Yes, by the installer
2. Yes, but not by the installer
3. No
98. Not Sure

[IF B4 = 3 or 98]

B5. Would you like someone to follow-up with you to resolve your remaining questions?

1. Yes
2. No

B6. Is your new water heater meeting your expectations?

1. Yes
2. No
98. Not Sure

[IF B6 = 2 or 98, THEN B7]

B7. How is your new water heater not meeting your expectations? [OPEN END]

B8. How would you rate your satisfaction with the new water heater so far?

1. Very dissatisfied
2. Somewhat dissatisfied
3. Neither satisfied nor dissatisfied
4. Somewhat satisfied
5. Very Satisfied
98. Not Sure

B9. Why did you rate your satisfaction with the water heater installation this way? [OPEN END]

C. MOTIVATION & PILOT PROGRAM SATISFACTION

C1. Why did you decide to participate in the GPC Water Heater Demand Response Pilot? [OPEN END]

C2. Thinking about your experience with signing up for the program and scheduling installation, how would you rate your overall experience with the Water Heater Demand Response Pilot so far?

1. Easy
2. Somewhat easy
3. Neither easy nor complicated
4. Somewhat complicated
5. Complicated
98. Not Sure

C3. Do you have any questions or concerns about the upcoming demand response events that will send signals to your water heater to turn it on or off depending on the power grid's needs?

1. Yes
2. No
98. Not Sure

[IF C3 = 1, THEN C4]

C4. What are your questions or concerns? [OPEN END]

C5. Do you have any other feedback not covered in this survey that you would like to provide? [OPEN END]

CONTACT PROTOCOLS

ILLUME will send a unique survey link to each participant on the list provided weekly by Georgia Power. The participant's name will be embedded in the survey introduction language, and the Georgia Power contact name, phone number and email will be included should the participants have questions. ILLUME will monitor survey completes and send no more than two reminder emails.

POST-INSTALLATION SURVEY INVITATION EMAIL

Subject Line: Georgia Power Water Heater Demand Response Pilot – Installation Satisfaction Survey
Sender: GPC Water Heater Pilot

Dear [CUSTOMER_NAME],

Thank you for participating in Georgia Power's Energy Efficiency Water Heater Demand Response Pilot. We invite you to share your installation experience and initial feedback through a brief online survey.

Please click on the link below to take this short survey:

[SURVEY LINK]

The survey will take approximately 5 minutes to complete. If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume where you left off by clicking on the

link from this email or hitting the back button in your browser. Results will not be recorded until the final submit button is clicked.

Don't miss out on this chance to share your experience!

Sincerely,

Georgia Power Energy Efficiency - Water Heater Demand Response Pilot
Audrey Ewen
G2GPCWHDR@southernco.com

POST-INSTALLATION SURVEY LANDING PAGE

[THIS IS THE LANGUAGE THE SURVEY RESPONDENT WILL SEE AFTER CLICKING THE LINK TO THE SURVEY. THIS PAGE WILL ALSO CONTAIN THE GEORGIA POWER COMPANY LOGO.]

Thank you for participating in Georgia Power's Energy Efficiency Water Heater Demand Response Pilot! Your response to this short survey will help us understand your installation experience and initial feedback regarding your new water heater. Your responses will be kept confidential and used to help Georgia Power provide the best value to our customers.

We appreciate your input!

If you have any questions, please contact Audrey Ewen, Program Manager of the Georgia Power Energy Efficiency Water Heater Demand Response Pilot at G2GPCWHDR@southernco.com.

POST-INSTALLATION SURVEY REMINDER EMAIL

Subject Line: REMINDER: Georgia Power Water Heater Demand Response Pilot – Installation Satisfaction Survey
Sender: GPC Water Heater Pilot

Dear [CUSTOMER_NAME],

Thank you for participating in Georgia Power's Energy Efficiency Water Heater Demand Response Pilot. We invite you to share your installation experience and initial feedback through a brief online survey. We anticipate closing this survey at [TIME] on [DATE]. **Don't miss out on this chance to share your experience!**

Please click on the link below to take this short survey:

[SURVEY LINK]

The survey will take approximately 5 minutes to complete. If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume where you left off by clicking on the link from this email or hitting the back button in your browser.

Thank you for your feedback!

Sincerely,
Georgia Power Energy Efficiency - Water Heater Demand Response Pilot
Audrey Ewen
G2GPCWHDR@southernco.com

APPENDIX C. SAMPLING MEMO

This appendix outlines the sampling plan for the assignment of the pre-notification and pre-heat treatment.

WATER HEATER PILOT: SAMPLE DESIGN

PREPARED FOR: Audrey Ewen, Eric Arnold, and Justin Hill, Georgia Power
PREPARED BY: Shannon Kahl and Jes Rivas, ILLUME Advising
DATE: December 12, 2018

This memo presents ILLUME's recommended sample design to test the impact of pre-heating and event pre-notification on the participant experience of Georgia Power's Water Heater Demand Response Pilot program.

OVERVIEW OF OBJECTIVES

Georgia Power will recruit approximately 100 participants[16] into its Water Heater Demand Response Pilot which will assess the energy and demand impacts from a minimum of six demand response (DR) events, three in summer and three in winter.

The objectives of the Pilot evaluation are to 1) quantify demand (kw) and energy (kWh) impacts attributable to water heater demand response events; 2) estimate energy savings achieved by new water heater; 3) assess customer experience with water heater demand response events; 4) understand customers' experiences with heat pump water heaters; 5) identify recommended recruiting approaches, program delivery, metrics, and data tracking for future water heater demand response programs evaluability.

Georgia Power is interested in testing the impacts of two variables; pre-notification of demand response events and pre-heating, on customer experience with the program and their water heaters. Future program design could offer either or both of these elements, as control system exist that allow for these features to be toggled on and off.

[16] Planned participation is currently 70 heat pump water heaters and 30 electric resistance water heaters.

SAMPLE DESIGN

We recommend dividing the 100 participants into four different treatment groups and calling a total of eight DR events, four during winter and 4 during summer so that all pilot participants have the same overall program experience. As illustrated in Table 32 and Table 33, this will allow each group to rotate through all 4 possible different combinations of receiving notification and/or preheating.

TABLE 32. WINTER EVENTS

	Event 1		**Event 2**		**Event 3**		**Event 4**		**Event 5**
	Notification		**Notification**		**Notification**		**Notification**		**Email & Text Notification**
Preheating	Yes	No	Yes	No	YES	No	Yes	No	YES
Yes	Group 1	Group 2	Group 3	Group 4	Group 2	Group 1	Group 4	Group 3	All groups
No	Group 3	Group 4	Group 1	Group 2	Group 4	Group 3	Group 2	Group 1	

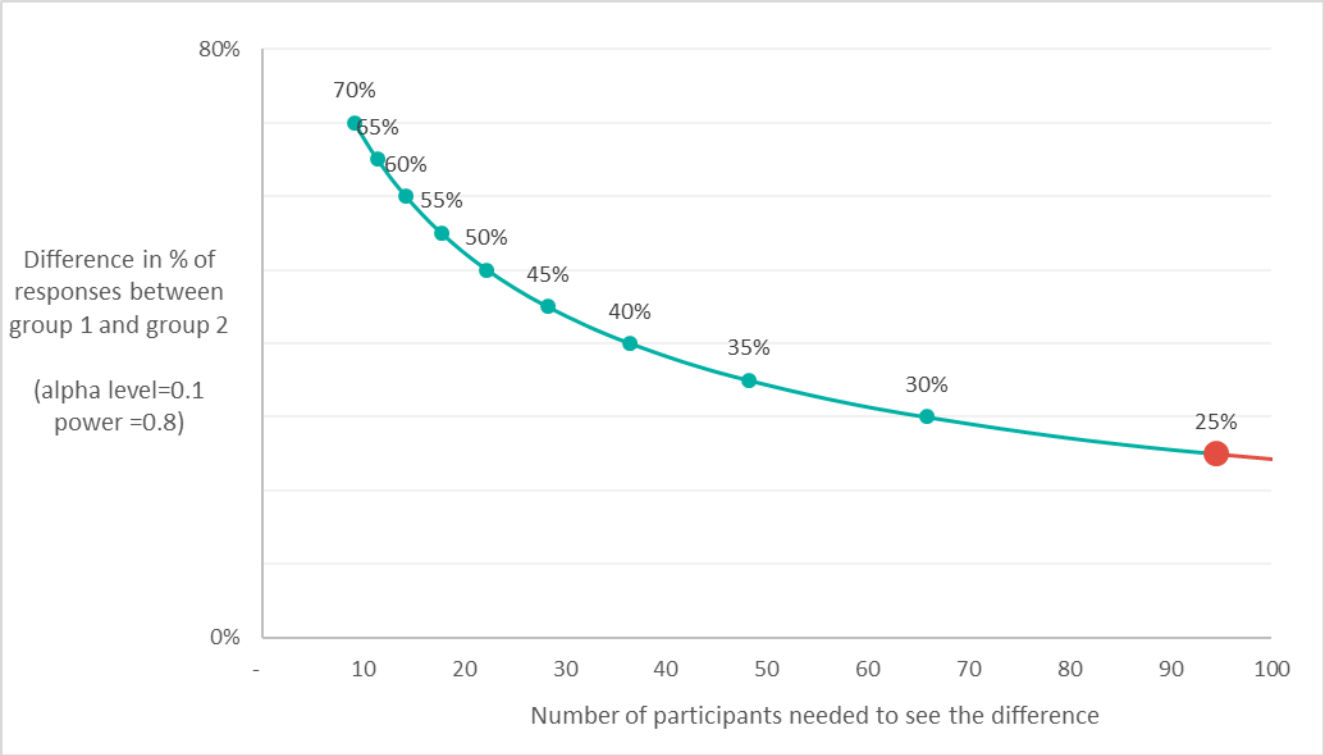
TABLE 33. SUMMER EVENTS

	Event 6		**Event 7**		**Event 8**		**Event 9**		**Event 10**
	Notification		**Notification**		**Notification**		**Notification**		**Email & Text Notification**
Preheating	Yes	No	Yes	No	Yes	No	Yes	No	YES
Yes	Group 1	Group 2	Group 3	Group 4	Group 2	Group 1	Group 4	Group 3	All groups
No	Group 3	Group 4	Group 1	Group 2	Group 4	Group 3	Group 2	Group 1	

CONSIDERATIONS

Because of the small pilot size, the analysis of this sample design will only detect very large differences between the different groups at statistically significant levels. To determine the impact of each element (notification and preheating), we will compare the two groups that received an element to the two groups that did not. For example, to determine the impact of preheating during Event 1, we would compare Groups 1 and 2 to Groups 3 and 4. This provides two groups of 50 which allows us to observe differences of about 30% or more (Figure 18) with reasonable precision. Our analysis will also attempt to identify trends and anecdotal findings from open-ended questions to help inform future program design.

FIGURE 18. MINIMUM % DIFFERENCE WE CAN STATISTICALLY OBSERVE WITH PILOT SAMPLE SIZE



GROUP ASSIGNMENT

ILLUME will randomly select participants to each of the four groups, which we will balance on:

- Water heater type (electric resistance or heat pump)
- Segment (GPC employee or non-employee)

In addition to randomly assigning participants to one of the four treatment groups, ILLUME will add variables, as illustrated in Table 34, to indicate when participants should receive notification and/or pre-heating to aid Georgia Power staff in accurately setting up each event.

TABLE 34. SAMPLE VARIABLES

Acct Number	Group	Event1 Notice	Event1 PreHeat	Event2 Notice	Event2 PreHeat	Event3 Notice	Event3 PreHeat	Event4 Notice	Event4 PreHeat
XXXX-XXXX1	1	Yes	Yes	Yes	No	No	Yes	No	No
XXXX-XXXX2	2	No	Yes	No	No	Yes	Yes	Yes	No
XXXX-XXXX3	3	Yes	No	Yes	Yes	No	No	No	Yes
XXXX-XXXX4	4	No	No	No	Yes	Yes	No	Yes	Yes

APPENDIX D. FULL CUSTOMER EXPERIENCE SURVEY

This appendix outlines the research goals, customer communications, and survey questions for the in-depth customer experience survey.

RESEARCH GOALS

The table below outlines specific research questions for the in-depth customer experience survey and cross-references the survey questions that will be used to help answer those questions.

TABLE 35: RESEARCH QUESTIONS

TOPIC	RESEARCH QUESTION	SURVEY QUESTIONS
Installation Experience *(for participants that did not complete the short post-installation survey)*	What motivates customers to participate in the program?	B3
	How satisfied are participants with the installation experience?	B1, B2, B4, B5
Demand Response Events	Are participants aware of when the demand response events are taking place?	C1 – C2
	How do participants engage with the demand response events?	C3 – C4
	What barriers to action exist for participants?	C5 – C9
Water Heater Customer Experience	What challenges have participants had with the water heater and/or EcoNet app?	D1 – D2, D5
	Which features of their Rheem water heater do participants use?	D3 & D4
	How satisfied are participants with their Rheem water heater and the EcoNet app?	D9, D10
Satisfaction	Are customers satisfied with program elements such as the enrollment process, the number of events, ease of overriding events, and event notification?	E1
	How does the GPC Water Heater Demand Response Pilot affect participant satisfaction with Geogia Power overall?	E2 & E3
Customer Attitudes and Behaviors	What are participant attitudes toward technology and saving energy?	F1 & F2
Demographics	What are the demographic characteristics of pilot participants?	G1 – G7

SURVEY GUIDE

A. INVITATION FOR ONLINE RESPONDENTS

INITIAL INVITATION

Subject Line: Georgia Power Water Heater Demand Response Pilot - Customer Experience Survey

Sender: GPC Water Heater Pilot

Dear [CUSTOMER_NAME],

Thank you for participating in Georgia Power's Water Heater Demand Response Pilot Program. We are very interested to learn how customers like you use your water heater and interact with the demand response program.

Please click on the link below to take this short survey:

[SURVEY LINK]

The survey will take approximately 10 minutes to complete. If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume where you left off by clicking on the link from this email or hitting the back button in your browser. Results will not be recorded until the final submit button is clicked.

Don't miss out on this chance to share your experience!

Sincerely,

Audrey Ewen
Georgia Power Energy Efficiency - Water Heater Demand Response Pilot
G2GPCWHDR@southernco.com

REMINDER INVITATION

Subject Line: REMINDER: Georgia Power Water Heater Demand Response Pilot - Customer Experience Survey

Sender: GPC Water Heater Pilot

Dear [CUSTOMER_NAME],

Thank you for participating in Georgia Power's Water Heater Demand Response Pilot Program. We invite you to share your experience through this 10-minute online survey. **Don't miss this chance to share your experience!**

Please click on the link below to take this short survey:

[SURVEY LINK]

The survey will take approximately 10 minutes to complete. If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume where you left off by clicking on the link from this email or hitting the back button in your browser.

Thank you for your feedback!

Sincerely,
Audrey Ewen
Georgia Power Energy Efficiency - Water Heater Demand Response Pilot
G2GPCWHDR@southernco.com

LANDING PAGE

[THIS IS THE LANGUAGE THE SURVEY RESPONDENT WILL SEE AFTER CLICKING THE LINK TO THE SURVEY. THIS PAGE WILL ALSO CONTAIN THE GEORGIA POWER COMPANY LOGO.]

Thank you for participating in Georgia Power's Water Heater Program! Your response to this survey will help us understand your experience with the program so far. Your responses will be kept confidential and will be used to help Georgia Power provide the best value to our customers.

We appreciate your input!

Open drop-down menus by clicking on this icon  within the survey.

Click on the "Next" and "Back" buttons at the bottom of each page to navigate through the survey.

B. INSTALLATION QUESTIONS

These questions will be asked only of respondents that did not complete the post-installation survey.

[IF InstallSurvey = 0 ASK THIS SECTION OTHERWISE SKIP TO SECTION C]

B1. What type of water heater was installed in your home?

1. Heat Pump Water Heater
2. Electric Resistance

98. [Not Sure]

B2. Did you switch from a natural gas or propane water heater to an electric water heater?

1. Yes
2. No
98. Not Sure
98. [Not Sure]

B3. Why did you decide to participate in the GPC Water Heater Demand Response Pilot? [OPEN END]

B4. How would you rate your satisfaction with the installation of your new water heater?

1. Very dissatisfied
2. Somewhat dissatisfied
3. Neither satisfied nor dissatisfied
4. Somewhat satisfied
5. Very Satisfied
98. Not Sure

B5. Why did you rate your satisfaction with the water heater installation this way? [OPEN END]

C. DEMAND RESPONSE EVENTS

[IF NOTICE = 1 ASK C1Error! Reference source not found.]

C1. Do you remember getting notified of a demand response event scheduled for [insert most recent demand response event date and time]? [SINGLE RESPONSE]

1. Yes
2. No [SKIP TO C3]

98. [Not Sure] [SKIP TO C3]

C2. What did you do after getting the notification about the demand response event? [SINGLE RESPONSE]

1. Nothing (allowed Georgia Power to adjust the water heater setting)
2. Opted out through email
3. Manually changed the temperature of the water heater during the event
4. Remotely changed the temperature of the water heater using EcoNet app during the event
5. Something else (please specify)

98. [Not Sure]

[IF NOTICE = 0 OR C1=2] Georgia Power held a water heater demand response event [INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME].

[Display for all] We'd like to hear about your experience with your water heater during the recent demand response event.

IF [NOTICE = 1 and EVENT # = 9]

C3. [Asked only during the Summer surveys]. You were notified about the most recent demand response event by text and email. For previous events, you were notified by email only. How do you prefer to receive notification about upcoming DR events?

1. Text only
2. Email only
3. Text and email
4. Other (Please specify)
98. [Not Sure]

C3. Were you at home [INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME]? [SINGLE RESPONSE]

1. At home the entire time
2. At home part of that time
3. Not at home during that time

98. [Not Sure]

[IF C3= 1 or 2]

C4. Did you or anyone in your home experience any of the following during that time frame ([INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME])? [MULTIPLE RESPONSE; ROTATE]

1. Water temperature would not get hot enough
2. Ran out of hot water
3. Water took too long to heat
4. Water was too hot
5. None of the above

98. [Not Sure]

[IF NOTICE = 1]

C5. Did you take any of the following actions during the last demand response event? [ONE RESPONSE FOR EACH ITEM]

	YES	NO	DON'T KNOW	NA
a. Decreased the temperature on my water heater to save more energy	1	2	3	4
b. Avoided taking a bath or shower	1	2	3	4
c. Avoided doing laundry	1	2	3	4
d. Avoided hand washing dishes	1	2	3	4
e. Avoided running the dishwasher	1	2	3	4
f. Avoided running my spa or pool pump	1	2	3	4
g. Avoided cooking	1	2	3	4
h. Turned off lights not in use	1	2	3	4
i. Turned off office equipment (computer, printer, etc.)	1	2	3	4
j. Turned off entertainment systems (TV, Nintendo, etc.)	1	2	3	4
k. Took other energy-saving action(s) (Please specify)	1	2	3	4

C6. Were any routines in your home affected by this demand response event? [SINGLE RESPONSE]

1. Yes
2. No

98. [Not Sure]

[IF C6 = 1]

C7. What routines were affected? [OPEN RESPONSE]

C8. Did you or others in your home experience any negative effects as a result of having your water heater's setting changed through the demand response event? [SINGLE RESPONSE]

1. Yes
2. No

98. [Not Sure]

[IF C8 = 1]

C9. Please describe any negative effects you or others in your home experienced. [OPEN RESPONSE]

D. RHEEM WATER HEATER CUSTOMER EXPERIENCE

D1. Have you had any difficulty connecting your Rheem water heater to Wi-Fi?

1. Yes (Please Explain) [OPEN RESPONSE]
2. No [SKIP TO D3]

98. [Not Sure]

[IF D1 = 1]

D2. Has the issue been resolved?

1. Yes
2. No

98. [Not Sure]

D3. Have you installed the Rheem EcoNet app?

1. Yes
2. No

98. [Not Sure]

[IF D3 = 1]

D4. Have you used the Rheem EcoNet app to….? (select all that apply) [MULTIPLE RESPONSE; RANDOMIZE]

1. Set a vacation schedule on your water heater
2. Adjust the modes on your water heater
3. Change the setpoint of your water heater
4. Pair your Rheem water heater with a Nest Learning thermostat
5. Set critical alerts or notifications
6. Other (Please specify)
7. None of the above

D5. Have you had any problems with the Rheem EcoNet app?

1. Yes (Please Explain) [OPEN RESPONSE]
2. No

98. [Not Sure]

D6. To what extent do you agree with the following statements about your Rheem water heater and the EcoNet app? [ONE RESPONSE FOR EACH ITEM; RANDOMIZE]

	DO NOT AGREE AT ALL	SLIGHTLY AGREE	AGREE SOMEWHAT	AGREE MODERATELY	AGREE COMPLETELY	DON'T KNOW
a. [IFD3 = 1] The Rheem EcoNet app is easy to use	1	2	3	4	5	98
b. Letting Georgia Power adjust my water heater doesn't bother me	1	2	3	4	5	98
c. I am satisfied with my water heater	1	2	3	4	5	98

[IF D6c < =3]

D7. Why did you rate your satisfaction with your water heater that way? [OPEN RESPONSE]

E. CUSTOMER SATISFACTION

E1. Please rate your satisfaction with each of the following aspects of the Water Heater Demand Response Pilot. [ONE RESPONSE FOR EACH ITEM]

	VERY DISSATISFIED	SOMEWHAT DISSATISFIED	NEITHER SATISFIED OR DISSATISFIED	SOMEWHAT SATISFIED	VERY SATISFIED	DON'T KNOW
a. Enrolling in the program	1	2	3	4	5	98
b. The number of demand response events	1	2	3	4	5	98
c. How your water heater settings adjust during demand response events	1	2	3	4	5	98
d. [*Summer only*] How your water heater responds after demand response events	1	2	3	4	5	98
e. The ease of opting out of demand response events	1	2	3	4	5	98
f. The amount of notice before a demand response event	1	2	3	4	5	98
g. Availability of hot water during a demand response event	1	2	3	4	5	98
h. [*Summer only*] Availability of hot water after a demand response event	1	2	3	4	5	98
i. The Water Heater Demand Response Pilot overall	1	2	3	4	5	98

E2. Taking into consideration all aspects of your utility service experience, please rate your ***current*** satisfaction with Georgia Power overall as your electric service provider? [SINGLE RESPONSE]

VERY DISSATISFIED	SOMEWHAT DISSATISFIED	NEITHER SATISFIED OR DISSATISFIED	SOMEWHAT SATISFIED	VERY SATISFIED	DON'T KNOW
1	2	3	4	5	98

[IF E2 < 3]

E3. Why did you rate it that way? [OPEN RESPONSE]

E4. [*Summer only*] The current Water Heater Demand Response Pilot ends in the fall of 2019. If Georgia Power offered another water heater demand response program in the future to customers with eligible water heaters, would you enroll?

1. Yes
2. No

98. [Not Sure]

[IF E4=1]

E5. [*Summer only*] What type of incentive would you like to receive for participating in another demand response program in the future?

[IF E4=2]

E6. [*Summer only*] Why wouldn't you enroll in another water heater demand response program again?

F. CUSTOMER ATTITUDES AND BEHAVIORS

F1. Do you or any member of your household own any of the following? (select all that apply) [MULTIPLE RESPONSE]

1. Smartphone
2. Wearable technology (e.g. smart watch or fitness tracker)
5. Smart LED bulbs
6. Smart appliances (e.g. smart ranges, refrigerators, washers & dryers, dishwashers)
7. Smart home security system
8. Voice enabled home assistant (e.g. Amazon Echo or Google Home)

9. None of the above

98. [Not Sure]

F2. Some people like to be the first people to try out a new product while others like to wait and see what works well or what becomes popular before making a purchase. Thinking about how soon you buy new technologies, which of the following best describes you? (You can think of things like electronics or appliances) [SINGLE RESPONSE]

1. I'm a risk-taker and I like to try new things as soon as possible, even if they are untested.
2. I typically purchase new technology sooner than a lot of my friends.
3. I'm typically in the middle of the group when purchasing new technology.
4. I purchase new technology *after* most of my friends have purchased it.
5. I am one of the last people to purchase new technology.
6. I prefer to use simple technologies that have been proven to work for many years.

98. [Not Sure]

G. HOUSEHOLD DEMOGRAPHICS

G1. Do you rent or own your home? [SINGLE RESPONSE]

1. Rent
2. Own

98. [Not Sure]

G2. How many years have you lived in your current home? [SINGLE RESPONSE]

1. One year or less
2. 2-3 years
3. 4-5 years
4. 6-10 years
5. More than 10 years

98. [Not Sure]

G3. When was your home built? [SINGLE RESPONSE]

1. Before 1900
2. 1900 to 1939
3. 1940 to 1959
4. 1960 to 1979
5. 1980 to 1989
6. 1990 to 1999
7. 2000 to 2004
8. 2005 or later

98. [Not Sure]

G4. Including you, how many people are currently living in your home year-round? Include all members of your household whether or not they are related to you, but do not include anyone who is just visiting, or children who may be away at college or in the military.

1. [NUMERIC OPEN END]

98. [Not Sure]

G5. In what year were you born?

1. [NUMERIC OPEN END]

G6. What is the highest level of education you have completed? [SINGLE RESPONSE]

1. Some high school or less
2. High school graduate or equivalent
3. Some college, no degree
4. Technical college degree or certificate
5. Two-year college degree
6. Four-year college degree
7. Graduate or professional degree

98. [Not Sure]

G7. Which categories describe you? (Select all that apply) [MULTIPLE RESPONSE]

1. American Indian or Alaska Native (for example, Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Native Village of Barrow Inupiat Traditional Government, or Nome Eskimo Community.)
2. Asian (for example, Chinese, Filipino, Asian Indian, Vietnamese, Korean, or Japanese)
3. Black or African American (for example, African American, Jamaican, Haitian, Nigerian, Ethiopian, or Somalian)
4. Hispanic, Latino, or Spanish origin (for example, Mexican or Mexican American, Puerto Rican, Cuban, Salvadorian, Dominican, or Colombian)
5. Native Hawaiian or Other Pacific Islander (For example, Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, or Marshallese)
6. Middle Eastern or North African (for example, Lebanese, Iranian, Egyptian, Syrian, Moroccan, or Algerian)
7. White (for example, German, Irish, English, Italian, Polish, or French)
8. Some other race, ethnicity, or origin

98. [Not Sure]

CLOSING: We thank you for your time spent taking this survey. Your response has been recorded.

APPENDIX E. FOLLOW UP CUSTOMER EXPERIENCE SURVEY

This appendix outlines the research goals, customer communications, and survey questions for the follow up customer experience survey.

RESEARCH GOALS

ILLUME researchers will conduct multiple online surveys with pilot participants to assess how awareness, engagement, satisfaction, and actions taken vary over time or by season. We will use these surveys to gather feedback that may help improve customer experience with their new water heater and demand response events during the pilot or a future program offering.

In addition to the short post-installation survey used to gather initial feedback on the water heater and installation experience, the ILLUME team will survey participants after the DR events. We will send the first DR event survey after a winter DR event. This survey will be in-depth and will be used to assess motivations for participation, user experience with enrollment, and the pilot. This survey instrument appears in the final section of this memo.

ILLUME will send short (5 minute) follow-up surveys after each consecutive DR event. We will use these shorter surveys to provide a longitudinal perspective into the customer experience, including understanding actions taken during and around DR events. This survey instrument will be provided in a separate document.

ILLUME will send links to these online surveys via email to the census of pilot participants. We will target a minimum 40 respondents per survey.

The table below outlines specific research questions for the in-depth customer experience survey and cross-references the survey questions that will be used to help answer those questions.

TABLE 36: RESEARCH QUESTIONS

TOPIC	RESEARCH QUESTION	SURVEY QUESTIONS
Demand Response Events	Are participants aware of when the demand response events are taking place?	C1 – C2
	How do participants engage with the demand response events?	C3 – C4
	What barriers to action exist for participants?	C5 – C9
Satisfaction	Are customers satisfied with program elements such as the enrollment process, the	E1

	number of events, ease of overriding events, and event notification?	
	How does the GPC Water Heater Demand Response Pilot affect participant satisfaction with Geogia Power overall?	E2 & E3

SURVEY GUIDE

A. INVITATION FOR ONLINE RESPONDENTS

INITIAL INVITATION

Subject Line: Georgia Power Water Heater Demand Response Pilot - Event #2

Sender: GPC Water Heater Pilot

Dear [CUSTOMER_NAME],

Thank you for participating in Georgia Power's Water Heater Demand Response Pilot Program. We are very interested in learning how customers interact with the demand response program and will be sending a short survey after each demand response event.

Please click on the link below to take this short survey:

[SURVEY LINK]

The survey will take approximately 5 minutes to complete. If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume where you left off by clicking on the link from this email or hitting the back button in your browser. Results will not be recorded until the final submit button is clicked.

Don't miss out on this chance to share your experience!

Sincerely,

Audrey Ewen
Georgia Power Energy Efficiency - Water Heater Demand Response Pilot
G2GPCWHDR@southernco.com

REMINDER INVITATION

Subject Line: REMINDER: Georgia Power Water Heater Demand Response Pilot – Event #2

Sender: GPC Water Heater Pilot

Dear [CUSTOMER_NAME],

Thank you for participating in Georgia Power's Water Heater Demand Response Pilot Program. We invite you to share your experience with the last demand response event through this 5-minute online survey. **Don't miss this chance to share your experience!**

Please click on the link below to take this short survey:

[SURVEY LINK]

The survey will take approximately 5 minutes to complete. If you cannot complete the survey all at one time or you accidentally exit the survey mid-course, you can resume where you left off by clicking on the link from this email or hitting the back button in your browser.

Thank you for your feedback!

Sincerely,
Audrey Ewen
Georgia Power Energy Efficiency - Water Heater Demand Response Pilot
G2GPCWHDR@southernco.com

LANDING PAGE

[THIS IS THE LANGUAGE THE SURVEY RESPONDENT WILL SEE AFTER CLICKING THE LINK TO THE SURVEY. THIS PAGE WILL ALSO CONTAIN THE GEORGIA POWER COMPANY LOGO.]

Thank you for participating in Georgia Power's Water Heater Program! Your response to this survey will help us understand your experience with the pilot program so far. Your responses will be kept confidential and will be used to help Georgia Power provide the best value to our customers.

We appreciate your input!

Open drop-down menus by clicking on this icon  within the survey.

Click on the "Next" and "Back" buttons at the bottom of each page to navigate through the survey.

C. DEMAND RESPONSE EVENTS

[IF NOTICE = 1 ASK C1]

C1. Do you remember getting notified of a demand response event scheduled for [INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME]? [SINGLE RESPONSE]

1. Yes
2. No [SKIP TO C3]

98. [Not Sure] [SKIP TO C3]

[IF C1 = 1]

C2. What did you do after getting the notification about the demand response event? [SINGLE RESPONSE]

1. Nothing (allowed Georgia Power to adjust the water heater setting)
2. Opted out through email
3. Manually changed the temperature of the water heater during the event
4. Remotely changed the temperature of the water heater using Rheem EcoNet app during the event
5. Something else (please specify)

98. [Not Sure]

[IF NOTICE = 0 OR C1=2] Georgia Power held a water heater demand response event [INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME].

[Display for all] We'd like to hear about your experience with your water heater during the recent demand response event.

C3. Were you at home [INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME]? [SINGLE RESPONSE]

1. At home the entire time
2. At home part of that time
3. Not at home during that time

98. [Not Sure]

IF [NOTICE = 1 and EVENT # = 9]

C3. [Asked only during the Summer survey] You were notified about the most recent demand response event by text and email. For previous events, you were notified by email only. How do you prefer to receive notification about upcoming DR events?

1. Text only
2. Email only
3. Text and email
4. Other (Please specify)

98. [Not Sure]

C4. Did you or anyone in your home experience any of the following during that time frame ([INSERT MOST RECENT DEMAND RESPONSE EVENT DATE AND TIME])? [MULTIPLE RESPONSE; ROTATE]

1. Water temperature would not get hot enough
2. Ran out of hot water
3. Water took too long to heat
4. Water was too hot
5. None of the above

98. [Not Sure]

[IF NOTICE = 1]

C5. [*Summer only*] Did you take any of the following actions during the last demand response event? [ONE RESPONSE FOR EACH ITEM]

	YES	NO	DON'T KNOW	NA
a. Decreased the temperature on my water heater to save more energy	1	2	3	4
b. Avoided taking a bath or shower	1	2	3	4
c. Avoided doing laundry	1	2	3	4
d. Avoided hand washing dishes	1	2	3	4
e. Avoided running the dishwasher	1	2	3	4
f. Avoided running my spa or pool pump	1	2	3	4
g. Avoided cooking	1	2	3	4
h. Turned off lights not in use	1	2	3	4
i. Turned off office equipment (computer, printer, etc.)	1	2	3	4
j. Turned off entertainment systems (TV, Nintendo, etc.)	1	2	3	4
k. Took other energy-saving action(s) (Please specify)	1	2	3	4

C6. Were any routines in your home affected by this demand response event? [SINGLE RESPONSE]

C7. Were any routines in your home affected by this demand response event? [SINGLE RESPONSE]

1. Yes
2. No

98. [Not Sure]

[IF C7 = 1]

C8. What routines were affected? [OPEN RESPONSE]

C9. Did you or others in your home experience any negative effects as a result of having your water heater's setting changed through the demand response event? [SINGLE RESPONSE]

1. Yes
2. No

98. [Not Sure]

[IF Error! Reference source not found. = 1]

C10. Please describe any negative effects you or others in your home experienced. [OPEN RESPONSE]

D. RHEEM WATER HEATER CUSTOMER EXPERIENCE [SUMMER ONLY]

D4. Have you used the Rheem EcoNet mobile app to….? (select all that apply) [MULTIPLE RESPONSE; RANDOMIZE]

1. Set a vacation schedule on your water heater
2. Adjust the modes on your water heater
3. Change the setpoint of your water heater
4. Pair your Rheem water heater with a Nest Learning thermostat
5. Set critical alerts or notifications
6. Other (Please specify)
7. None of the above

D5. Have you had any problems with the Rheem EcoNet mobile app?

1. Yes (Please Explain) [OPEN RESPONSE]
2. No

98. [Not Sure]

[If Event # = 8]

D6. To what extent do you agree with the following statements about your Rheem water heater and the Rheem EcoNet mobile app? [ONE RESPONSE FOR EACH ITEM; RANDOMIZE]

	DO NOT AGREE AT ALL	SLIGHTLY AGREE	AGREE SOMEWHAT	AGREE MODERATELY	AGREE COMPLETELY	DON'T KNOW
a. The Rheem EcoNet mobile app is easy to use	1	2	3	4	5	98
b. Letting Georgia Power adjust my water heater doesn't bother me	1	2	3	4	5	98
c. I am satisfied with my water heater	1	2	3	4	5	98

[IF D6c < =3]

D7. Why did you rate your satisfaction with your water heater that way? [OPEN RESPONSE]

E. CUSTOMER SATISFACTION

E1. Please rate your satisfaction with each of the following aspects of the Water Heater Demand Response Pilot. [ONE RESPONSE FOR EACH ITEM]

	VERY DISSATISFIED	SOMEWHAT DISSATISFIED	NEITHER SATISFIED OR DISSATISFIED	SOMEWHAT SATISFIED	VERY SATISFIED	DON'T KNOW
b. The number of demand response events	1	2	3	4	5	98
c. How your water heater settings adjust during demand response events	1	2	3	4	5	98
d. [*Summer only*] How your water heater responds after demand response events	1	2	3	4	5	98
e. The ease of opting out of demand response events	1	2	3	4	5	98
f. The amount of notice before a demand response event	1	2	3	4	5	98
g. Availability of hot water during a demand response event	1	2	3	4	5	98
h. [*Summer only*] Availability of hot water after a demand response event	1	2	3	4	5	98
i. The Water Heater Demand Response Pilot overall	1	2	3	4	5	98

E2. Taking into consideration all aspects of your utility service experience, please rate your ***current*** satisfaction with Georgia Power overall as your electric service provider? [SINGLE RESPONSE]

VERY DISSATISFIED	SOMEWHAT DISSATISFIED	NEITHER SATISFIED OR DISSATISFIED	SOMEWHAT SATISFIED	VERY SATISFIED	DON'T KNOW
1	2	3	4	5	98

[IF E2< 3]

E3. Why did you rate it that way? [OPEN RESPONSE]

E4. [*Summer only*] The current Water Heater Demand Response Pilot ends in the fall of 2019. If Georgia Power offered another water heater demand response program in the future to customers with eligible water heaters, would you enroll?

1. Yes
2. No

98. [Not Sure]

[IF E4=1]

E5. [*Summer only*] What type of incentive would you hope to receive for participating in another demand response program?

[IF E4=2]

E6. [*Summer only*] Why wouldn't you enroll in another water heater demand response program?