DR Emerging Technology (DRET) Voice Automation Technology for Load Management Study

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Abbreviations and Acronyms

CDD	Cooling degree days
CI	Confidence interval
DR	Demand response
DRET	Demand Response Emerging Technology
EV	Electric vehicle
IoT	Internet of Things
NEM	Net energy metered
PSPS	Public Safety Power Shutoff
TOU	Time-of-use

EXECUTIVE SUMMARY

Phase 2 of this Demand Response Emerging Technology (DRET) Voice Automation demonstration project (pilot) leveraged residential voice-assistant technology (i.e., Amazon's Alexa smart speaker) as well as cellular telephone app functionality to engage with and educate residential customers on energy usage, bill forecasts, and time-of-use (TOU) rates. The first phase of this study, completed in 2021, targeted a small number of PG&E employees and others nominated by them to participate. The second phase of this DRET demonstration project tested an updated version of the cellular telephone app, in addition to the smart speaker capabilities, among a larger group of PG&E coworkers, friends, and family members over a more extensive time period.

There are three key drivers for initiating the test of the technology:

1) provide customers with rate information such as TOU rates;
2) empower customers to control their energy usage and costs through Integrated Demand Side Load Management technology solutions; and
3) protect the environment and improve grid reliability by notifying customers of high-demand periods associated with less renewable energy.

The pilot has the following objectives:

- develop, test, deploy and refine the Energy Expert Alexa smart speaker skills and cell phone application;
- understand the effectiveness of the smart speaker and cell phone app as a platform to provide information to residential customers about their energy use, energy generation, TOU rates, DR event notification, and electric rate choices; and
- provide notifications of events of immediate impact to their safety and lives, including Public Safety Power Shutoff events.

PROJECT DESCRIPTION

The Voice Automation pilot conducted by PG&E's DRET program aimed to test and refine the Energy Expert cellular telephone app and Alexa smart speaker skills, which provide information and education to residential utility customers. The second phase of the pilot, initiated in April 2022, involved approximately 250 residential customers who tested the app and Alexa capabilities. The evaluation of this phase focused on analyzing data collected by the Energy Expert app and Alexa smart speaker, studying participant energy usage changes following usage-related notifications, and conducting a process evaluation to understand customer perceptions, interactions, and feedback on the app and smart speaker's usability and features.

PROJECT FINDINGS/RESULTS

Table 1 summarizes the key research questions and findings from the study.

TABLE 1: SUMMARY OF KEY RESEARCH QUESTIONS AND FINDINGS

Research Question	Findings
How do customers perceive Energy Expert?	Participants generally reported that the information they received from the pilot is accurate and useable. Most respondents also rated the information as easy to understand, although some respondents reported challenges understanding the information. Survey respondents found information about power outages to be the most valuable. There were clear differences between PG&E employees and other pilot participants in their ratings of the value of different types of information the pilot provided. Non-PG&E employees were more likely to provide high ratings for almost all information types, with the most notable difference in the value ratings for information about peak and off-peak times.
How do customers interact with Energy Expert?	Survey respondents most often reported using Energy Expert to get information about electricity usage or bills or on-peak and off-peak times; they used both the app and their smart speakers to find information about both topics with roughly equal frequency.
Are customers satisfied with Energy Expert?	A majority of customers (60%) reported that they were "very" or "somewhat" satisfied with their experience accessing information from Energy Expert, whether through the app, a smart speaker, or notifications.
Do customers feel that using Energy Expert changed their knowledge of energy rates and their usage of electricity?	Most of those who accessed the information reported that Energy Expert increased their understanding of their rate plan at least "a little bit." Half of survey respondents reported they had taken some action as a result of the information they received from Energy Expert. Most of these respondents reported the pilot had given them a general increased awareness of their energy use.
What feedback do customers have on the Energy Expert app's usability and features?	Customers expressed a desire for real-time energy usage data or additional data on energy costs. Additionally, some customers suggested opportunities to improve the app design.
Which features of Energy Expert are used most regularly?	About half of participants asked Alexa about electricity costs or their bill; in fact, the 'getElectricityCost' intent was the most popular with 73 unique conversations throughout the analysis period.
Do interactions with certain features diminish over time?	Participants interacted with Alexa the most during the earlier months of the pilot; interactions diminished over time.

Research Question	Findings
Does customer energy usage change following receipt of usage-related notifications?	Customers who received High Price notifications exhibited hourly peak-period load reductions that ranged from 3% to 5%, but the reductions were not statistically significant due to the small sample size available; these impacts were incremental to impacts attributable to their TOU rate. With the available data and scope for this study, it was not possible to measure load impacts associated with Flex Alert notifications. The pilot included two customers who signed up to receive SmartDay notifications; these customers tended to have lower demand on the days with SmartDay notifications versus those without. However, a larger population is needed to draw conclusions regarding the incremental effect of Energy Expert.

PROJECT RECOMMENDATIONS

Recommendation A: Explore opportunities to expand the Energy Expert capabilities to additional smart speaker platforms such as Google Home and Apple HomePod, which would increase the population of customers who could use the voice assistant technology.

Recommendation B: Ensure customer outreach occurs at regular intervals during future pilots or implementations to maintain customer engagement. Outreach messaging could include tips on using the app or smart speaker interface or reminders of the available features and capabilities.

Recommendation C: The Energy Expert platform shows potential for driving peak-period load reductions. A larger sample size is needed, however, to validate the preliminary findings from this demonstration. If PG&E is interested in further exploration of demand reductions or energy savings, it is recommended that the enrollment targets be based on achieving specific levels of statistical precision. Conducting a statistical power analysis of the target population is the most robust approach to determining minimum sample sizes needed to detect specific impact magnitudes. In the absence of conducting a statistical power analysis, a target enrollment of 2,000 for each customer segment of interest typically provides sufficient statistical power to detect impacts as small as 1% to 2%. Smaller sample sizes can still result in statistically significant impacts, but there is greater risk of not detecting impacts if there is significant customer attrition or if impacts are small. Ultimately, conducting a statistical power analysis helps utility staff make a more informed decision regarding enrollment targets and can allow for greater confidence in success with smaller enrollment targets.

Recommendation D: PG&E should identify ideal user personas for Energy Expert and conduct user testing with the wider customer population to ensure the app meets the needs of those users. Identification of ideal user personas is recommended because design recommendations will likely differ if the app is intended to raise energy awareness among customers who have limited understanding, as opposed to providing an additional tool to sophisticated customers who already understand and monitor energy use. Alternatively, or in addition, the app could be further developed to provide different experiences and features for each persona (or customer segment), providing each with important information applicable to them. For example, customers with solar generation, who comprised more than 30% of the pilot participants, have different information needs and interests such as monitoring their net consumption or generation compared to customers without solar. Electric vehicle owners are an additional customer segment who may have segment specific information interests and who could benefit from this technology.

INTRODUCTION

In 2020, PG&E's Demand Response Emerging Technology (DRET) program initiated a two-phase Voice Automation Pilot to test a cellular telephone app, branded as Energy Expert, that provides information and education to the residential utility customers. Energy Expert is available for iOS (via the App Store) and Android (via Google Play). Customers can also enable Energy Expert to be operated from Amazon smart speakers so that customers can ask questions about bills, energy usage, and the best times to use an appliance or charge an electric vehicle (EV).

There are three key drivers for initiating the test of the technology:

- To provide customers with rate information during the state's transition of its residential customers to time-of-use (TOU) rates. According to recent PG&E internal research (Pulse Wave 3), while most residential customers surveyed (83%) are aware of TOU rates, fewer than half (41%) report that they understand how their energy use can impact their bills.
- To enable customers to take control of their energy usage and costs through Integrated Demand Side Load Management. Less than half of PG&E's residential customers (40%) understand the benefits of shifting the time of their energy use—such as adjusting when they use common major electric appliances like clothes washers, dryers, and dishwashers, and when they charge their EV.
- To protect the environment and improve grid reliability by providing notifications when rates are high, which is associated with electricity being in great demand and as a result being sourced from less renewable sources.

The pilot has the following objectives:

- To develop, test, deploy, and refine the Energy Expert Alexa smart speaker skills and cell phone application.
- To understand the effectiveness of the smart speaker and cell phone app as a platform to provide information to residential customers about their energy use, energy generation, TOU rates, DR event notification, and electric rate choices.
- To provide notifications of events of immediate impact to their lives, including Public Safety Power Shutoff (PSPS) events.

ASSESSMENT OBJECTIVES

The focus of this research is on the evaluation of the second phase and follows the completion of Phase One, near the end of 2021. Phase Two of the pilot launched in April 2022 after updated versions of the Energy Expert app became available for download by PG&E employees and customers. Phase Two included approximately 250 residential customers who have downloaded and tested the app or Alexa capabilities. The key objectives of this evaluation are as follows:

- Study data collected by the Energy Expert app to:
    - document and analyze the different types of interactions along with the frequencies to develop a sense of how participants are using the available tools, features, and Alexa skills over time; and

  - identify which features are used most regularly and understand whether interactions with certain features diminish over time.

- Analyze changes in participant energy usage following receipt of usage-related notifications, to the extent that the data available for analysis allows.
- Conduct a process evaluation to gain an understanding of customer:
  - perceptions of Energy Expert;
  - interactions and satisfaction with Energy Expert;
  - perceptions of how using Energy Expert has changed their knowledge of energy rates and their usage of electricity; and
  - feedback on Energy Expert app usability and features.

BACKGROUND

The objective of this DRET study is to leverage residential voice-assistant technology and cellular telephone app to educate residential customers on Integrated Demand Side Load Management technologies and energy information such as energy usage and bill forecasts, rates and TOU automation/optimization, availability of Internet-of-Things (IoT) and connectivity, configuration, and notification of utility information. At the study's launch, PG&E was developing its plan to default its residential customers to TOU rates starting April 2021. This DRET demonstration project leveraged residential Voice Assistant technology (i.e., Amazon Alexa), along with cellular telephone app functionality more generally, to educate residential customers.

The first phase of this study, completed in 2021, targeted a small number of PG&E employees and others nominated by them to participate. PG&E's DRET team worked with the supplier of the app—Universal Devices—and Amazon to leverage the notification function built into the app for SmartDays and PSPS communications. The focus of this evaluation is on the second and final phase of this DRET demonstration project, which tested an updated version of the phone app—Energy Expert—among a larger group of PG&E customers, coworkers, friends, and family members over a more extensive time period.

The second phase of the demonstration project started in the spring of 2022. Two-hundred and fifty-three customers signed up for the pilot, and customers interacted with Alexa or the Energy Expert app from late February 2022 through the end of November 2022, when the observation period for this evaluation ended.

EMERGING TECHNOLOGY/PRODUCT

SMART SPEAKER INTEGRATION

Customers were able to link their Alexa smart speaker to the Energy Expert tool, enabling them to use voice commands to learn information about their energy usage, obtain recommendations, and receive important notifications. The Energy Expert capability in Alexa consisted of approximately 15 different skills, described as interactions in the following section. Approximately half of the interactions enabled customers to ask questions related to their energy consumption, bills, or rates, and the other half were related to managing the Energy Expert tool and notification settings.

Alexa Interactions

Customers were able to ask Alexa several different types of questions related to energy usage and related costs. These questions are described below.

"Get Electricity Cost"

The most common interaction customers used was the function to **"get electricity cost."** When prompted, the smart speaker could provide customers with the total cost and quantity of their electricity consumed during a specific time frame. This information would be provided in the following format: *"Your total electricity use for the last 14 days is 8.7 kWh or $33.70. Would you like your electricity use for another period of time?"*

"Get Bill"

Another way customers could understand their past usage was through a function to **"get bill."** By initiating this conversation, customers were provided their bill total from a specific month in the past. These messages sounded like: *"Your last electricity costs from your bill for the period of 2022-03-03 to 2022-03-31 is $124.52. Anything else?"*

"Get When Lowest Costs"

Customers on time-varying rate plans (i.e., TOU) could also inquire about when their energy rates would be the lowest to plan when to use their highest energy-consuming appliances. This information could be initiated through two different functions, **"get good time for"** and **"get when lowest costs."** Each of these functions would provide an answer in the following format: *"The best time is now, and it will use approximately 4.5 kilowatt-hours for a cost of $1.22, but if you wait to 4:00 pm it will cost $1.58. Anything else?"*

"Get Rate Plan"

There was also the capability for customers to learn about their current rate and what rates were available to them. Customers could hear about the rate they were on by inquiring to **"get current rate plan."** This function gave them information like*: "Your current rate plan is Time of Use 4 to 9PM. Better for customers who stay up late. May benefit smaller households in coastal areas with moderately sized homes or condos. Prices are highest from 4 to 9PM at $0.41 per kilowatt hour during the summer weekdays, and $0.35 per kilowatt hour during the winter. Would you like more details?"*

"Get Best Rate Plan"

Customers could inquire to **"get best rate plan,"** which would give them information similar to: *"Your current rate plan is Electric Schedule E-1. If you switched to Time of Use 5 to 8PM, you could save about 3 percent or $165 annually on your electricity costs."*

"Get Available Rate Plan"

Additionally, customers could hear about all the potential rates available to them by asking to **"get available rate plan."** In this type of conversation, the smart speaker listed out all plans a customer could be on. This looks like: *"The 2nd rate plan is Time of Use 5 to 8PM. Better for customers who end the night early. May benefit those who are home during the day and tend to live in smaller rented dwellings. Prices are highest from 5 to 8PM at $0.37 per kilowatt hour during the*

summer weekdays, and $0.29 per kilowatt hour during the winter. Would you like more details on this rate plan, or hear about the next one?"

"Get Outage Information"

The customer could also ask for current outage information, which told the customer if the power at their residence was currently active. This response came in the format of: *"Power for your residence at [ADDRESS] is currently active. For more information, please go to PGE.com/PSPSupdates. Anything else?"*

Additionally, the customer could inquire if there was a forecasted PSPS for their address. The response for this sounded like: *"Your address of [ADDRESS] does not currently have any notices of public safety power shutoff impacts. For more information, please go to PGE.com/PSPSupdates. Anything else?"*

Notification Management

Aside from conversations specifically related to energy usage, bills, rates, and outages, customers could also change basic settings related to their Energy Expert tool. Through the Energy Expert tool, customers could receive notifications about various topics which will be discussed in detail in a later section.

Through their smart speaker, customers could change notification settings for different alerts allowed through the Energy Expert application. Customers were prompted in the following ways:

1. They could say **"get notification settings"** to understand for what notifications they could opt in. This would sound like: *"You can request the notification setting for the following: PSPS, high price, SmartDay, and flex alert. Which one do you want?"*
2. Customers could also enable notifications through smart speaker conversations: *"You can enable high price notification with the following delivery channels: push, text, and Alexa reminder. What is your preferred channel?"*
3. Finally, there was an option to disable notifications through their smart speakers: *"You can disable high price for the following delivery channels: push, text, and Alexa reminder. Which channel do you want to disable?"*

An additional feature of the smart speaker was being able to store messages and read them out to the customers. For example: *"You have three messages. Would you like to hear them now?"*

Finally, customers could check the overall health of their Energy Expert configuration and get helpful tips such as: *"Share My Data is not linked. Please use the app to re-link. Anything else?"*

Smart Phone App

The Energy Expert smart phone app was initially developed to help customers initialize the Energy Expert capabilities on the Alexa smart speaker. However, due to customer interest in the app, additional capabilities were developed. Ultimately, the Energy Expert app was able to provide customers with several features including a presentation of their energy usage data, billing history, rate comparison, and notification configurations. Screen captures of these capabilities and the customer experience are presented in the following figures.

Figure 1 presents the home screen for the Energy Expert app. On the home screen customers can view their last 11 months of billing history, see a rate plan comparison, access notification settings for notifications including PSPS and SmartDays, and access the PG&E Help Center.

FIGURE 1: ENERGY EXPERT APP HOME SCREEN

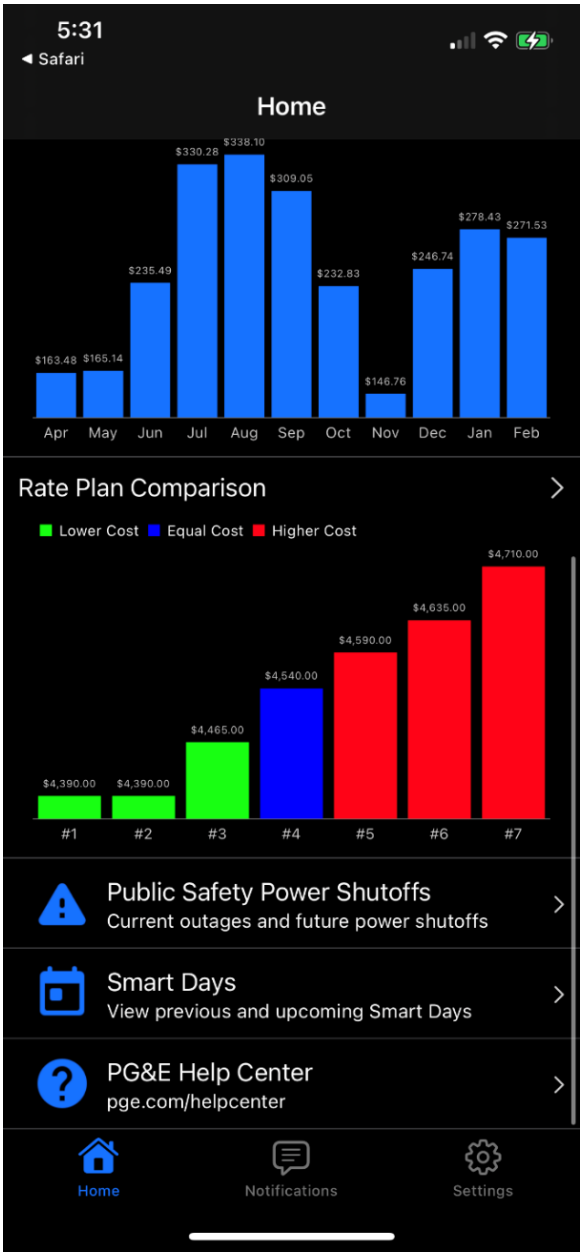


Figure 2 shows the rate plan comparison view. This view includes the various available rates and the cost for the customer on each rate plan. This information can help the customer determine if they are on the best rate for them and if they have opportunities to save money by changing to a different rate.

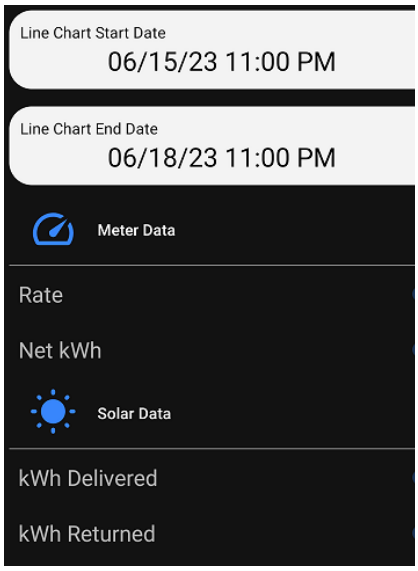
FIGURE 2: ENERGY EXPERT APP RATE PLAN COMPARISON

Figure 3 shows the consumption data and related configuration options. Customers may specify the date range and turn on and off various graph inputs such as the Rate, Net kWh, kWh Delivered, and kWh Returned for the consumption graph. Note the graph is configured to show both positive and negative load values, which is optimized for customers with solar generation who want to monitor their surplus energy returned to the grid. Definitions of the graph inputs are outlined below:

1. Returned: Total kWh returned to the Grid
2. Net: Net kWh used by the customer
3. Delivered: Total kWh delivered to the customer

Rate: Price per kWh in dollars

FIGURE 3: ENERGY EXPERT APP CONFIGURATION AND CONSUMPTION SCREENS



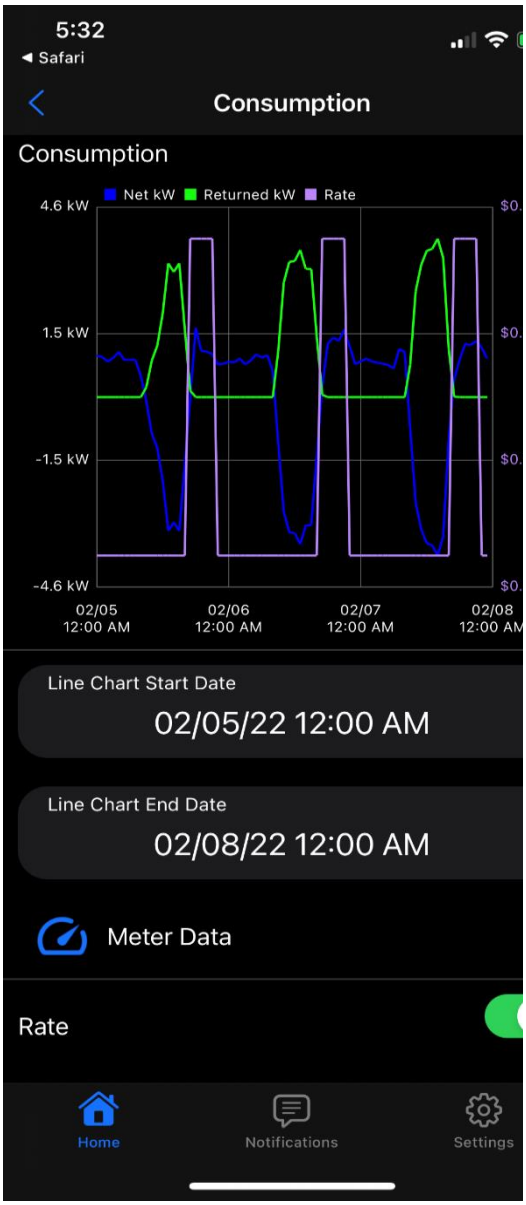
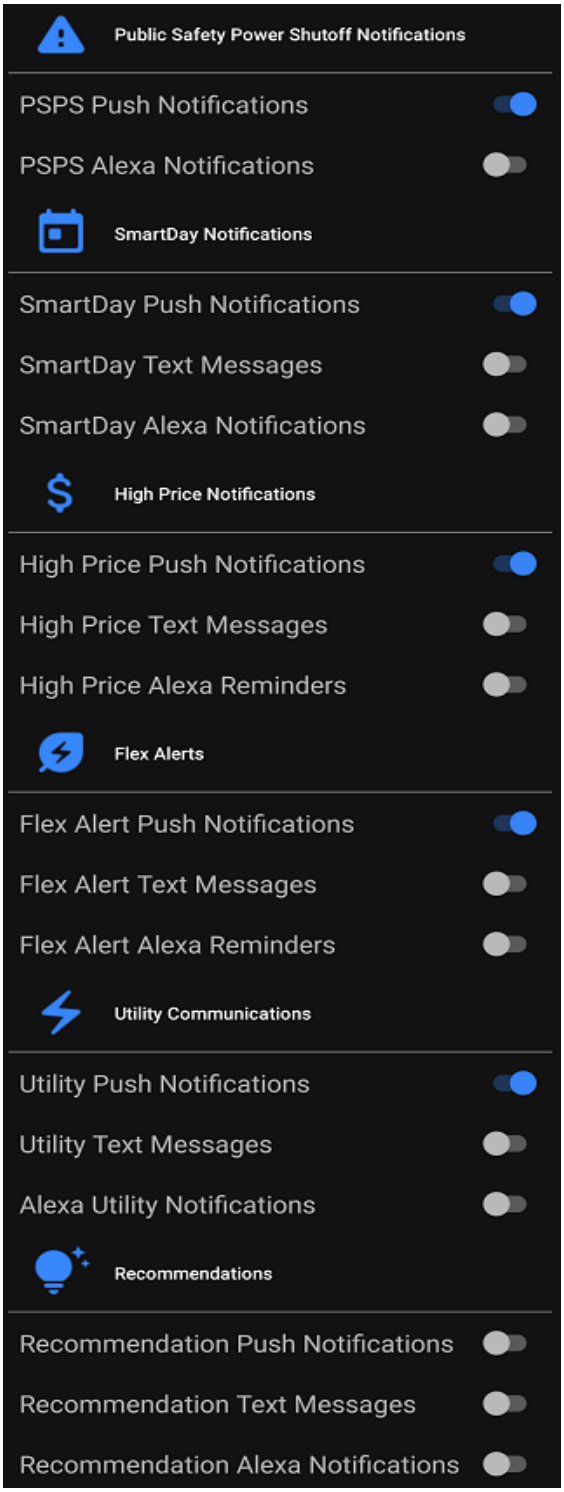


Figure 4 shows the notification configuration menu in the Energy Expert app. On this screen, customers can turn each notification type on or off and can specify their preferred delivery channels including push notification from the app, text message, or notification via Alexa. Details regarding each of the available notification types are described further in the following section.

FIGURE 4: NOTIFICATION CONFIGURATION OPTIONS



NOTIFICATIONS

Through the Energy Expert tool, customers were also able to enable notifications through three different channels. Customers could choose notifications to be read through their smart speaker, texted to their phone, or pushed to the Energy Expert smart phone app. These notifications were completely optional, and customers could opt in and opt out at any time. There were six different types of notifications that customers could receive: High Price, Flex Alert, PSPS (Public Safety Power Shutoff), SmartDay, Utility, and Recommendations. Each of the notifications are described in the following section.

HIGH PRICE

The first type of notification for which customers could opt in was a High Price notification. These notified customers when peak periods for TOU rates were occurring. Customers who opted into the High Price notifications received notifications three times per day for each day they were enrolled. These three notifications occurred one hour prior to the TOU peak period start, at the start of the TOU peak period, and at the end of the TOU peak period. They would look like:

> *"Higher energy prices start in 1 hour."*
>
> *"Higher energy prices start now."*
>
> *"Higher energy prices have now ended."*

Of the 245 total customers, 148 customers opted in to receive these notifications, and 97 did not. Of those who received these notifications, on average they received 342 notifications over 114 days. Based on the available data, it appeared that 36 customers opted out of these notifications before the last day of notifications that were sent out under the pilot.

FLEX ALERT

The second type of notification for which customers could opt in was a Flex Alert notification. Flex Alert notifications are issued by the California Independent System Operator (CAISO) when electricity supply shortages are expected (e.g., extreme weather events). The timing of these notifications was variable based on the supply shortage. These notifications also came in three parts: an hour prior to the event, at the start of the event, and at the end of the event. They would look like:

> *"Flex Alert is in effect from 09/01/2022 04:00 PM to 09/01/2022 09:00 PM. Please help us prevent rotating power outages by adjusting your appliances."*
>
> *"Flex Alert is now active, and it's expected to last till 09/01/2022 09:00 PM. Please help us prevent rotating power outages by reducing energy usage."*
>
> *"Flex Alert is now over."*

These notifications were received by 182 customers. On average, each of these customers received 33 notifications.

PSPS (PUBLIC SAFETY POWER SHUTOFF)

The next notification option available was a PSPS notification. These notifications are location based and are issued when high winds are forecasted, which can cause

power lines to fall or fail. Utilities in California may de-energize specific circuits when winds and wildfire risks are high. The notifications would look like: "Due to weather, PG&E may turn off power for safety at [ADDRESS] on 4/26/21. Est shutoff: 5:00 PM to 6:00 PM. Est restoration: 4/26/21 by 8:00 PM. Weather can affect shutoff and restoration."

A total of 9 customers received these notifications. Each customer received an average of 12 notifications. The PSPS notifications issued by PG&E during the Pilot were system tests. PG&E did not call any actual PSPS events whereby the utility would have proactively de-energized specific circuits to reduce risks of wildfire during the test period.

SmartDay

Customers enrolled on PG&E's SmartRate plan were able to receive SmartDay notifications. SmartRate is one of PG&E's residential demand response (DR) programs, whereby customers pay a higher price for electricity during peak hours on SmartDays in exchange for a discounted price of electricity on typical days. SmartDay events are called on especially hot days, when demand for California's electricity resources peak. During SmartDay events, customers are asked to shift or reduce electricity usage between 4:00 PM and 9:00 PM. These notifications looked like: *"PG&E has called a SmartDay event for Tuesday, 09/06/2022. Remember to reduce your energy use between 4:00 PM and 9:00 PM, when Smart Rate prices are highest."*

This was the least common type of notification. A total of 7 customers received these notifications, and each of those customers received an average of 10 notifications.

Utility

There was also an option for customers to receive utility-related notifications. These notifications came in five different formats.

- 221 customers received a notification that read: "*Would you like to be notified when a different rate can help reduce your electricity bill?*"
- 176 customers received a notification that read: "*Would you like to be notified of important events, such as Public Safety Power Shutoffs, as well as those that can help you save on your energy bills?*"
- 163 customers received a notification that read: *"Are you on the right rate?"*
- 101 customers received a notification that read: "*Noticed you haven't linked Alexa. May we ask why?*" Three options were provided for the customers to choose from.
- 2 customers received a notification that read: "*During the last month, we have noticed your usage has increased during peak hours. Please visit PGE.com for more information."*

Recommendations

Finally, customers could receive notifications that related to recommendations regarding their energy usage. A total of 185 customers received at least one recommendation notification. These came with three possible pieces of information.

- *"Based on your recent usage, your next electricity bill is expected to be about*

[$10.00], which is [10%] more than your previous electricity bill."

- *"We noticed that last week you used about [25%] more energy than usual."*
- *"Did you know that you could save about [8%] by switching to the rate plan 'Home Charging'?"* This type of notification runs on a schedule, each month checking if another rate plan is cheaper by at least 8%.

Table 2 summarizes the number of customers who received each of the notification types, along with the average number of notifications received by each customer. For example, 148 customers received the High Price notifications, and each customer received an average of 342 High Price notifications.

TABLE 2: NUMBER OF CUSTOMERS AND AVERAGE NOTIFICATIONS PER CUSTOMER BY NOTIFICATION TYPE

Notification Type	Number of Customers	Average Notifications per Customer
High Price	148	342
Flex Alert	182	33
PSPS*	9	12
SmartDay	7	10
Utility	221	3
Recommendation	185	2
Total	**245**	**-**

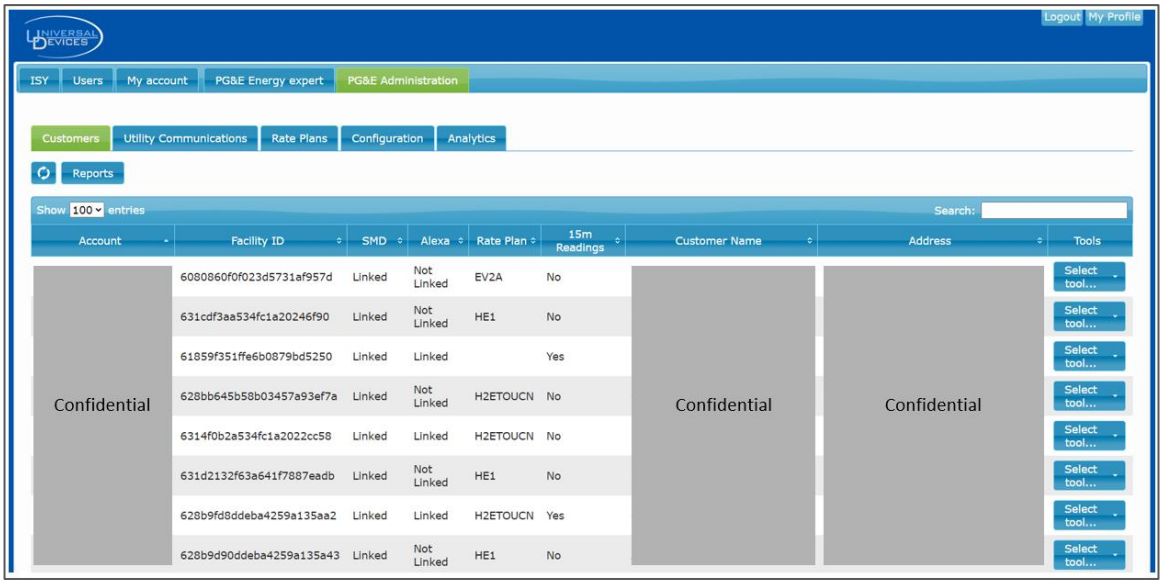
** PSPS notifications were system tests and not notification of actual PSPS events.*

UTILITY INTERFACE

Energy Expert includes an Administrative (Admin) Interface for PG&E staff to manage the customer experience and gain insights from the integrated analytics platform. The interface has several features including a customer participation list, report generation, rate plan details, configuration options, editable terms and conditions for participants, notification configuration options, recommendation options, and analytics. Universal Devices also developed a user guide for the Admin Interface to assist PG&E program staff with using the various features and tools.

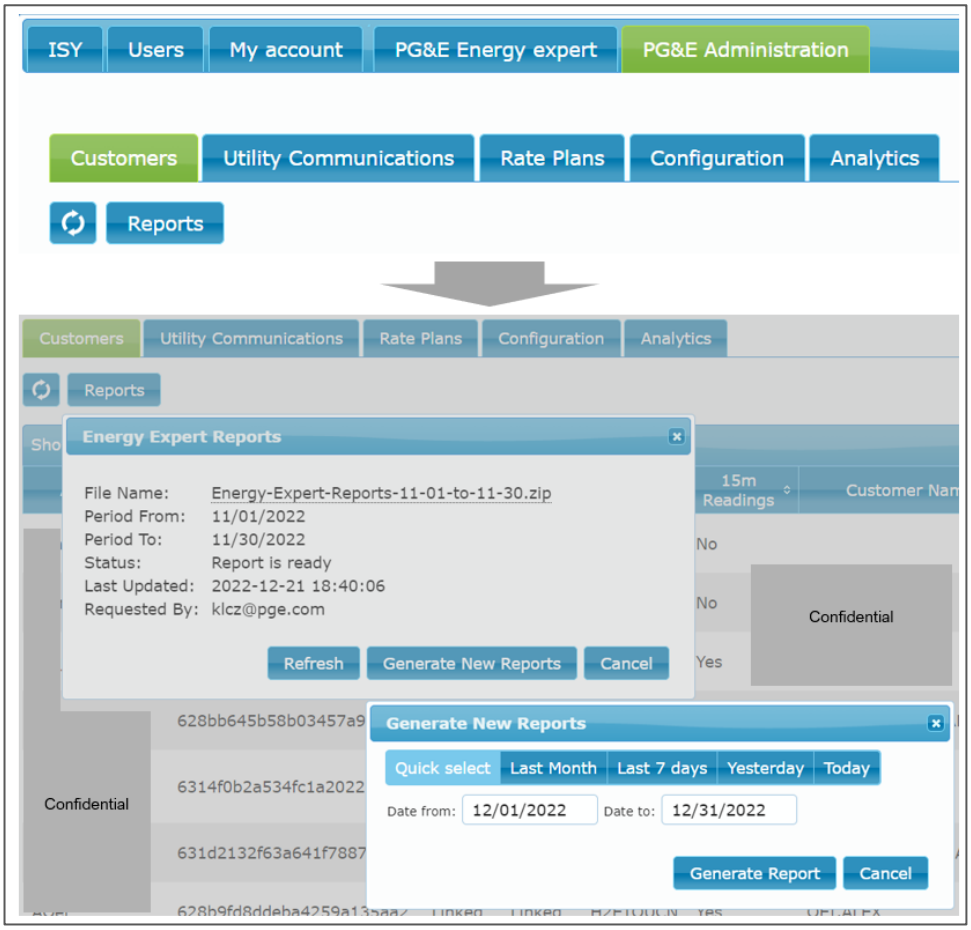
Figure 5 shows the customer participation table view, which includes customer identification and contact information fields along with details regarding the customer rate plan, 15-minute versus hourly interval data readings, and the status of Alexa being linked to the Energy Expert capabilities. This table, along with various reports discussed in the remainder of this section, can be exported in spreadsheet format for use with programs such as Microsoft Excel.

FIGURE 5: CUSTOMER PARTICIPATION TABLE VIEW



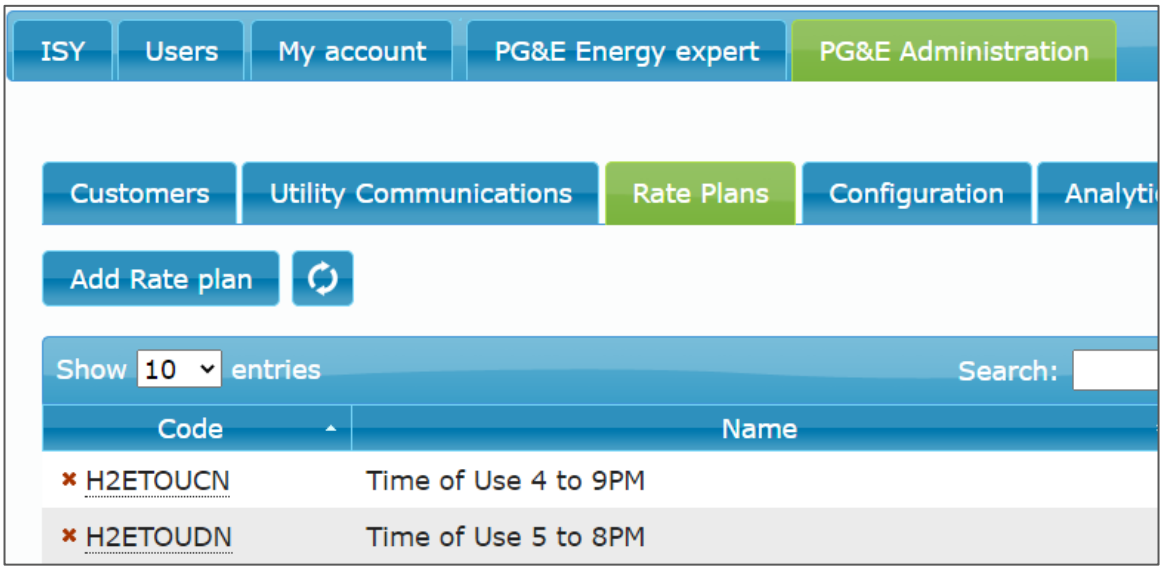
The Admin Interface also allows utility staff to generate reports covering customizable time periods. Figure 6 provides a screen capture of the report generation interface and time-period options. The generated reports contain either 15-minute or hourly load data for each participant, along with detailed logs containing all customer notifications and interactions with Alexa for the defined period. The reports generated can be used for internal analysis at the utility or for evaluation activities such those contained in this document.

FIGURE 6: REPORT GENERATION INTERFACE



Rate plans drive many of the underlying features of the Energy Expert tool, and can be added, edited, or removed by the administrator of the app. Figure 7 provides a screen capture of the Rate Plan interface and shows two of PG&E's most common TOU rates. Approximately 15 fields are customizable for each rate plan, including mapping to GridX codes that incorporate multiple rate parameters to provide customers the bill impacts of specific rate choices.

FIGURE 7: RATE PLAN CONFIGURATION INTERFACE



Under the configuration tab the program administrator can customize the customer-facing terms and conditions, High Price notifications for TOU customers, Flex Alert and SmartRate notifications, along with several different recommendation options. Figure 8 shows the configuration options for the Flex Alert messaging. Each of the other tabs have a similar interface with customizable options.

FIGURE 8: CONFIGURATION OPTIONS

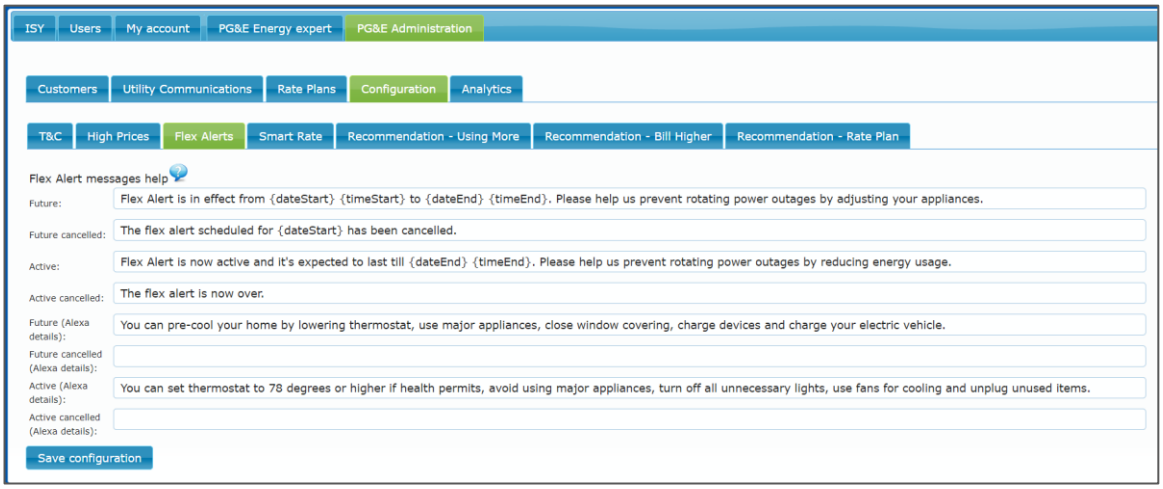
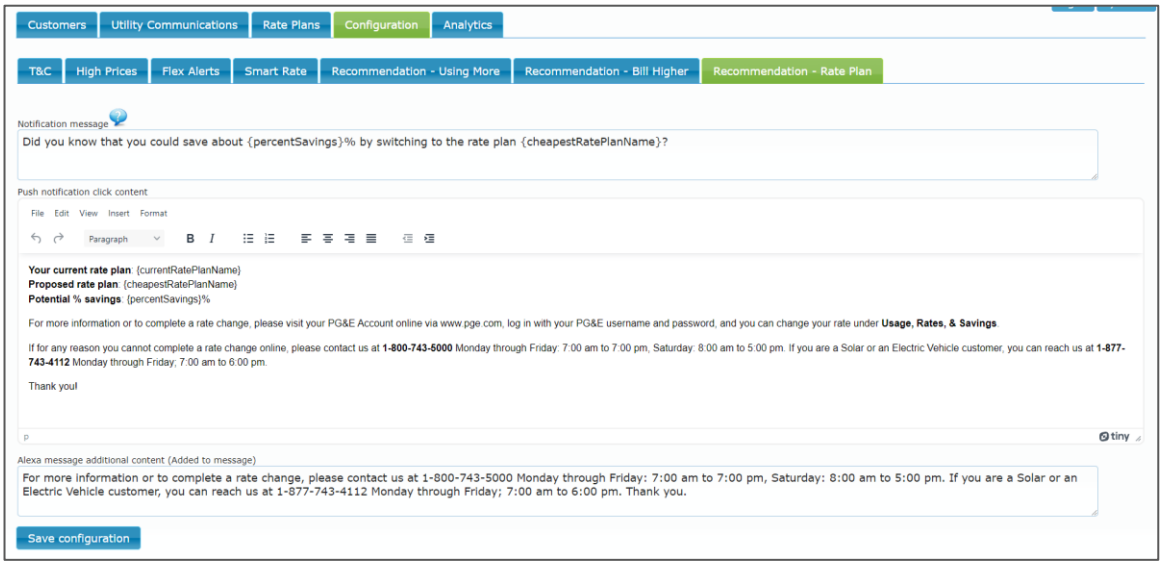


Figure 9 shows the Rate Plan Recommendation configuration options. Under this tab, the messaging and parameters for the Rate Plan Recommendation algorithm can be modified. The notifications for alerting customers to higher-than-normal usage (Using More) or if a higher-than-normal bill is expected (Bill Higher) have similar configuration options.

FIGURE 9: RATE PLAN RECOMMENDATION CONFIGURATION



The Admin Interface also includes built-in analytics tools. These include tracking and reporting of notification deliveries by channel over customizable time periods (Figure 10) and monitoring of notifications sent by notification type, e.g., PSPS, High Price, etc. (Figure 11).

FIGURE 10: NOTIFICATION DELIVERY TRACKING

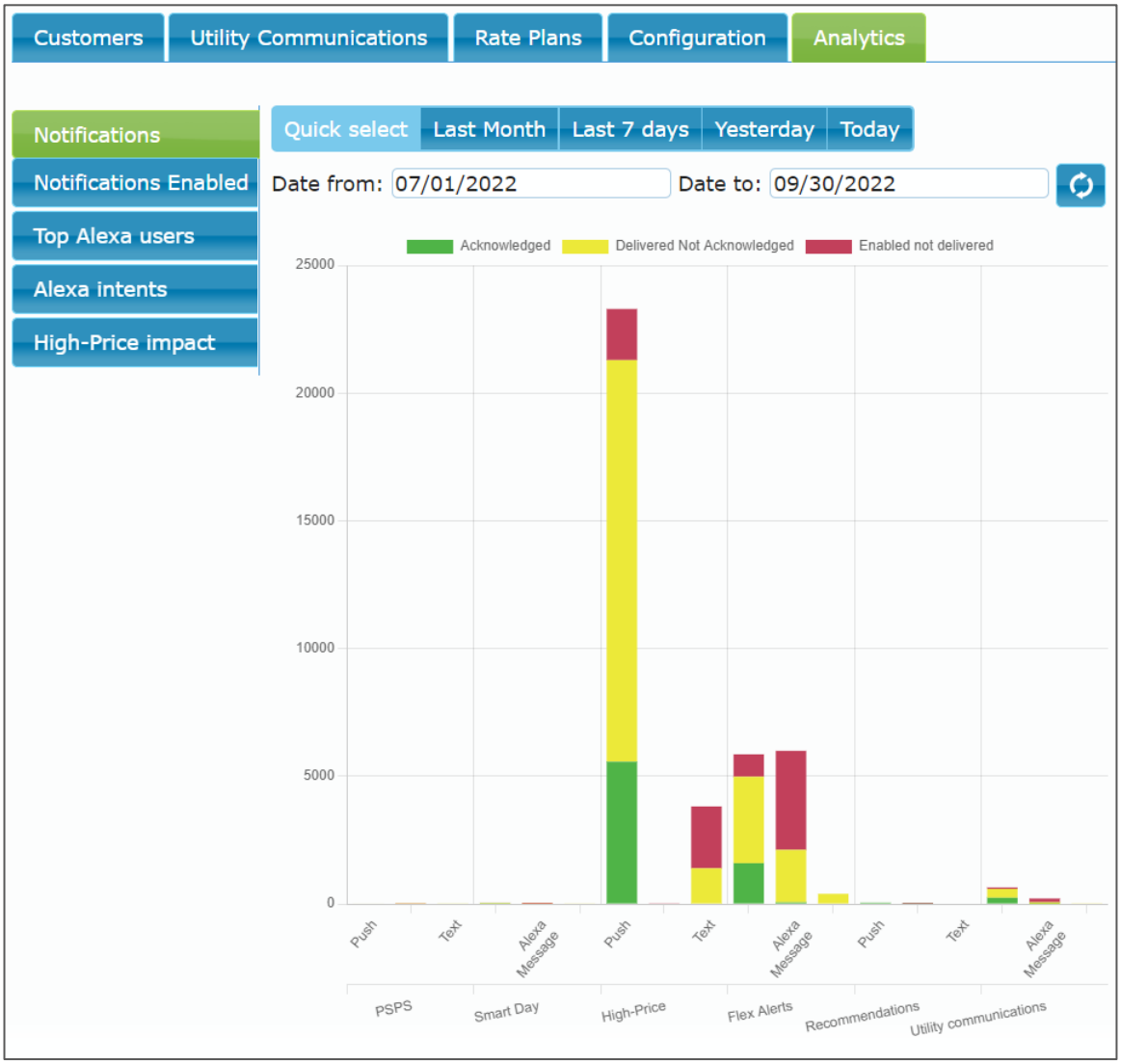
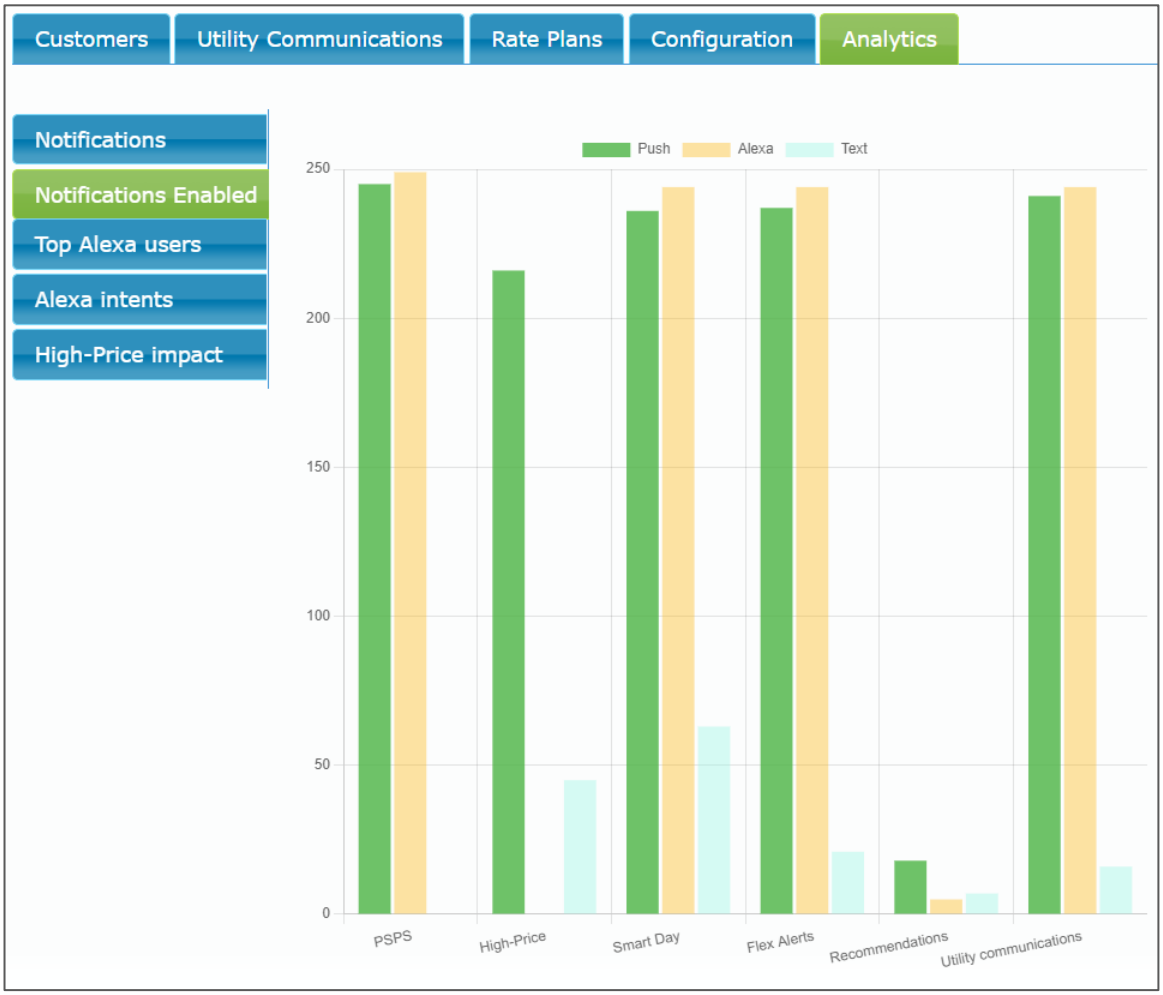
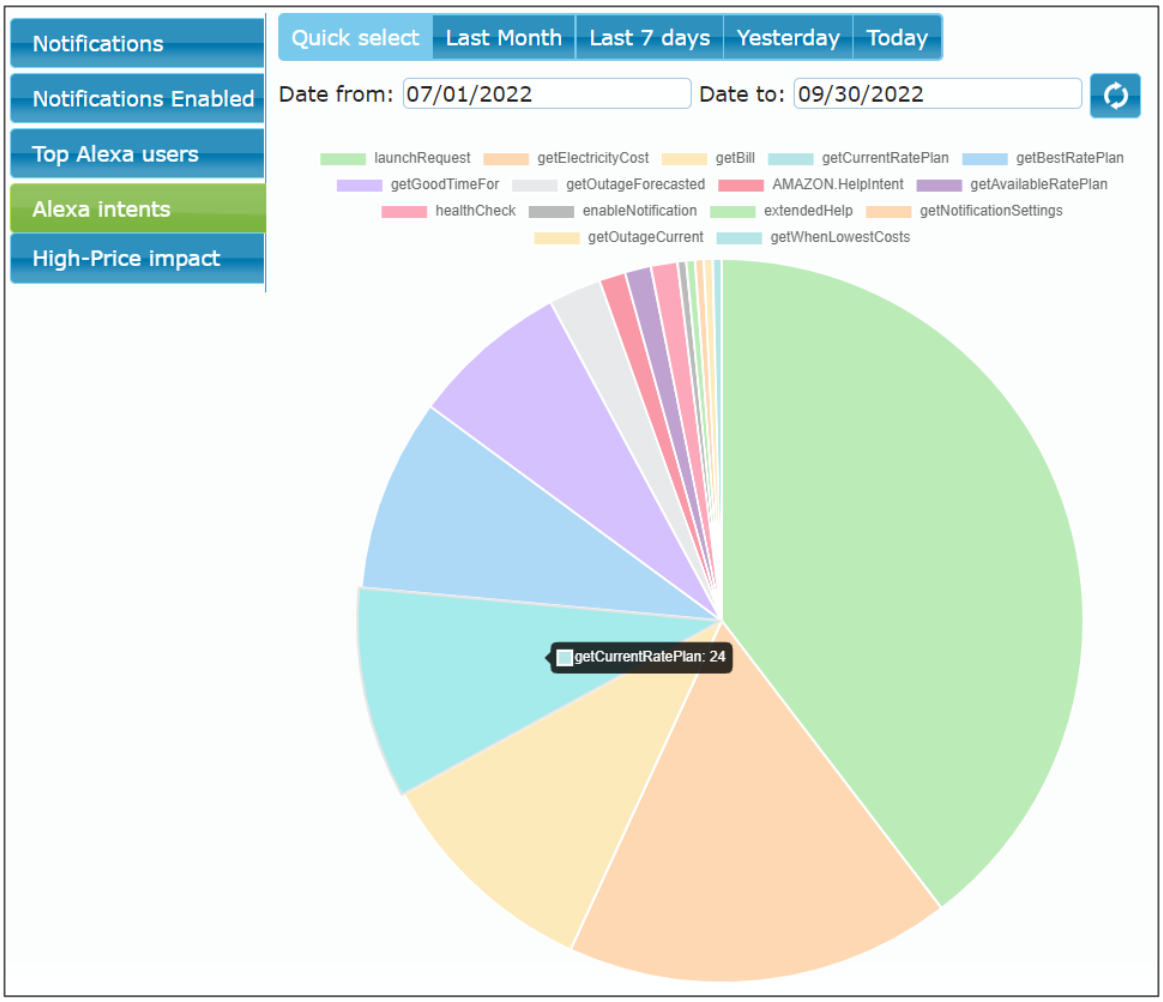


FIGURE 11: NOTIFICATIONS BY TYPE



Analytics are also available to identify the most commonly used Alexa interactions (intents) during a user-defined period of time, as shown in Figure 12. In this example, "Get Current Rate Plan" had been requested 24 times between July 1 and September 30.

FIGURE 12: ALEXA INTERACTION TRACKING



The analytics capabilities also include a load comparison feature for the customers receiving the High Price notifications, shown in Figure 13. This feature allows the user to specify date ranges for the comparison and provides summaries of the participating customers' load before and after receiving the notifications on a historical basis, days notifications were not sent, days push notifications were sent, days receipt of the notification was acknowledged, and days receipt of the notifications was acknowledged within 30 minutes. The user can also select (click on) columns within the graph and see estimated demand reduction calculations relative to historical data. Program staff may find these calculations informative as "directional findings", meaning they may help to identify if customers are reducing usage in response to the notification. However, impact estimates from tools such as this typically differ from those in formal load impact evaluations, and program staff should keep that in mind if they use the impacts for corporate reporting purposes.

The primary reason that impacts from an analytics tool such as this may differ from impacts estimated under a formal load impact evaluation is that a formal evaluation will either use a control group in order to account for exogenous/unobservable factors or weather-normalize the load for a within-subjects analysis. This aspect is mentioned not to take anything away from the value of the tool, but to ensure program staff are aware of the possibility of different impact findings from a formal load impact evaluation.

FIGURE 13: HIGH PRICE NOTIFICATION LOAD COMPARISON

METHODOLOGY

DATA SOURCES

Five main data sources were provided to support the analysis of customer interactions with the smart speaker, notifications, and load impacts on customers who either interacted with their smart speaker or received notifications from the Energy Expert tool.

1. General customer information was provided. This included a field identifying customers who had linked their smart speaker to the Energy Expert tool. This file also identified what type of rate each customer was on. The rate information allowed the evaluator to account for different usage patterns associated with different rate plans.
2. Smart speaker interaction data was also provided. This file had a row for each line of dialogue spoken by the smart speaker. It included unique identifiers for each customer, a timestamp of when the interaction occurred, and a categorization of the content of the conversation.
3. Notifications sent to each customer were documented. This included unique identifiers for each customer, a timestamp of the notification, a categorization for the type of notification, and the text of the notification sent out. This file also included a field that identified the method of communication, including text, push, or smart speaker.
4. Interval load data was provided for each of the customers in the above datasets. This was available in 15-minute intervals and hourly intervals. The file included unique identifiers, timestamps, the kW delivered in the interval, the kW generated in the interval, and the total kW of the interval (delivered minus generated).
5. Customer surveys were conducted to collect information from participants regarding their experience on the pilot.

LOAD IMPACT ESTIMATION

The load impact analysis focused on examining customer response to three different types of notifications: High Price, Flex Alert, and SmartDay. Each of these notifications included a call to action during a specific period of time that could result in an observable reduction in electricity demand.

The analysis was conducted on a subset of the pilot population. Based on the small sample size available, it was determined that it would be most reliable to include only a homogenous group of customers. Therefore, the analysis was limited to customers on TOU rates to minimize confounding factors from different rate structures. Customers with solar were also excluded because daily generation patterns can vary significantly across customers and mask usage trends. Finally, the analysis was limited to summer months (June through September).

As will be discussed in the Load Analysis results section, the customers who did not sign up to receive notifications had different consumption patterns compared to those customers who did sign up for notifications. This meant that the non-notified customers were not a suitable control group for the notified customers. While a

matched control group was an additional analysis option, with such a small sample size the benefits of implementing a matched control group did not outweigh the cost of implementing that type of analysis, as the results would still not likely be statistically significant. Accordingly, the load impact estimation was conducted as a within-subjects analysis.

Equation 1 presents the model specification used for the analysis. Terms are defined in Table 3. Multiple model specifications were tested, and the model that best predicted customer demand was selected. The model was implemented as a panel regression model, with customer-level fixed effects. Customer fixed effects regression allows each customer's mean usage to be modeled separately, which results in smaller standard errors (and therefore more precise estimates).

EQUATION 1: EX POST REGRESSION

$$kW_{it} = A \times weekend_t + \sum_{h=1}^{24} B_h \times faFlag_{it} + \sum_{h=1}^{24} C_h \times sdFlag_{it} + \sum_{h=1}^{24} D_h \times hpFlag_{it} + E \times cdd_t + F \times cdd_t^2 + \sum_{h=1}^{24} G_h + hour_{ht} + v_i + \varepsilon_{it}$$

TABLE 3: REGRESSION DESCRIPTION

Model Term	Description
kW_{it}	Net electrical kW demand for customer *i*, at time *t*
A through G	Regression model coefficients
$weekend_t$	Binary indicator for type of day at time *t*; equal to 1 for weekends and 0 for weekdays
$faFlag_{it}$	Binary indicator for hour of a Flex Alert event at time *t*; equal to 1 if hour is during a Flex Alert for customer *i*; equal to 0 for other hours and customers
$sdFlag_{it}$	Binary indicator for hour of a SmartDay at time *t*; equal to 1 if hour is during a SmartDay event for customer *i* and equal to 0 for other hours and customers
$hpFlag_{it}$	Binary indicator for hour of a High Price event at time *t*; equal to 1 if hour is during a High Price event for customer *i* and equal to 0 for other hours and customers
cdd_t	Cooling degree days at time *t*
cdd_t^2	Cooling degree days at time *t*, squared
$hour_{ht}$	Binary indicator for hour *h* at time *t*
v_i	Customer fixed effects variable that controls for unobserved factors that are time-invariant and unique to each customer *i*
ε_{it}	Error term

Customer Surveys

Apex developed and fielded an online survey for pilot participants. Potential respondents received up to three invitations to complete the survey by email between April 20 and May 9, 2023, with the survey closing on May 15. To increase the legitimacy of the survey request, incentives came from a PG&E email address. As detailed in Table 4: Survey Response Disposition, we ultimately received 36 responses from among the 199 pilot participants for whom email addresses were available resulting in a response rate of 19% as calculated by the number of survey responses received divided by the number of eligible respondents. We did not offer an incentive to survey respondents.

Table 4: Survey Response Disposition

Disposition	Count
Complete Survey	36
Disqualified*	7
Undeliverable Emails	2
No Response	154
Total	**199**

** Respondents answering "No" or "Don't know" when asked to confirm that they had joined the Energy Expert pilot.*

RESULTS

PARTICIPATION

A total of 253 customers signed up for the pilot and were identified in the enrollment dataset provided by Universal Devices. Table 5 provides the number of non-solar customers on a TOU rate, non-solar customers not on a TOU rate, and the number of solar or net energy metered (NEM) customers. NEM customers are required by PG&E to be enrolled on a TOU rate. Approximately 43% of participants were enrolled on a TOU rate and did not have solar generation. Of note is that the population in this pilot was primarily composed of PG&E employees, along with PG&E employee friends and family.

TABLE 5: CUSTOMER COUNTS

Customer Type	Total Customers	Percent
TOU	109	43%
Non-TOU	79	31%
Solar	65	26%
Total Customers	**253**	**100%**

Table 6 presents the portion of the pilot population who linked Energy Expert to their Alexa device. In total, 89 customers linked to Alexa. It should be noted that Alexa was the only type of smart speaker supported for the pilot, and nearly half of the survey respondents stated they did not have an Alexa smart speaker. Those participants who did not link to Alexa may not have had an Alexa smart speaker or may not have had a smart speaker at all. Those without Alexa were able to use the Energy Expert app on their smart phone.

TABLE 6: ALEXA COUNTS

Customer Type	Total Customers
Linked to Alexa	89
Not Linked to Alexa	164
Total Customers	**253**

KEY FINDINGS

- A total of 253 customers enrolled in the pilot.
- Of those, 89 customers linked Energy Expert to Alexa.

INTERACTION ANALYSIS

The objective of the interaction analysis was to discover how customers used their smart speaker devices. Nearly 90 customers were identified as having linked their smart speaker to the Energy Expert tool, and 31 unique customers had interactions with the smart speaker.

Figure 14 summarizes the number of unique customers that engaged in each type of conversation. About half of the customers asked about electricity costs or their bill, with approximately one-third or less of the customers initiating the other conversation topics.

FIGURE 14: UNIQUE CUSTOMERS BY INTENT

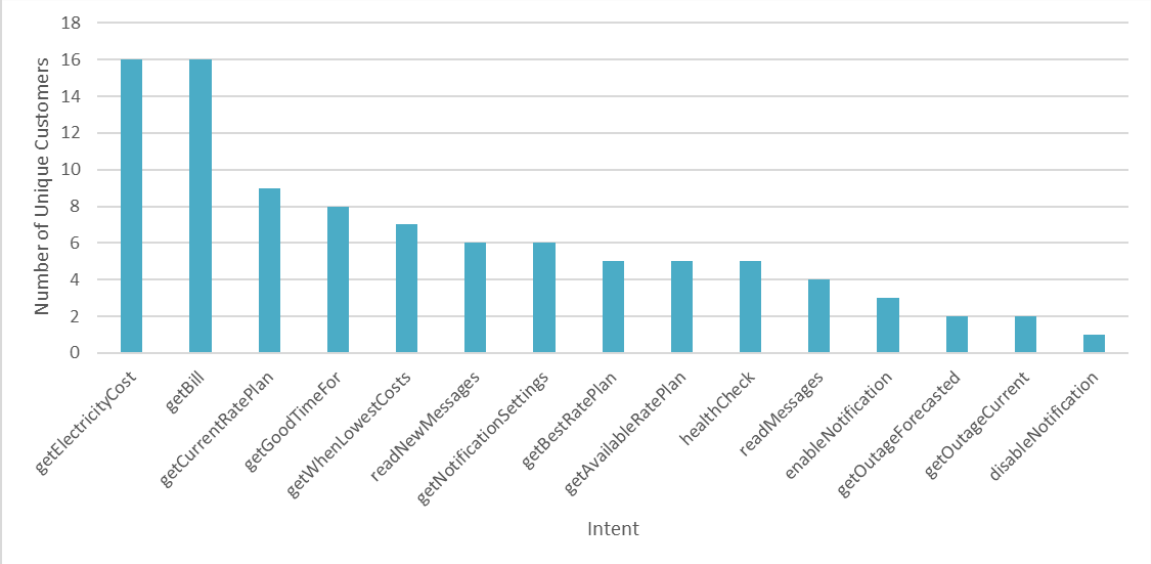


Figure 15 presents the counts of conversation by conversation type. The 'getElectricityCost' was the most popular with 73 unique conversations, followed by 'getGoodTimeFor' with 63. The 'getElectricityCost' conversation allowed customers to receive their usage data for a specified period of time, and how much that usage cost them. The 'getGoodTimeFor' conversation gave customers a recommendation on the cheapest time for them to use high energy appliances.

The group of participants only used the 'healthCheck' and 'disableNotification' option seven and three times, respectively.

FIGURE 15: UNIQUE CONVERSATIONS BY INTENT

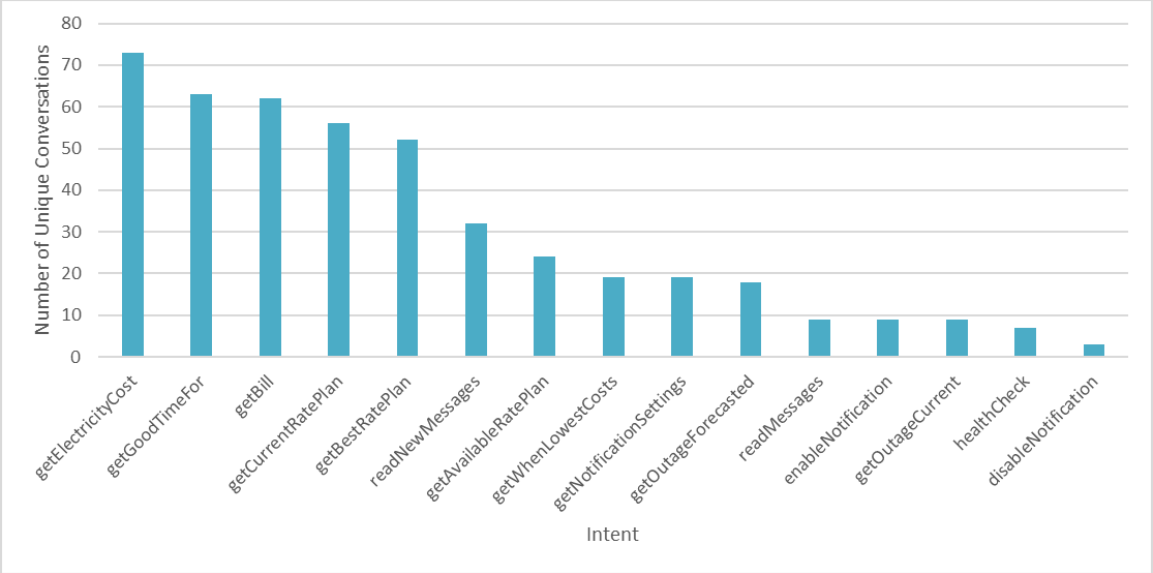
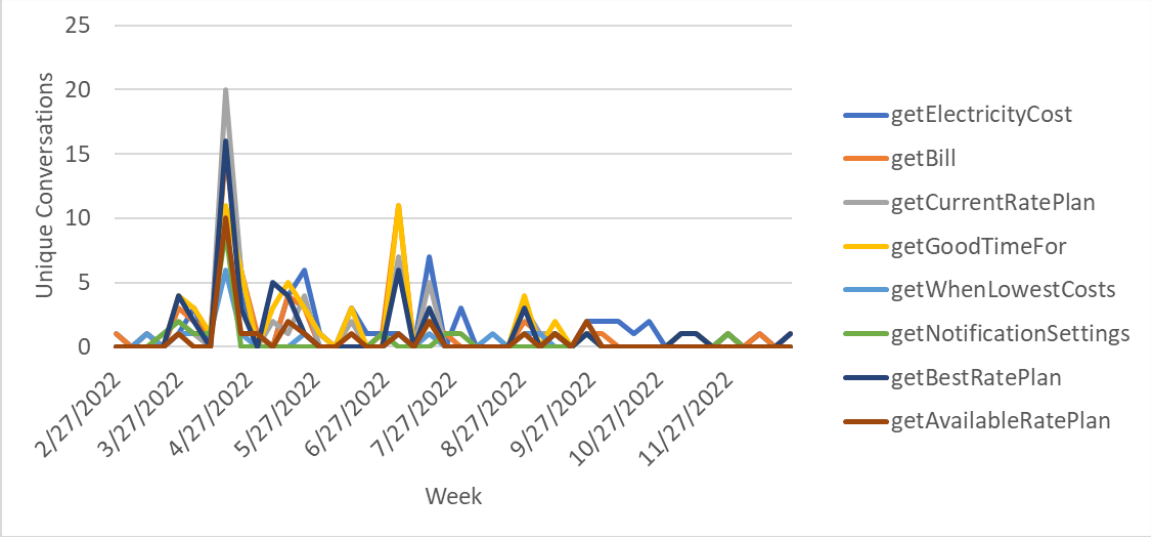


Figure 16 illustrates the number of unique conversations per week throughout the analysis period from March 3 to December 30, 2022. By far, the largest number of conversations occurred in the first week of April. During this period, there were roughly 56 unique conversations in which a customer asked about their current rate plan and sixteen customers asked which rate plan would be best for them. Following a couple of smaller spikes in the number of interactions in June and July, the number of conversations decreased over time.

According to Universal Devices, customer engagement and outreach were put on hold during the late summer and were not authorized to resume during the remainder of the observation period. Other similar pilots such as the Universal Devices Gateway Pilot conducted at SCE have shown the importance of customer outreach in promoting customer engagement. Had customer outreach continued in the late summer and early fall, it is likely additional interactions with Alexa would have been observed.

FIGURE 16: INTERACTIONS OVER TIME



KEY FINDINGS

- Fifteen types of interactions with Alexa were available for customers.
- About half of the customers asked about electricity costs or their bill, with approximately one-third or less of the customers using the other interactions.
- The 'getElectricityCost' intent was most popular with 73 unique conversations.
- Participants interacted with Alexa the most during the earlier months of the pilot and decreased over time in the later months.

LOAD ANALYSIS

The load analysis focused on 202 unique customers across 3 customer segments: Non-Solar TOU, Non-Solar Non-TOU, and Solar. Customers included in the analysis had reliable AMI data for the summer months from June to September. Three types of notifications that could have resulted in load shifting were offered to customers:

High Price, Flex Alert, and SmartDay. The objective of the load impact analysis was to determine if there were observable demand reductions attributable to event notifications. Table 7 shows the number of unique customers that received each type of notification. A customer only needed to receive one notification to be counted in its corresponding category. It should be noted that only five unique customers received SmartDay notifications and had sufficient AMI data to be included in the analysis.

TABLE 7: ANALYSIS DATASET CUSTOMER COUNTS

Customer Segment	High Price Customers	Flex Alert Customers	SmartDay Customers	Total Customers
Non-Solar TOU	70	45	2	**75**
Solar	53	47	0	**61**
Non-Solar Non-TOU	7	48	3	**66**
Total Customers	**130**	**140**	**5**	**202**

* Customers could sign up for multiple notifications (rows will not sum to total); customer counts reflect customers with complete load data available for analysis.

Table 8 summarizes the number of notifications by time of day. Nearly all alerts occurred between 4:00 PM and 8:00 PM. Six notifications occurred at 2:00 PM and 89 occurred at 9:00 PM.

TABLE 8: DISTRIBUTION OF NOTIFICATION TIMING

Notification Type	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM
High Price	4	149	1,841	2,045	2,045	2,044	1,701	-
Flex Alert	-	45	477	477	477	477	477	89
SmartDay	2	2	21	21	21	19	19	-

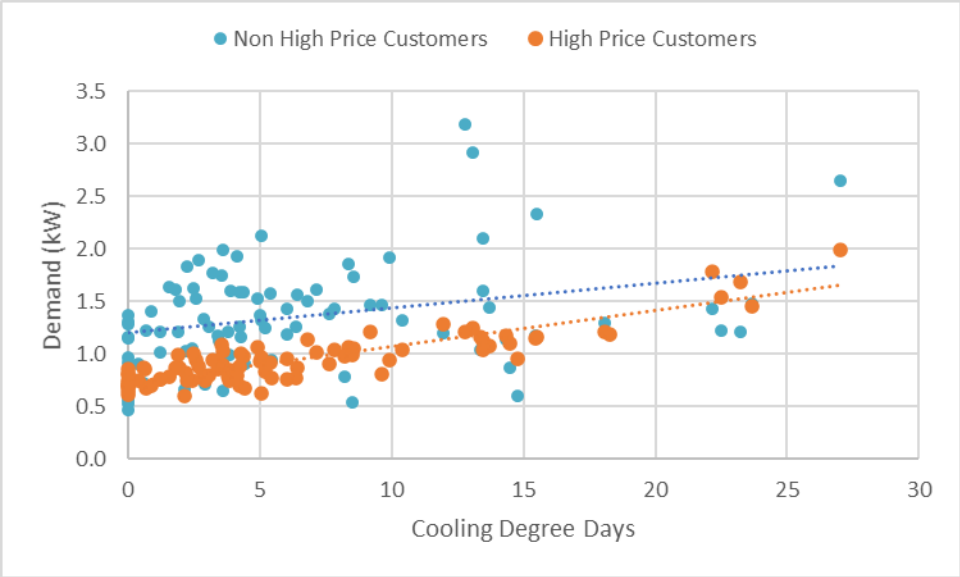
HIGH PRICE NOTIFICATIONS

The analysis of the impact of the High Price notifications on customer usage was limited to customers who were on a TOU rate and did not have rooftop solar. Load impacts can be affected by the daily generation of rooftop solar and confounding factors of different rate structures, so NEM customers and customers on non-TOU rates were excluded from the analysis.

Customers who signed up for High Price notifications tended to have lower afternoon electricity demand when compared to customers who did not sign up for High Price notifications. Figure 17 illustrates the relationship between electricity demand and weather for customers who signed up for High Price notifications (in orange) and those who did not (in blue). Each marker represents the average electricity demand at 1:00 PM on an individual weekday.[1] The x-axis represents the cooling degree days (CDD) for each day. For each day, CDD are equal to be the number of degrees by which the average temperature exceeds 65 degrees Fahrenheit. If the average temperature is 65 degrees or cooler, CDD is equal to zero.

As the figure indicates, High Price notification customers tend to have lower demand than non-High Price notification customers across a variety of weather conditions. Customers who received notifications also appear to have less variability in their load than those who did not. Due to this difference, it was determined that the customers who did not sign up for these notifications would not be an effective comparison group for those who did.

FIGURE 17: HIGH PRICE NOTIFICATIONS: ELECTRICITY USAGE COMPARED TO WEATHER



Because of the absence of a suitable control group, the analysis was conducted as a weather-normalized within-subjects model. This method compares demand for customers who signed up for High Price notifications on days they received notifications to days when they did not. This approach was possible because most customers who received High Price notifications did not receive these notifications every day during the observation period, thus providing a counterfactual.

[1] The analysis dataset includes weekdays from June through September 2022.

Figure 18 summarizes the number of High Price notifications received throughout the analysis period by customers who signed up to receive them. Most customers who opted in for these notifications received them less than half of the days included in the analysis period (roughly 125 days).

FIGURE 18: DISTRIBUTION OF HIGH PRICE NOTIFICATION DAYS

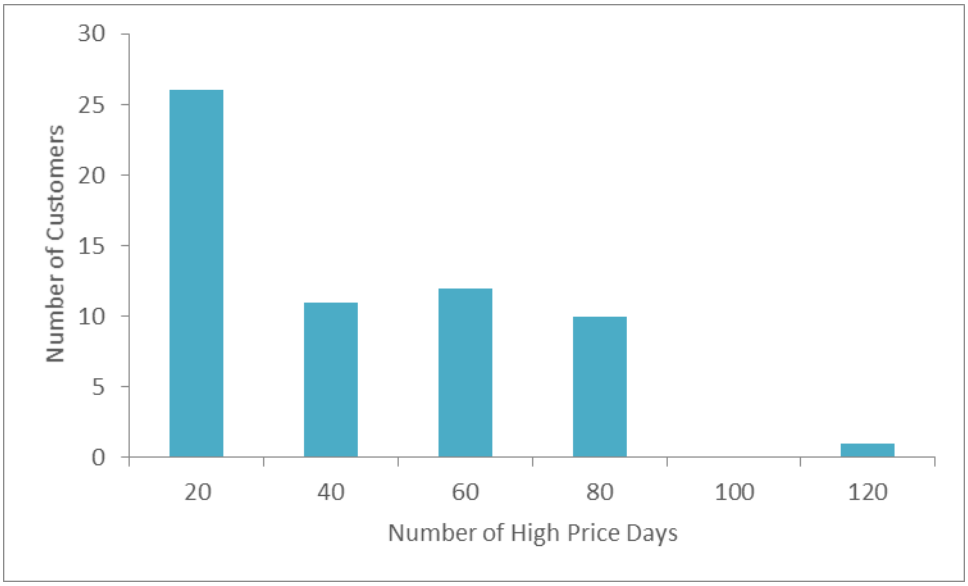


Figure 19 illustrates modeled average hourly kW demand for Non-Solar TOU customers on a High Price notification day. The orange line represents the kW demand customers are expected to have on a notification day using the approach described in the methodology section, and the blue line represents modeled customer demand in the absence of notifications (the reference load). The difference between the two represents the estimated load impact attributable to High Price notifications. As the figure indicates, customers provided a modest response to High Price notifications in the form of demand reductions during the peak period.

FIGURE 19: MODELED HIGH PRICE IMPACTS

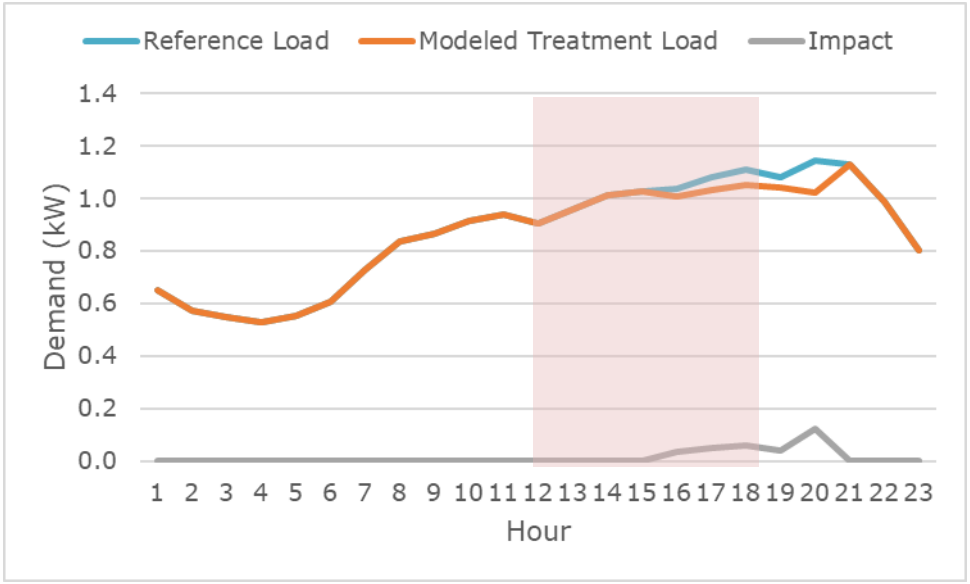


Table 9 presents the average reference load and treatment load for each hour of a modeled High Price event. As indicated previously, the impact is equal to the difference between the reference load and the treatment load. A positive impact indicates a demand reduction, while a negative impact indicates a demand increase. The table also includes the 90% confidence interval on the load impact estimate. A confidence interval that contains zero indicates an impact that is not statistically significant. Customers who received High Price notifications exhibited hourly peak-period load reductions that ranged from 3% to 5%. These impacts were incremental to impacts attributable to their TOU rate. However, it should be noted the impacts were not statistically significant due to the small sample size available.

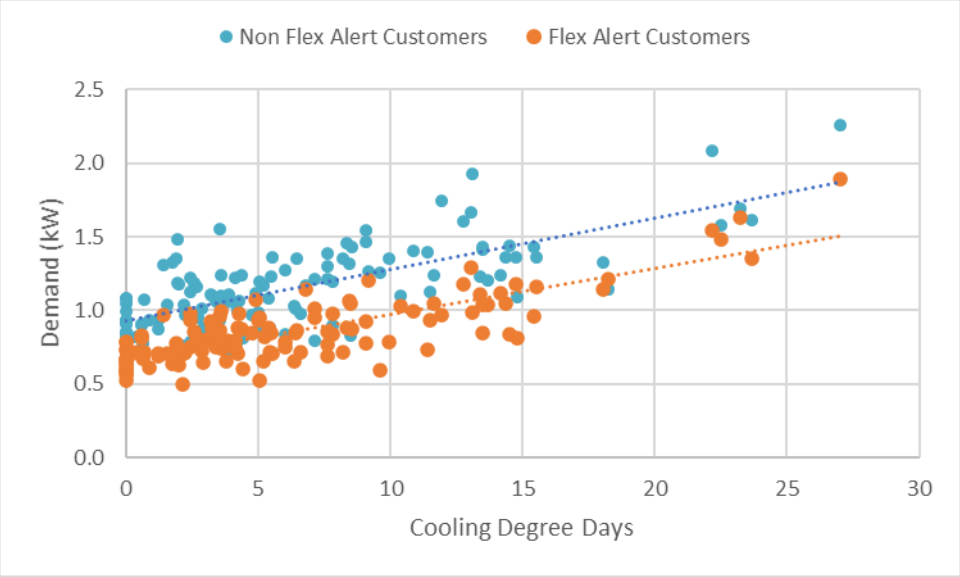
TABLE 9: HIGH PRICE NOTIFICATION LOAD IMPACTS

Hour	Reference Load (kW)	Modeled Treatment Load (kW)	Impact (kW)	90% Confidence Interval	Percent Impact
4:00 PM	1.04	1.01	0.03	(-0.19, 0.13)	3.3%
5:00 PM	1.08	1.03	0.05	(-0.21, 0.12)	4.6%
6:00 PM	1.11	1.05	0.05	(-0.20, 0.08)	5.6%
7:00 PM	1.08	1.04	0.04	(-0.17, 0.09)	3.8%
8:00 PM	1.15	1.02	0.12	(-0.27, 0.03)	12.2%

FLEX ALERT NOTIFICATIONS

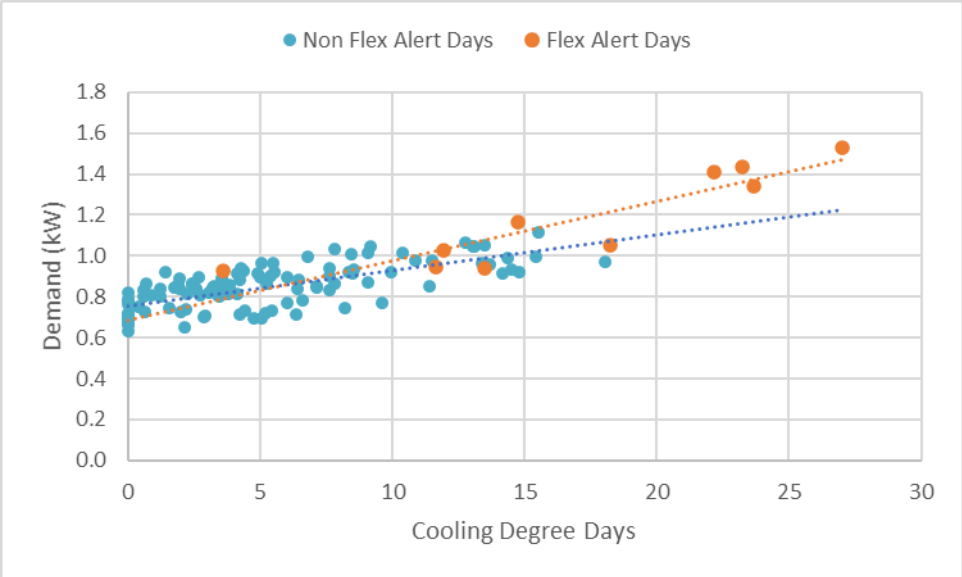
In Figure 20, each marker represents one weekday in the analysis period. The y-axis represents average customer demand for the 1:00 PM hour and the x-axis is CDD. Generally, customers who signed up for Flex Alert notifications had lower afternoon demand than those who did not. Accordingly, the non-notified customers were not a good comparison group for those who received notifications, and the analysis needed to focus on notified customers.

FIGURE 20: FLEX ALERT NOTIFICATIONS ELECTRICITY USAGE COMPARED TO WEATHER



A key difference between the High Price notifications and the Flex Alert notifications is that Flex Alerts are designed to be sent out on extreme weather days. Figure 21 plots the average Flex Alert customer demand on notification days (orange) and non-notification days (blue) against daily CDD. As illustrated in the figure, Flex Alert notification days occurred on six of the ten hottest days in the analysis period. Unfortunately, there were not enough hot non-Flex Alert days to use as a counterfactual in the load impact analysis.

FIGURE 21: FLEX ALERT DAY WEATHER



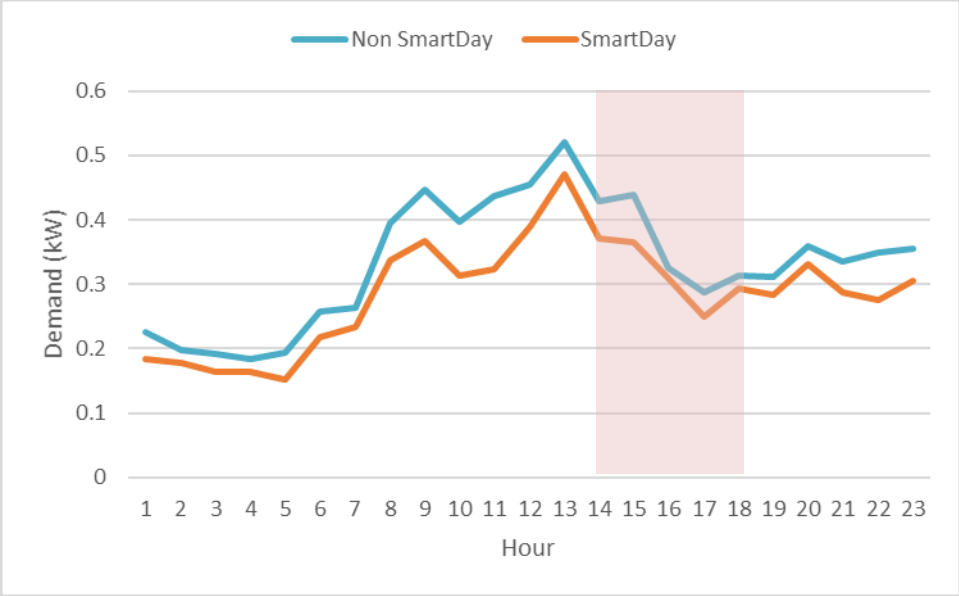
Due to the information presented in Figure 20 and Figure 21, it is not possible to estimate load impacts for this population using a weather-normalized within-subjects model, nor is it possible to use the pilot participant non-Flex Alert population as a control group. A matched control group methodology would be an alternative approach for estimating load impacts associated with Flex Alert notifications, however this approach is outside of the scope of this study. Furthermore, given the small sample size it is unlikely that results obtained through a matched control group would be statistically significant.

SMARTDAY NOTIFICATIONS

Two customers had sufficient data to be included in a load analysis of the SmartDay notifications; they received SmartDay notifications, were on a TOU rate, and were not solar customers. These two customers had a total of 13 SmartDay notification days during the analysis period.

Figure 22 illustrates average hourly load for customers receiving SmartDay notifications. The orange line represents their kW demand on SmartDays, and the blue line represents their demand on average summer weekdays on which a SmartDay notification was not dispatched. The two SmartDay customers appear to have lower demand on days they received notifications. However, a larger population of customers is needed to draw any conclusions regarding the incremental effect of Energy Expert on SmartDay customer demand.

FIGURE 22: SMARTDAY LOAD SHAPES



KEY FINDINGS

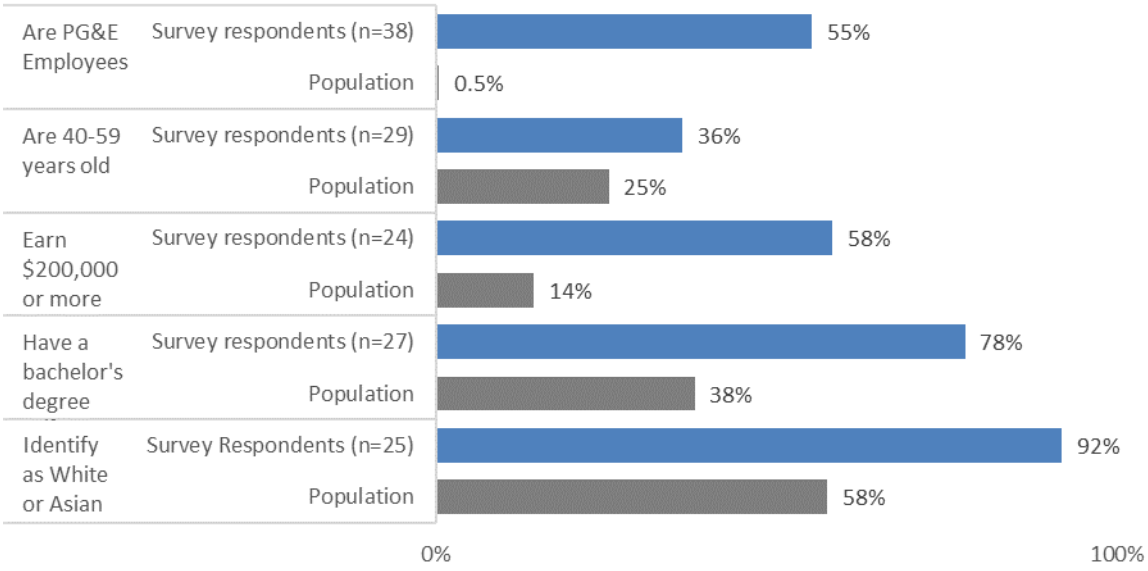
- Six types of notifications were available to pilot participants via their preferred notification channel.
    - The most common notification was the High Price alert during the TOU peak period, followed by the Flex Alert notification.
- High Price notification customers showed hourly TOU peak-period load reductions in the 3% to 5% range.
    - Impacts are incremental to underlying impacts attributable to the TOU rate.
    - Impacts are directional and not statistically significant, due to the small sample size.
- Flex Alert days tended to be hotter than most other days, and customers who signed up for notifications had different consumption patterns from customers who did not request notifications.
    - Due to these aspects, it is not possible to estimate load reductions without use of a matched control group, which was outside of the scope of this project.
- The two customers who received SmartDay notifications tended to show lower load on the days with SmartDay notifications compared to non-Smart Days with similar weather patterns.
    - However, a larger population is needed to draw conclusions regarding the incremental effect of Energy Expert on SmartDay load patterns.

CUSTOMER SURVEYS

RESPONDENT CHARACTERISTICS

Reflecting the pilot's "friends and family" rollout approach, survey respondents differed from the larger population of PG&E customers in notable ways. Slightly more than half of respondents (55%) reported that they, or someone else in their household, were PG&E employees. Respondents were also notably wealthier and more educated than the population of PG&E customers as a whole. Figure 23 illustrates the most notable differences between survey respondents and the population of PG&E customers. More detailed comparisons of demographic characteristics between survey respondents and the broader PG&E customer population are presented in the Appendix.

FIGURE 23: NOTABLE DEMOGRAPHIC DIFFERENCES BETWEEN SURVEY RESPONDENTS AND PG&E CUSTOMER POPULATION

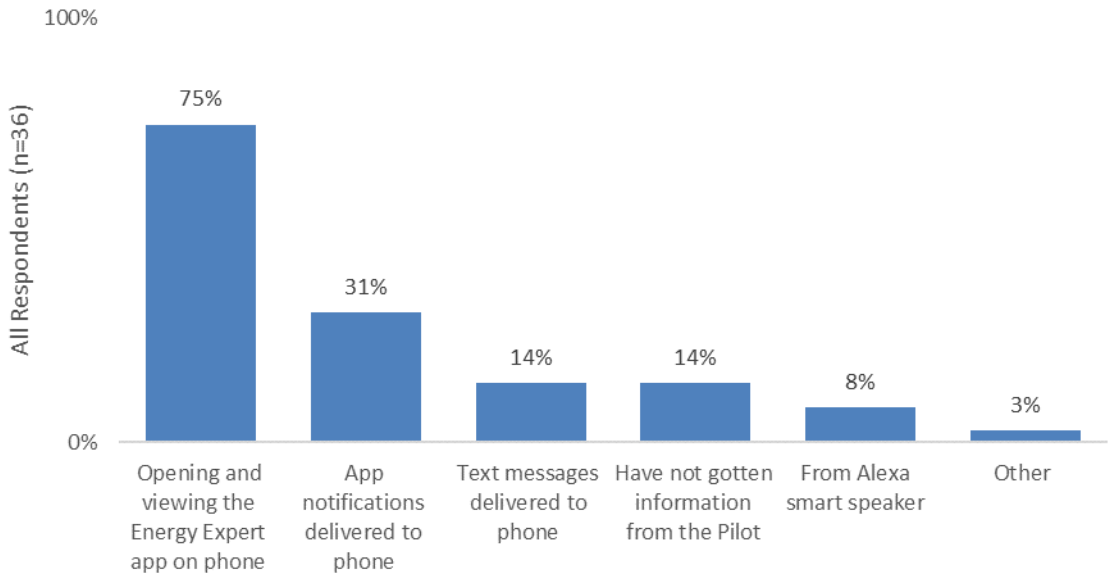


Population data from 2022 American Community Survey 5-year estimates aggregated across zip codes in PG&E

Experience With Energy Expert Communication Channels

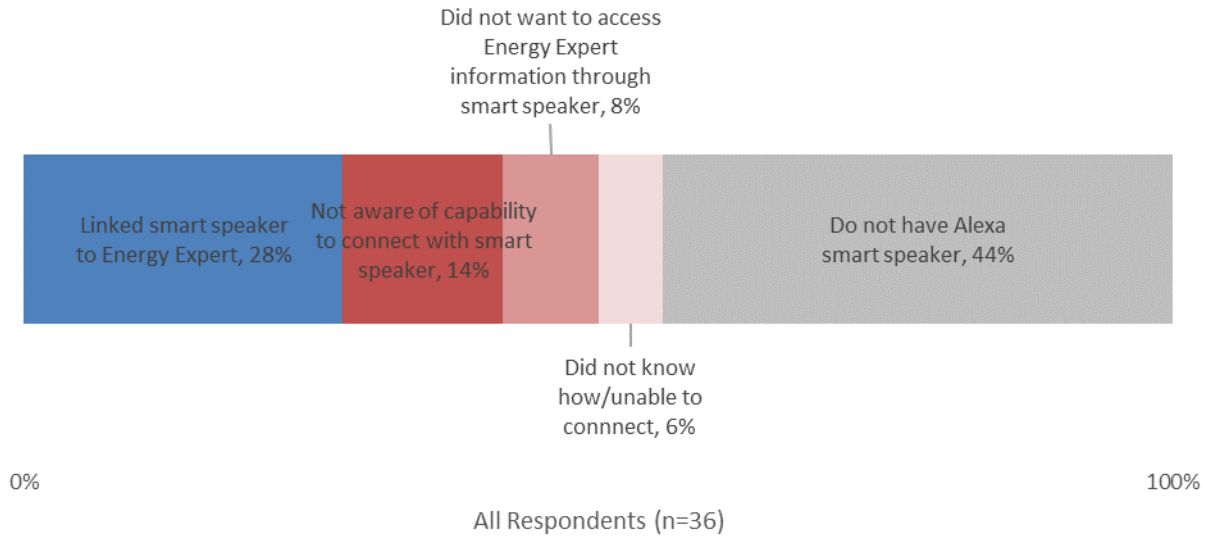
Survey respondents most often accessed information from the Energy Expert pilots by opening the app on their phones, followed by app notifications (Figure 24). Relatively few respondents reported accessing information through their Alexa smart speakers, although, as discussed below, a larger number reported connecting Energy Expert to their smart speakers.

Figure 24: Means of Accessing Energy Expert Information



Slightly more than half of survey respondents (20 of 36, 56%) reported that they had an Alexa smart speaker (Figure 25). Half of those respondents (10 of 20) reported they had linked their smart speakers to the Energy Expert app. Respondents who had not linked their smart speakers most often (5 of 10) reported they were not aware of the capability to do so. Those who were aware but opted not to link their smart speakers were divided between respondents who did not want to access Energy Expert information through their smart speakers (3 respondents) and those who did not know how to link Energy Expert to their smart speakers (2 respondents).

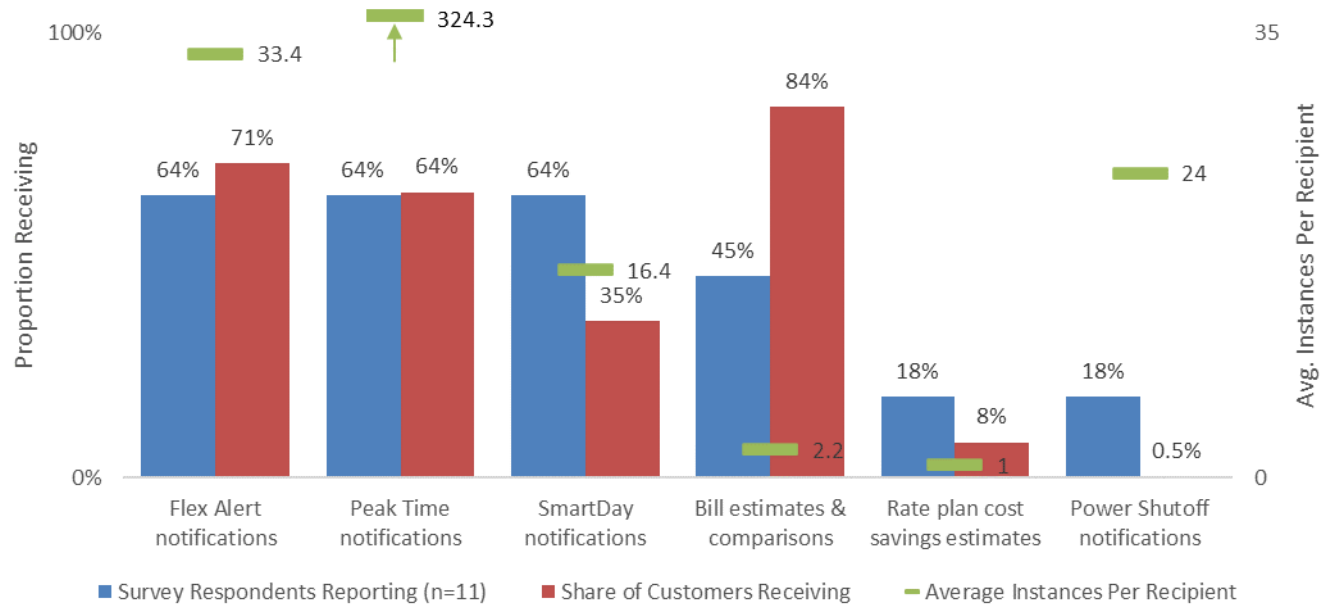
FIGURE 25: SMART SPEAKER CONNECTION STATUS



Respondents who received Energy Expert notifications most often (6 of 11) reported receiving them daily or multiple times a day. This is consistent with the frequency with which the pilot sent notifications about peak times, one of the most frequent types of notifications respondents reported receiving. Most respondents (7 of 11) reported they knew how to change the quantity of notifications they received from the Energy Expert app.

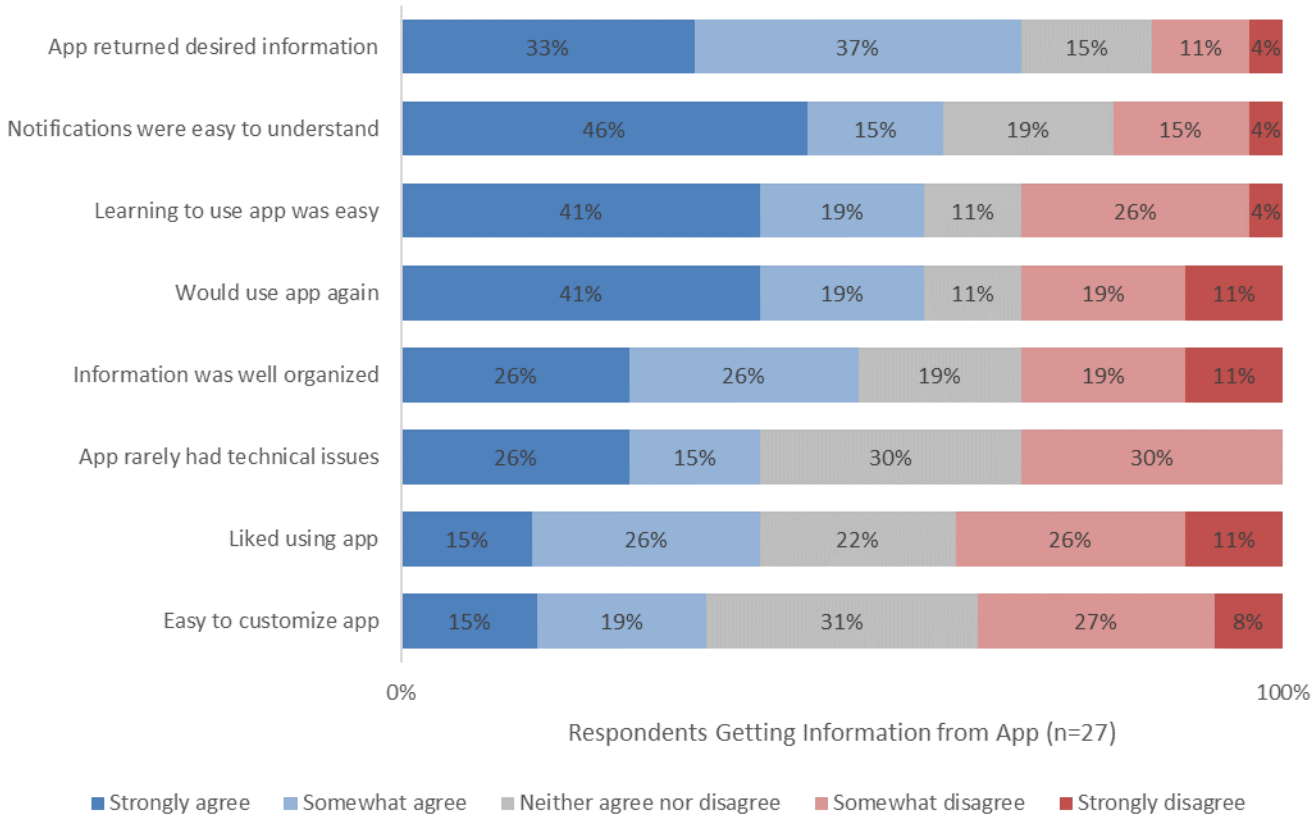
The proportion of survey respondents who reported receiving notifications about Flex Alerts and peak times largely paralleled the share of respondents that the program's notification logs indicate received those notification types (Figure 26). Survey respondents were less likely to recall receiving notifications providing bill estimates and comparisons to previous months. This difference in rates of recall may reflect that pilot participants received far fewer instances of bill estimate and comparison notifications (an average of 2.2 per customer receiving that notification type) than Flex Alert (33.4 per customer) or peak time (324.3 per customer) notifications. In fact, peak time notifications were delivered multiple times each day: an hour prior to the start of higher energy prices, when higher energy prices started, and when higher energy prices ended. Somewhat paradoxically, more survey respondents recalled receiving SmartDay notifications than log data suggest respondents actually received that notification type. This difference may reflect respondents hearing about SmartDays from other sources. SmartRate is a voluntary plan whereby customers pay a reduced electric rate in exchange for agreeing to shift or reduce electricity usage when SmartDays are called. A minimum of nine SmartDays are called each year, and notifications are sent before every SmartDay the day prior by email and/or text.

FIGURE 26: SURVEY RESPONDENT RECALL OF NOTIFICATIONS



Survey findings suggest that the Energy Expert app worked for most participants, although a minority struggled with multiple aspects of the app. Respondents most often agreed that the app returned the desired information and that notifications were easy to understand (Figure 27). Of the eight questions presented to respondents in the question battery, the lowest proportion of respondents agreed that they liked using the app or that it was easy to customize.

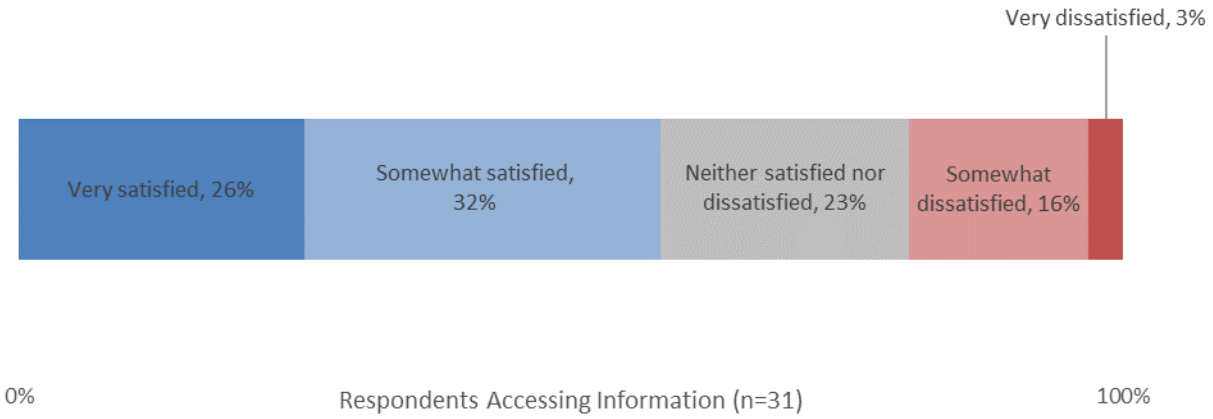
FIGURE 27: SURVEY RESPONDENT RATINGS OF APP ASPECTS



Survey respondents were provided the opportunity to suggest features and/or capabilities that the app did not currently provide. Survey respondents' suggestions for improving the app primarily focused on additional types of information the app could provide (12 of 17 respondents). Most often, respondents seeking additional information expressed a desire for real-time energy usage data (6 respondents) or additional data on energy costs (3 respondents). Some respondents (5 of 17) also suggested opportunities to improve the app design, with two noting that the rate plan comparison did not clearly identify which rate plan the user was on currently.

Overall, respondents were largely satisfied with their experience accessing information from Energy Expert, whether through the app, a smart speaker, or notifications. Approximately 60% reported that they were "very" or "somewhat" satisfied (Figure 28).

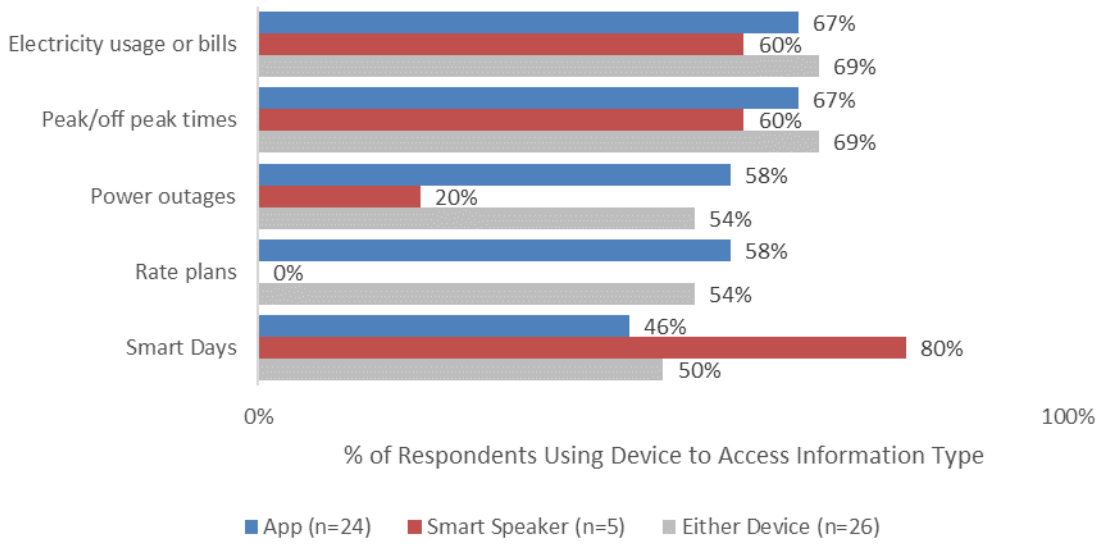
FIGURE 28: SURVEY RESPONDENT SATISFACTION WITH ACCESSING ENERGY EXPERT INFORMATION



VALUE OF ENERGY EXPERT INFORMATION

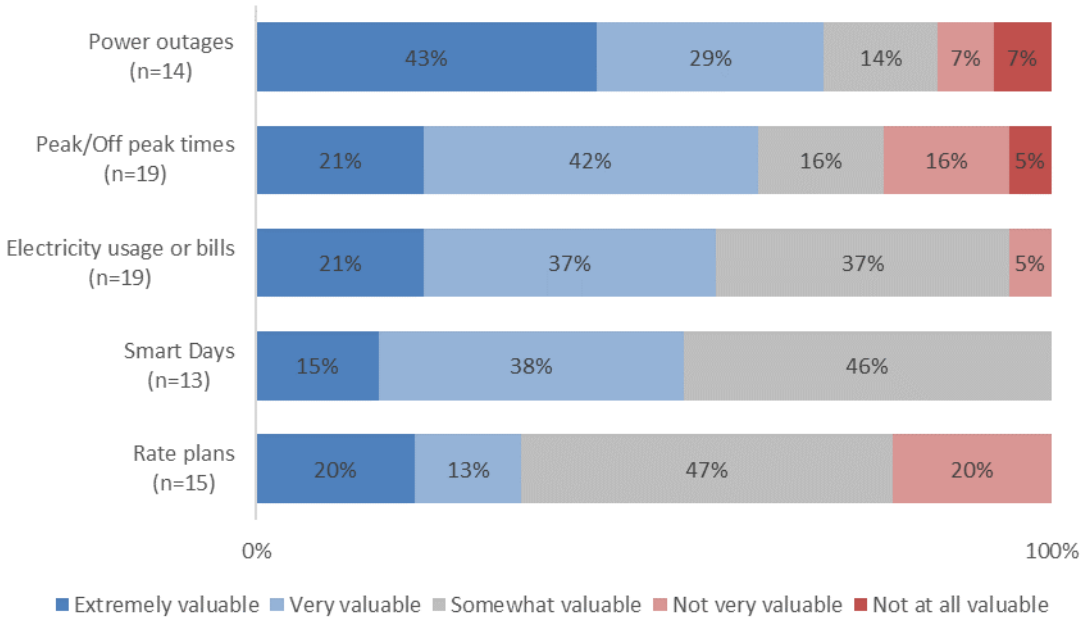
Survey respondents most often reported using Energy Expert to get information about electricity usage or bills or peak and off-peak times (Figure 29). Respondents used both the app and their smart speakers to find information about both topics with roughly equal frequency. Respondents were more likely to report using the app for information about power outages and rate plans, while they more often reported using smart speakers for information about SmartDays.

FIGURE 29: TYPES OF INFORMATION ACCESSED BY DEVICE



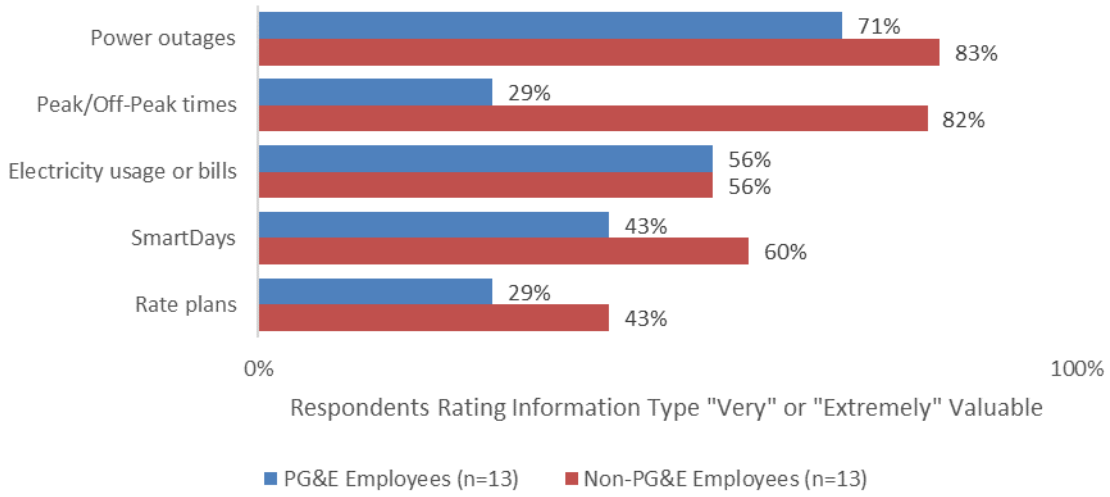
In total, survey respondents found information about power outages to be the most valuable, while they gave lower ratings to the value of information about rate plans (Figure 30). These ratings may reflect a relatively high level of energy awareness among pilot participants, which was reflected in open-ended responses throughout the survey referencing things like voltage optimization and more advanced energy monitoring solutions. As one respondent wrote in an open-ended response, "I already work at the company and know the rates."

FIGURE 30: VALUE OF INFORMATION TYPES (ALL RESPONDENTS)



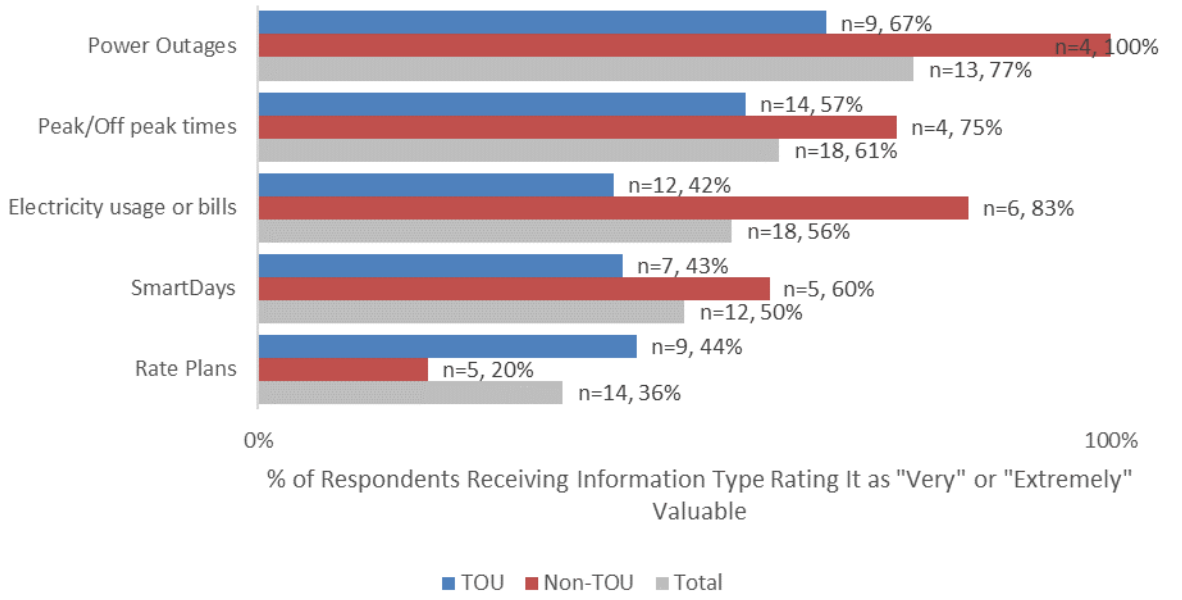
There were clear differences between PG&E employees and other pilot participants in their ratings of the value of different types of information the pilot provided. Non-PG&E employees were more likely to provide high ratings for almost all information types, with the most notable difference in the value ratings for information about peak and off-peak times (Figure 31). By contrast, PG&E employees tended to rate information on power outages higher than they rated other information types.

FIGURE 31: VALUE OF INFORMATION TYPES BY PG&E EMPLOYMENT STATUS



There were also differences in respondents' ratings of the value of pilot information between participants on TOU rates and those not on TOU rates (Figure 32). Respondents not on TOU rates were more likely to rate each information type as "very" or "extremely" valuable, with the exception of information about rate plans. These responses may reflect participants on TOU rates entering the pilot with a greater baseline level of energy awareness due to the need to track peak energy usage times.

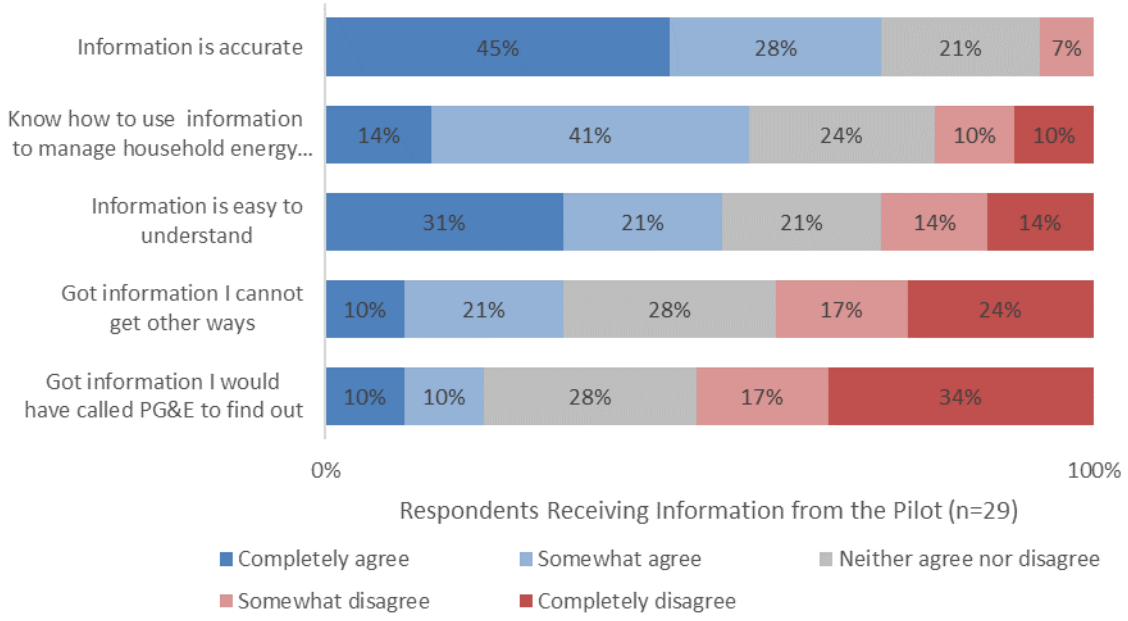
FIGURE 32: VALUE OF INFORMATION TYPES BY TOU OR NON-TOU RATE CLASS



Despite respondents' relatively low ratings of the value of information about rate plans, most (10 of 15) of those who accessed the information reported that Energy Expert increased their understanding of their rate plan at least "a little bit." There was no clear difference in these ratings between PG&E employees and other respondents. None of the respondents, however, reported that Energy Expert suggested they change to a different rate plan.

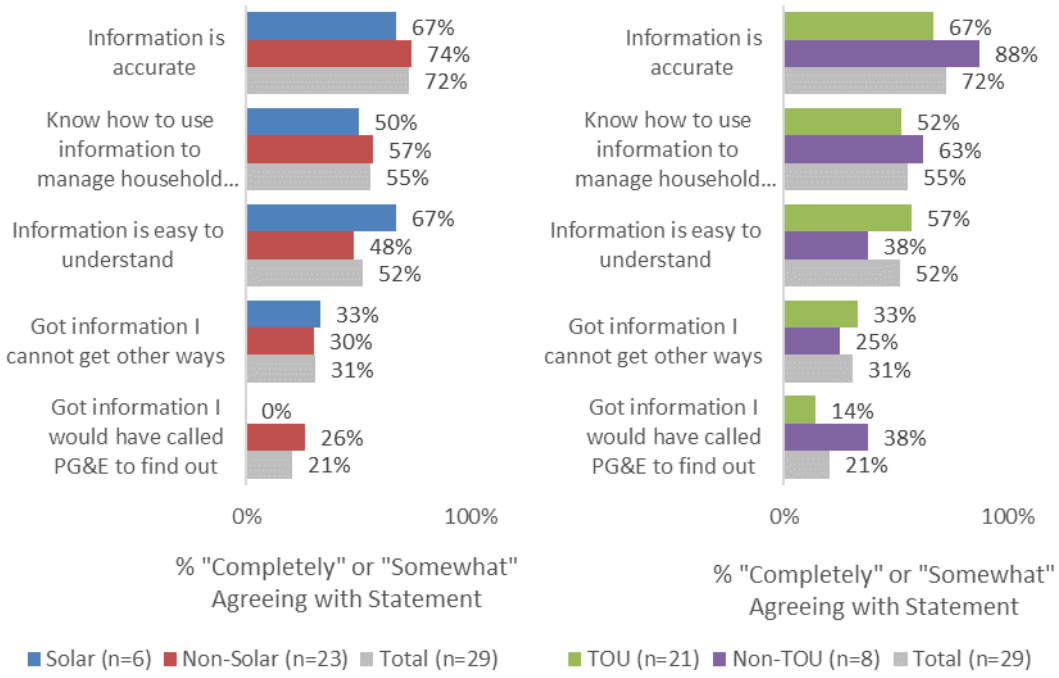
Participants generally reported that the information they received from the pilot is accurate and useable (Figure 33). Most respondents also rated the information as easy to understand, although some respondents reported challenges understanding the information, which they noted in open-ended responses throughout the survey. For example, one respondent suggested that the app should provide an "easier to read or a 'dumbed down' version, because the only thing I understood was when higher prices started and ended." Respondents' ratings suggest that the pilot generally did not provide them with new information that they could not access other ways or that they would have called PG&E to find out. These ratings likely reflect the generally higher levels of energy awareness among pilot participants noted above.

FIGURE 33: RATING OF INFORMATION CHARACTERISTICS



The extent to which the pilot provided customers with information they would have called PG&E to find out was one of the most notable differences between respondents with solar generation at their homes and those without solar as well as those on TOU rates and those not on TOU rates (Figure 34). Customers without solar and those not on TOU rates were both notably more likely to report the pilot provided them with information they otherwise would have called PG&E to find out. These groups were also less likely to report pilot information was easy to understand, although the differences were not as stark.

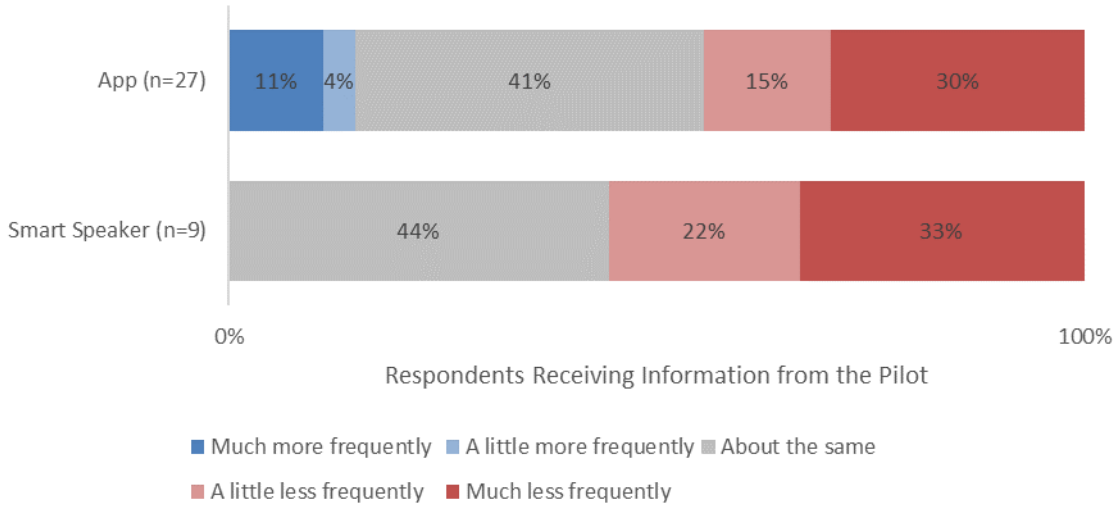
FIGURE 34: RATING OF INFORMATION CHARACTERISTICS BY SOLAR GENERATION AND RATE CLASS



Use of Energy Expert Information

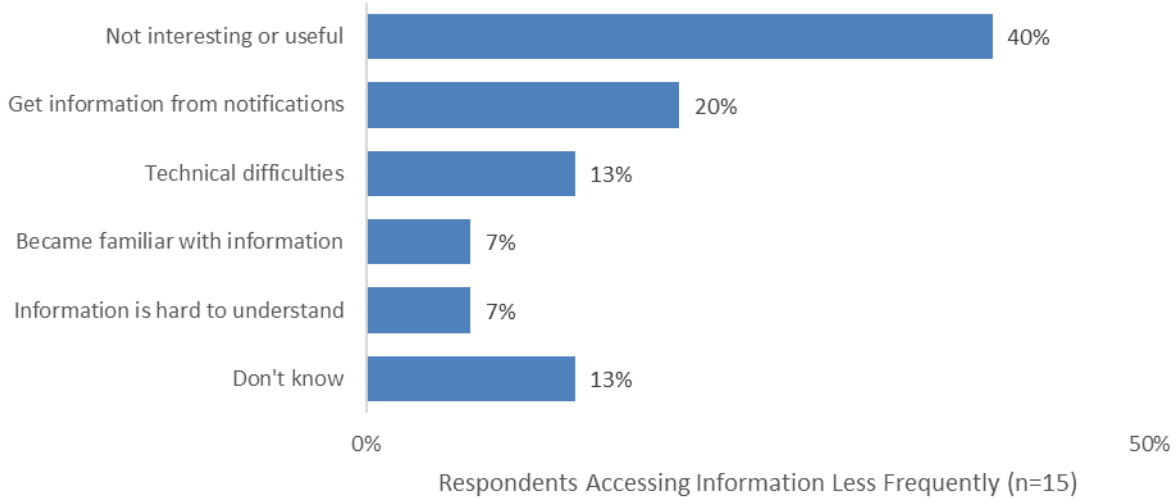
Both app and smart speaker users reported that the frequency with which they access Energy Expert information had decreased between the time they first joined the pilot and when they completed the survey (Figure 35). These responses were not notably different between PG&E employees and non-employees.

Figure 35: Change in Frequency of Accessing Information Since Joining Pilot



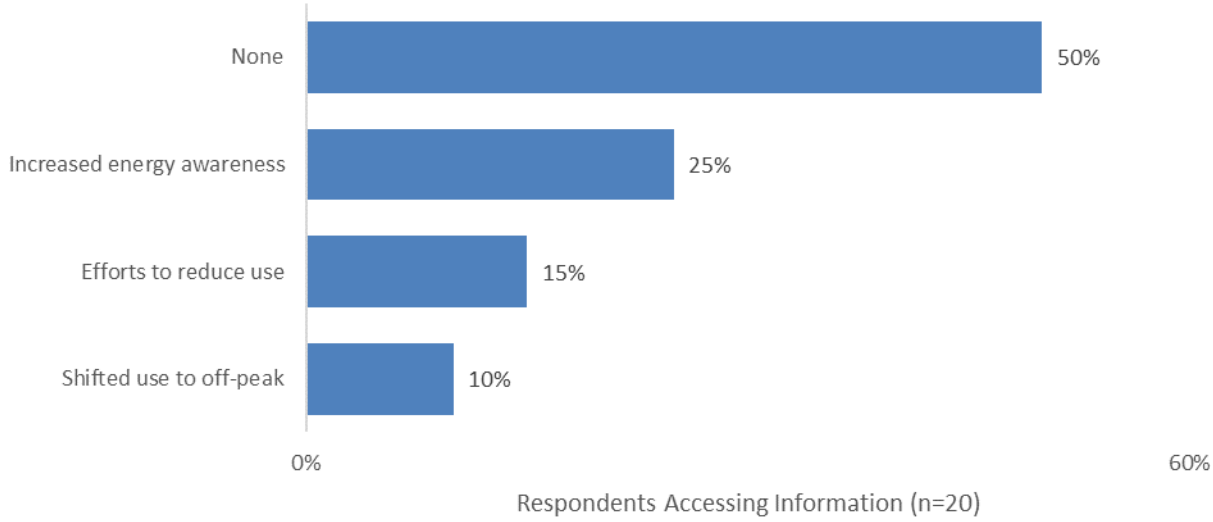
Respondents reported the frequency with which they access pilot information had decreased because they did not find the information interesting or useful most often (Figure 36). These responses may further reflect the higher levels of energy awareness among pilot participants noted previously. As one respondent wrote in an open-ended response, "I have my own solution [for tracking energy use] that is real-time and much more advanced." PG&E employees were also more likely (4 of 7, 57%) than non-PG&E employees (2 of 8, 25%) to report the information was not interesting or useful. These survey findings are consistent with the overall trend of interactions with the Alexa smart speaker skills shown in Figure 16. As noted earlier, the lack of new features and engagements starting in October 2022 also likely contributed to the decline in interactions with Energy Expert.

FIGURE 36: REASONS FOR ACCESSING INFORMATION LESS FREQUENTLY



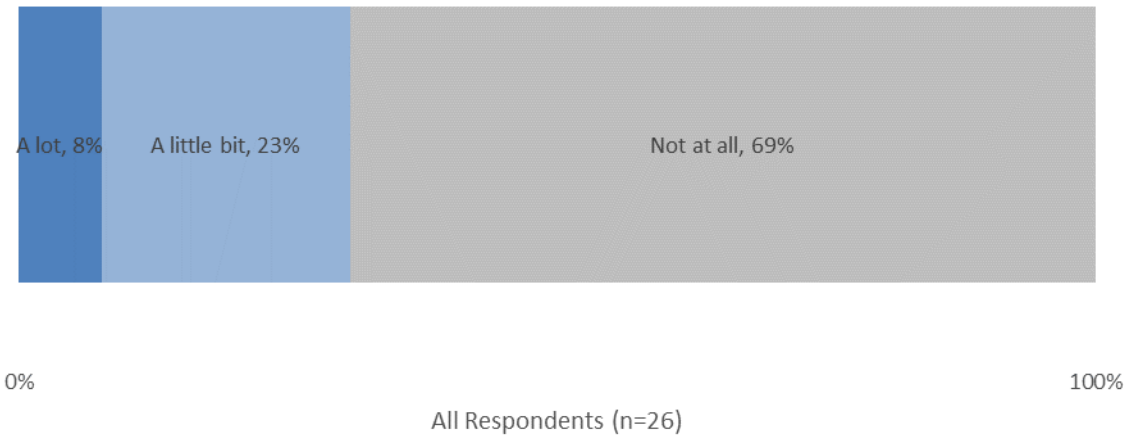
Half of survey respondents reported they had taken some action as a result of the information they received from Energy Expert (Figure 37). Most of these respondents reported the pilot had given them a general increased awareness of their energy use. For example, respondents stated that they were "more conscious of my usage" and "more aware of peak price period." Some respondents also reported efforts to reduce their overall energy use or shift to off-peak times, although most gave little detail on the specific actions they had taken.

FIGURE 37: ACTIONS TAKEN IN RESPONSE TO ENERGY EXPERT INFORMATION



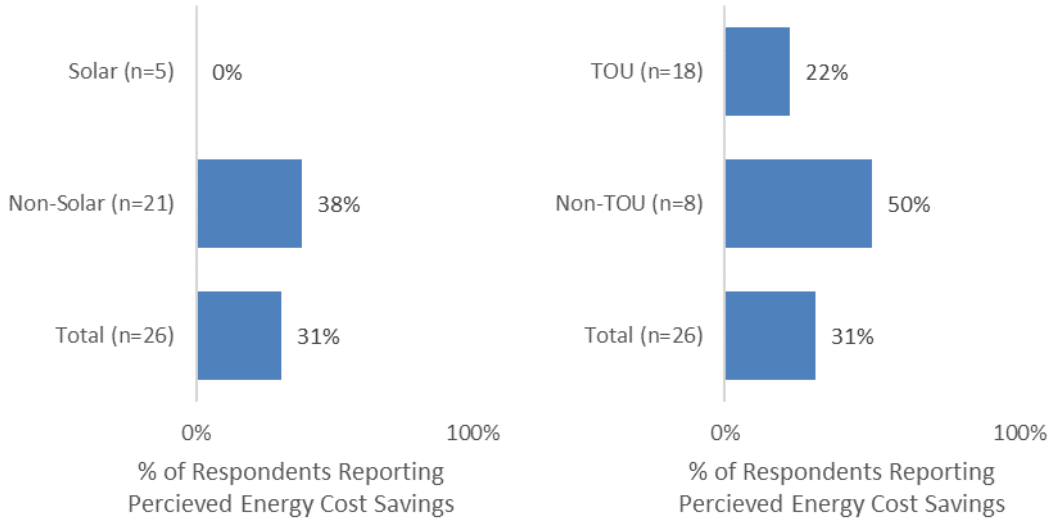
Most respondents reported that the information and alerts Energy Expert provides had not resulted in energy bill savings for their household (Figure 38). These responses are consistent with respondents' reports that they had not taken action as a result of Energy Expert information or that the information had led to a general increase in energy awareness, but not specific actions.

FIGURE 38: REPORTED ENERGY COST SAVINGS RESULTING FROM ENERGY EXPERT INFORMATION



Respondents without solar generation and those not on TOU rates were more likely to report perceived energy cost savings due to the information they receive from Energy Expert (Figure 39). As with previous findings, this may reflect a greater potential to benefit from pilot information among customers entering the pilot with a lower baseline level of energy awareness.

FIGURE 39: REPORTED ENERGY COST SAVINGS BY SOLAR GENERATION AND RATE CLASS



KEY FINDINGS

- Most survey respondents gave high ratings to aspects of using the app, and relatively few reported technical issues.
- A majority of respondents also reported it was easy to connect the app to their Alexa smart speaker and relatively few reported they did not know how or were unable to connect.
- Overall, most survey respondents were satisfied with their experience accessing Energy Expert information.
- Participants most often reported using Energy Expert to get information about electricity usage or bills or peak and off-peak times.
- Survey respondents differed from the larger population of PG&E customers in some important ways, and throughout the survey respondents indicated a relatively high level of energy awareness.

CONCLUSIONS & RECOMMENDATIONS

Conclusion 1: The pilot effectively developed technology allowing customers to access energy use and rate plan information through a mobile app, notifications, and smart speaker integration. Most survey respondents gave high ratings to aspects of using the app, and relatively few reported technical issues. A majority of respondents also reported it was easy to connect the app to their Alexa smart speaker and relatively few reported they did not know how or were unable to connect. Overall, most survey respondents were satisfied with their experience accessing Energy Expert information.

Conclusion 2: About one third of the pilot participants linked Energy Expert to Alexa. About half of the customers asked about electricity costs or their bill, with approximately one-third or less of the customers using the other interactions. The 'getElectricityCost' feature was most popular with 73 unique conversations. Alexa was the only type of smart speaker supported by the pilot, and nearly half of the survey respondents stated they did not have an Alexa smart speaker. Those participants who did not link to Alexa may not have had an Alexa smart speaker or may not have had a smart speaker at all. Those without Alexa were able to use the Energy Expert app on their smart phone.

> **Recommendation A:** Explore opportunities to expand the Energy Expert capabilities to additional smart speaker platforms such as Google Home and Apple HomePod, which would increase the population of customers who could use the voice assistant technology.

Conclusion 3: Participants interacted with Alexa and the Energy Expert app the most during the earlier months of the pilot and interactions diminished over time. Customer engagement and outreach was put on hold during the late summer and was not authorized to resume during the remainder of the observation period. Other similar pilots such as the Universal Devices Gateway Pilot conducted at SCE have shown the importance of customer outreach in promoting customer engagement.

> **Recommendation B:** Ensure customer outreach occurs at regular intervals during future pilots or implementations to maintain customer engagement. Outreach messaging could include tips on using the app or smart speaker interface or reminders of the available features and capabilities.

Conclusion 4: Six types of notifications were available to pilot participants via their preferred notification channel. High Price notification customers showed hourly TOU peak-period load reductions in the 3% to 5% range. Impacts are incremental to underlying impacts attributable to the TOU rate. However, the impacts are "directional" in nature and not statistically significant due to the small sample size.

> **Recommendation C:** The Energy Expert platform shows potential for driving peak period load reductions. A larger sample size is needed, however, to validate the preliminary findings from this demonstration. If PG&E is interested in further exploration of demand reductions or energy savings, it is recommended that the enrollment targets be based on achieving specific levels of statistical precision. Conducting a statistical power analysis of the target population is the most robust approach to determining minimum sample sizes needed to detect specific impact magnitudes. In the absence of conducting a statistical power analysis, a target enrollment of 2,000 for each customer segment of interest typically provides sufficient statistical power to detect impacts as small as 1% to 2%. Smaller sample sizes can still result in statistically significant impacts, but there is greater risk of not detecting impacts if there is significant customer attrition or if impacts are small. Ultimately, conducting a statistical power analysis helps utility staff make a more informed decision regarding enrollment targets, and can allow for greater confidence in success with smaller enrollment targets.

Conclusion 5: Additional user testing is needed to successfully roll out the technology to PG&E's broader customer population. Survey respondents differed from the larger population of PG&E customers in some important ways, and throughout the survey respondents indicated a relatively high level of energy awareness. Customers with less energy awareness may have a different experience with the Energy Expert app and smart speaker integration than the relatively knowledgeable pilot participants. The minority of pilot participants reporting challenges with aspects of using the app indicates that the experience can vary between individuals. Additional user testing will be needed to ensure that the customers PG&E seeks to target with Energy Expert technology are able to benefit from it.

> **Recommendation D:** PG&E should identify ideal user personas for Energy Expert and conduct user testing with the wider customer population to ensure the app meets the needs of those users. Identification of ideal user personas is recommended because design recommendations will likely differ if the app is intended to raise energy awareness among customers who have limited understanding as opposed to providing an additional tool to sophisticated customers who already understand and monitor energy use. Alternatively, or in addition, the app could be further developed to provide different experiences and features for each persona (or customer segment), providing each with important information only applicable to them. For example, customers with solar generation, who comprised more than 30% of the pilot participants, have different information needs and interests such as monitoring their net consumption or generation compared to customers without solar. EV owners are an additional customer segment who may have segment specific information interests and who could benefit from this technology.

APPENDIX:

DETAILED DEMOGRAPHIC COMPARISONS

This appendix presents detailed demographic comparisons between survey respondents and PG&E's larger residential customer base, drawing on 2022 American Community Survey five-year estimates aggregated across zip codes in PG&E territory.

	Survey Respondents (n=29)	Population
Single family, detached	79%	62%
Single family, attached	7%	7%
Duplex	3%	3%
Triplex or quad	0%	6%
Multifamily, 5-9 units	0%	5%
Multifamily, 10-19 units	7%	4%
Multifamily, 20-49 units	0%	4%
Multifamily, 50 units or more	3%	7%
Mobile home	0%	4%
Other	0%	0%

	Survey Respondents (n=30)	Population
Own	77%	58%
Rent	23%	42%

Age	Survey Respondent Household Members (n=91)	Population
0-17	27%	23%
18-39	26%	31%
40-59	36%	25%
60 or older	10%	21%

Race/Ethnicity	Survey Respondents (n=25)	Population
Hispanic/Latino	4%	33%
American Indian and Alaska Native	0%	0%
Asian	36%	17%

Race/Ethnicity	Survey Respondents (n=25)	Population
Black or African American	0%	4%
Native Hawaiian and Pacific Islander	0%	0%
White/Caucasian	56%	40%
Other	0%	0%
Two or more races	4%	4%

Level of Education Achieved	Survey Respondents (n=27)	Population
Less than high school graduate	4%	14%
High school graduate	0%	19%
Some college or Associate degree	19%	29%
Bachelor's degree	48%	23%
Post-graduate degree	30%	15%

Annual Household Income	Survey Respondents (n=24)	Population
Less than $50,000	8%	34%
$50,000 to $74,999	4%	15%
$75,000 to $99,999	8%	12%
$100,000 to $149,999	4%	16%
$150,000 to $199,999	17%	9%
$200,000 or more	58%	14%