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# Mid-Term Evaluation of Valley Clean Energy's Agricultural Pumping Dynamic Rate Pilot

Daniel G. Hansen
Michael Ty Clark

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800 University Bay Dr #400
Madison, WI 53705-2299

608.231.2266
www.CAEnergy.com

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# EXECUTIVE SUMMARY

Power outages in August 2020 led the California Public Utilities Commission (Commission) to open a proceeding to consider actions in preparation for potential extreme weather in the summers of 2022 and 2023. The resulting Decision D.21-12-015 (the Decision) adopted a range of supply- and demand-side measures to address this issue, including two dynamic rate pilots to be implemented during a three-year period from 2022 through 2024. The Decision required mid-term and final evaluations of each pilot. This document represents the mid-term evaluation of Valley Clean Energy's (VCE's) agricultural pumping dynamic rate pilot (AgFIT, or the Pilot).

The objective of the AgFIT Pilot was to test the interest and ability of agricultural customers in VCE's service territory to respond to hourly price signals. The primary question was whether they would choose to respond when provided a CalFUSE-based hourly price signal supported by well pump automation and customer support.

The Decision contains the following requirements for the evaluations:

1. The response of agricultural loads to prices.
2. The monthly bill impacts of the pilot dynamic rate in comparison to a customer's otherwise applicable tariff (OAT).
3. An evaluation of the recovery of generation and resource adequacy (RA) costs for customers on the pilot tariff.
4. An evaluation of the recovery of delivery costs for customers on the pilot tariff.

<u>Pricing and Billing Methods</u>

The dynamic prices consist of two components: a generation rate component corresponding to the services provided by VCE; and a distribution rate component for the services provided by PG&E. The Pilot pricing methodology was changed on May 1, 2023. In the evaluation, we refer to the first pricing method as AgFIT 1.0 and the second method as AgFIT 2.0. A final decision on the pricing method for the Pilot's third growing season (in 2024) has not been made as of this writing. The primary difference between the AgFIT 1.0 and 2.0 pricing methods is the means of obtaining OAT levels of revenues:

- AgFIT 1.0 uses a fixed-quantity subscription priced at OAT levels;
- AgFIT 2.0 replaces the fixed-quantity subscription with an adder to the dynamic prices, calculated such that the average dynamic price is equal to the average seasonal OAT price paid by customers on the rate schedule.

In addition, at the same AgFIT 2.0 was implemented, the method used to recover non-marginal generation costs was changed in a manner that reduced intra-day price variability.

According to the Decision, the shadow bill approach was adopted "to address PG&E's and CLECA's objections about the revenue neutrality of the VCE Pilot rate." Under this method, the customer continues to pay for its current usage at the OAT rates (e.g., Schedule AGC), which did not require changes to PG&E's billing systems for the Pilot. For each month and service account (pump), the difference between the OAT bill and the AgFIT (shadow) bill is recorded. At the end of the year, the monthly credits or debits are added up for each service account to determine whether a credit is paid to the customer. For any given service account, the customer is eligible to receive a credit if the sum of the shadow bills is less than the sum of the OAT bills. In contrast, if the sum of the shadow bills is greater than the sum of the OAT bills, the customer is not responsible for paying an additional amount beyond their OAT bills for that service account.

Participant Summary

The customers enrolled in the Pilot thus far are a mix of small, medium, and large agricultural customers that employ irrigation pumps to water different types of crops. The Pilot does not have a limit on the number of customers if the aggregate peak load of Pilot customers does not exceed 5 MW. Most enrolled Pilot customers have multiple pumps (service accounts). There were two customers with a combined total of 17 pumps in September 2022. By September 2023, the enrollment count increased to five customers with a combined total of 33 pumps. The aggregate peak load of Pilot customers was 1.84 MW in August 2023.

Key Findings

- Automation technology helps agricultural pumping customers respond to all price signals. The technology includes the MyPolaris interface that allows Pilot participants to schedule pump usage for up to a week in advance, transacting at the dynamic price tenders at the time of scheduling. Based on customer interviews and the quantitative evidence, the automation technology introduced in AgFIT (along with the Pilot's customer education and engagement efforts) enables participants to respond to price signals in a way they had not previously done. We have a limited sample of data indicating automation-enabled TOU response prior to the introduction of dynamic pricing, and additional evidence of response to dynamic prices in one form or another. There is more to be learned about the best pricing method to combine with the automation to elicit the most (and most economically beneficial) load response from agricultural pumping customers.

- It has been difficult to find an appropriate method for anchoring AgFIT bills to OAT revenue recovery levels. Under AgFIT 1.0, subscriptions pricing was used to ensure that OAT-level revenues were recovered for the customer's historical load profile. In theory this method works well and has been applied elsewhere, but the unpredictable loads of agricultural pumping customers presented challenges. AgFIT 2.0 attempted to solve this problem by adopting a one-part pricing method that removed the subscription pricing element and in exchange adjusted the dynamic prices to reflect OAT price levels. However, this change traded one problem for another closely related problem: selecting the OAT price level to be used for the price adjustment.

- Pilot participants reduced their share of usage during the peak pricing period (5 to 8 p.m.) relative to pre-Pilot levels. Two of the five participants reduced the share by half, while another two reduced the peak share to nearly zero. In some of these cases, the peak share reduction was accompanied by significant reductions in overall usage, which may reflect a change in overall pumping needs rather than a Pilot response.

- There is mixed evidence that the Pilot customers responded to dynamic price differences across days. Under AgFIT 1.0, one of the two customers responded differently to the set of high-priced days compared to a similar set of low-priced days, while the other customer appeared to respond to the average daily price profile rather than the prices specific to each day. Under AgFIT 2.0, one of the five active customers responded differently on the high-price days, while three of the five customers responded to the daily average price profile (i.e., using less during hours that tended to have the highest prices, but not necessarily differentiating across days with different price levels). Because the subscription was removed at the same time the method used to recover non-marginal generation costs was changed, it is difficult to determine how each change affected customer response. Additional pilot experience and customer interviews will provide information on the extent to which customers have operational constraints (e.g., a pump that needs to run 24/7 to meet irrigation needs) that take priority over responding to dynamic prices.

- While the dynamic prices appear to provide incentives to reduce both customer bills and VCE capacity costs, there is a disconnect between the dynamic prices paid to customers and the marginal *energy* costs for VCE. That is, because VCE's CAISO settlement is based on PG&E's load profile, using dynamic pricing to induce customers to use less during the costliest hours is unlikely to result in corresponding energy cost savings for VCE. The revenue and cost implications of this disconnect are probably not significant during a small pilot program but may present issues as dynamic pricing scales to higher participation levels.

- While on AgFIT, the customer pays its current OAT bill and will receive a credit each year if the sum of its OAT bills is greater than the sum of its shadow (Pilot) bills. However, those OAT bills may be higher than their pre-Pilot OAT bills if they stop managing their billed demand and instead focus on the dynamic prices. Therefore, the presence or absence of an AgFIT credit is not necessarily indicative of whether the customer benefited from Pilot participation. In addition, the shadow bill credit methodology gives Pilot participants a strong incentive to continue to respond to OAT price signals (e.g., demand charges).

# 1 INTRODUCTION AND PURPOSE OF THE STUDY

Power outages in August 2020 led the California Public Utilities Commission (Commission) to open a proceeding to consider actions in preparation for potential extreme weather in the summers of 2022 and 2023. The resulting Decision D.21-12-015 (the Decision) adopted a range of supply- and demand-side measures to address this issue, including two dynamic rate pilots to be implemented during a three-year period from 2022 through 2024. The Decision required mid-term and final evaluations of each pilot. This document represents the mid-term evaluation of Valley Clean Energy's (VCE's) agricultural pumping dynamic rate pilot (AgFIT, or the Pilot).[1]

The agricultural sector accounts for 18 percent of VCE's total annual load and 16 percent of its peak demand (i.e., 35 MW out of 215 MW of peak demand).[2] The Pilot allows VCE to enroll agricultural pumping customers up to a 5 MW aggregated peak load cap, enabling up to 15 percent of its agricultural load to shift in response to changing market conditions.

The objective of the AgFIT Pilot was to test the interest and ability of agricultural customers in VCE's service territory to respond to hourly price signals. The primary question was whether they would choose to respond when provided a CalFUSE-based hourly price signal supported by well pump automation and customer support.

The core element of the Pilot is to present participants with dynamic prices to assist in meeting the following goals:

- Reduce grid infrastructure costs and greenhouse gas emissions.
- Improve reliability and integration of renewables.
- Facilitate greater integration and fair compensation of distributed energy resources.[3]

The Decision states that the Pilot "provides an opportunity to assess the potential of a dynamic retail rate approach to incentivizing load shift" and that "[i]f loads do respond to the dynamic prices, then the Pilot will have achieved the intended purpose of shifting load to enhance system reliability."[4]

[1] The other dynamic pricing pilot approved in the Decision is being implemented by Southern California Edison.

[2] Opening Prepared Testimony of Gordon Samuel on Behalf of Valley Clean Energy, Rulemaking 20-11-003, September 1, 2021, p. 1.

[3] CPUC Decision 21-12-015, p. 86.

[4] CPUC Decision 21-12-015, p. 91.

The Decision contains the following requirements for the evaluations[5]:

1. The response of agricultural loads to prices.
2. The monthly bill impacts of the pilot dynamic rate in comparison to a customer's otherwise applicable tariff (OAT).
3. An evaluation of the recovery of generation and resource adequacy (RA) costs for customers on the pilot tariff.
4. An evaluation of the recovery of delivery costs for customers on the pilot tariff.

The report is organized as follows. Section 2 contains a description of the Pilot; Section 3 contains our evaluation of customer load response; Section 4 contains the Pilot and OAT bill comparisons; Section 5 discusses Pilot cost recovery issues; Section 6 contains our summary of participant and stakeholder comments on the Pilot; and Section 7 provides a summary and conclusions.

# 2 DESCRIPTION OF THE DYNAMIC PRICING PILOT

AgFIT has three key design elements in place to accomplish its goals:

1. Dynamic price signals that incentivize behavioral and/or automated demand response to provide operational benefits and customer bill savings.

2. Automation incentives for remote control of irrigation systems.

3. Targeted marketing, education, and outreach (ME&O) and customer support.

In this section, we describe how dynamic prices were implemented in AgFIT, how the pricing method has changed over the course of the Pilot, and the shadow bill methodology. We then illustrate the prices observed to date and present information about the Pilot participants.

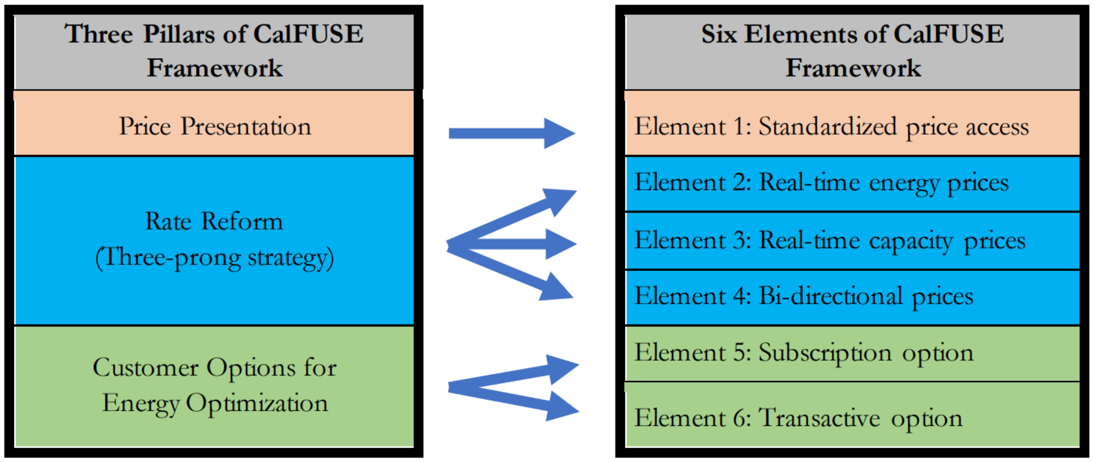
## 2.1 Pricing Method Description

The dynamic prices consist of two components: a generation rate component corresponding to the services provided by VCE; and a distribution rate component for the services provided by PG&E. VCE selected TeMix as the vendor to provide its proprietary cloud-hosted TeMix Platform™ that operates 24/7 to support the six steps of the CalFUSE framework itemized in Figure 1 below.[6]

[5] CPUC Decision 21-12-015, p. 94. There is a fifth requirement, as follows: "In the case that VCE incorporates binding forecast projections, the evaluation should also include an assessment of this element." However, VCE implemented "binding forecast projections" for all Pilot customers (i.e., there was no control group of customers presented with price forecasts with no opportunity to lock them in), so this requirement is met through the analysis of the response of agricultural loads to prices.

[6] The figure is taken from page 6 of the June 22, 2022 Energy Division white paper entitled "Advanced Strategies for Demand Flexibility Management and Customer DER Compensation".

**Figure 1: CalFUSE Framework**




A key input to the TeMix distribution rate component is week-ahead hourly circuit load forecasts, which are provided by PG&E through a third-party vendor, while week-ahead generation price forecasts are provided by a different third-party vendor.

The integration and automation of pumping loads with the Pilot price signals is through the equipment and related data integration provider (Automation Service Provider, or ASP) via its proprietary software. The ASP that was selected by VCE is Polaris.

The pilot was funded in June 2022 and launched on August 1, 2022.[7] Starting in May 2023, the Pilot pricing method was changed from a two-part design to a one-part design, and subscription, shadow billing and transactive responsibilities are now performed by Polaris. The first phase of the AgFIT Pilot with a subscription priced at OAT rate levels and dynamic prices reflecting marginal costs is referred to as AgFIT 1.0 (August 2022 through April 2023); and the second phase with no subscription and dynamic prices scaled to OAT rate levels is referred to as AgFIT 2.0 (beginning May 1, 2023). A final decision on the pricing method for the Pilot's third growing season has not been made as of this writing.

<u>AgFIT 1.0 Pricing</u>

When the Pilot became active in August 2022, a two-part pricing method was employed. The customer is provided a subscription, which is a fixed quantity of energy per hour priced at OAT rates. The subscription hourly quantities (kWh) are based on the customer's usage in the same month of the previous year (2021).

The subscription price was developed by applying an escalation factor to the previous year's (2021) OAT bill. The escalation factors were fixed within a rate schedule and month based on class-average changes in bills across years. An alternative method (employed by SCE in its dynamic rate pilot) would have been to price the subscription by

[7] It is our understanding that it was an intense effort by the CPUC, VCE, PG&E, Polaris, and TeMix starting in early 2022, to get the pilot approved, funded, contracted, and to standup all the teams to manage, deploy, configure, test, and securely operate 24/7 the multiple software platforms, cloud computing systems, pump controls, and interfaces to existing CAISO, near real-time metering, monthly billing data, and circuit forecasting and to recruit, train, and support customers to participate in the pilot.

billing each customer's historical usage at current OAT rates. This would have done a better job of aligning the effect of rate changes with the customer's specific usage profile but would have required more time and data to implement. Therefore PG&E opted to use the simpler escalation method to allow the Pilot to proceed at an earlier date.

The subscription component of the bill serves two purposes. First, it reduces the customer's bill volatility due to dynamic prices, with the customer only paying (or being paid) those prices for usage that deviates from their subscription quantity.[8] In the extreme, a customer who uses exactly its subscription quantity during an hour will not pay the dynamic price at all. This risk mitigation can be especially important during extended periods of high dynamic prices. In addition to shielding some or all of a customer's usage from high prices, it also provides an opportunity for the customer to sell back some of its subscription at the locational dynamic prices, thus releasing energy for those who value it more.

Second, the subscription provides a means of linking the overall bill level to the OAT (and the revenue requirement assumed when the OAT for each rate class was established), thus preserving any rate class pricing differences. Because dynamic prices are intended to reflect the utility's retail locational marginal cost, in theory the deviations of the bill from the OAT-based subscription level should be matched by the avoided costs associated with the price response. However, a utility's average cost (total revenue requirement divided by total load) is almost always greater than the marginal cost. Thus, the Pilot cannot simply charge the marginal costs for all usage; it requires a mechanism to collect the non-marginal "missing money" to meet the revenue requirement, at least approximately. The subscription charges accomplish that. The dynamic prices in AgFIT 1.0 recover some non-marginal costs using scarcity pricing in which more of the costs are recovered when net loads[9] or the net load ramp is high and less when they are low. The rest of the non-marginal costs such as public purpose charges and transmission charges are recovered in a flat adder.

In a simple two-part pricing rate, the customer pays for deviations from their subscription quantity at hourly prices that reflect market conditions.[10] This is reflected in the simplified bill calculation for month *m* below (where *i* indexes all hours during the month):

$$\text{Two-part Pricing Bill}_m = \Sigma_i \, \{(P^{Sub}{}_i \times Q^{Sub}{}_i) + P^{Dyn}{}_i \times (Q^{Obs}{}_i - Q^{Sub}{}_i)\}$$

[8] In contrast, under a "one-part" real-time pricing program, the customer pays the hourly price for all of its usage in the hour.

[9] Net load is the CAISO load less the solar plus wind generation. Net load ramp is a positive difference between the net load for the hour and the net load three hours earlier.

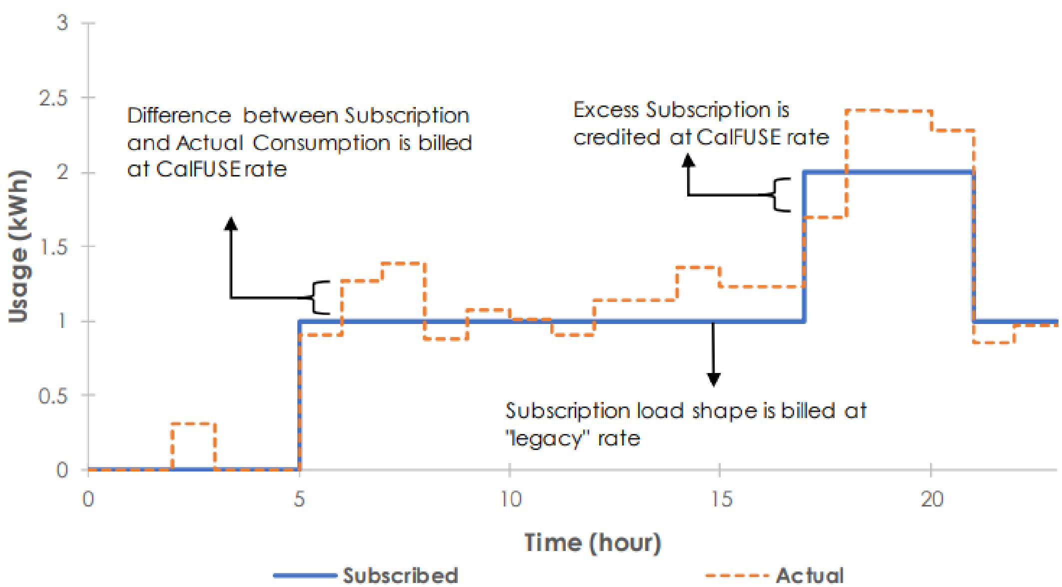
[10] These prices can be guaranteed up to six days ahead, day-ahead, hour-ahead, or only known after the fact.

**Table 1: Variables in a Two-Part Pricing Bill Calculation**

| Variable | Description |
|---|---|
| $P^{Sub}{}_i$ | Subscription price during time interval *i* in $/kWh |
| $Q^{Sub}{}_i$ | Subscription quantity during time interval *i* in kWh |
| $P^{Dyn}{}_i$ | Dynamic price during time interval *i* in $/kWh |
| $Q^{Obs}{}_i$ | Observed (metered) usage during time interval *i* in kWh |

The settlement process is illustrated in Figure 2 below, which is taken from the Energy Division's "Advanced Strategies for Demand Flexibility Management and Customer DER Compensation" white paper.[11] In the figure, the "CalFUSE rate" is synonymous with the dynamic settlement price used in AgFIT.

**Figure 2: Example Showing the Subscription as a Hedging Product**




In addition to the elements described above, the Pilot offers additional opportunities for customers to lock in the prices paid for scheduled load (or received for subscription amounts that will be unused) up to six days ahead of time. Specifically, each day the customer is presented with six days of hourly dynamic "tender prices". The customer can choose to schedule a pump to run or not run for any hour in that six-day window. Once scheduled, the difference between the customer's current position (i.e., the sum of customer's subscription quantity in that hour and previous transactions for that hour) and the usage scheduled for that hour is purchased or sold in a transaction at the dynamic

[11] "Advanced Strategies for Demand Flexibility Management and Customer DER Compensation" Energy Division White Paper, page 67: ED-White-Paper-Advanced-Strategies-for-Demand-Flexibility-Management-June-2022.pdf (dret-ca.com)

tender price. The price and quantity are fixed and guaranteed by the transaction. The transactions are essentially adjustments to the customer's "forward contract" (i.e., the energy that has been pre-purchased) priced at the dynamic tender prices.

The final settlement for any given hour reflects the following three components:

- The subscription quantity purchased at subscription prices;
- Purchases or sales of fixed quantities of energy at dynamic tender prices; and
- The purchase or sale of the difference between the customer's metered net load and the net transacted quantity at ex-post prices.

The dynamic tender prices are set to recover the marginal energy costs, which reflect CAISO locational marginal prices (LMPs); long-run generation capacity marginal costs; long-run distribution capacity marginal costs; and other non-marginal revenue components and policy costs currently included in the tariffed retail rates.

AgFIT 2.0 Pricing

The AgFIT 2.0 pricing method replaces the two-part pricing method described above with a one-part method that uses only dynamic tenders. While the customer does not purchase a subscription at OAT-based prices, the 2.0 pricing method links overall Pilot price levels to OAT levels by shifting the prices of the dynamic tenders from the TeMix Platform™ up or down so the average matches an OAT average price. In addition, the customers are allowed to purchase fixed quantities of electricity at these binding dynamic adjusted tenders up to seven days in advance; this feature is similar to AgFIT 1.0 pricing. The extension of the tenders from six to seven days in advance is unrelated to AgFIT 2.0.

Under the AgFIT 2.0 "one-part" pricing program, the customer pays the day-ahead hourly price for all of its usage in the hour unless the customer purchases two to seven days ahead at the forward adjusted dynamic prices. Any difference between the net sum of the forward transactions and the actual meter reading is automatically transacted at the day-ahead price.

The AgFIT 2.0 dynamic prices are adjusted by comparing the weekly average dynamic prices (i.e., the upcoming 168 hourly prices that would have served as the dynamic prices under AgFIT 1.0) to the seasonal average price paid per kWh for the customer's OAT. The OAT value is calculated at the rate schedule level and therefore could differ from the AgFIT customer's historical or current average OAT price. The AgFIT 2.0 rate adjustment is constant across all hours of the week, equal to the difference between the average OAT price and the average of the (unadjusted) dynamic prices. The averaging is conducted daily.

Another change to the pricing methodology occurred at the same time AgFIT 2.0 was implemented. Specifically, non-marginal generation costs that had been recovered using a dynamic scarcity price were changed to be recovered on a flat cents/kWh basis. This change is unrelated to the other methodological changes but has the effect of reducing the potential for customers to benefit from shifting usage by lowering intra-day price differences.

Table 2 summarizes the differences between the AgFIT 1.0 and 2.0 pricing methods. The primary difference is the removal of the fixed-quantity subscription in AgFIT 2.0 and the resulting need to implement an alternative method to recover embedded costs (the flat adder).

**Table 2: Comparison of AgFIT 1.0 and 2.0**

| Characteristic | AgFIT 1.0 | AgFIT 2.0 |
|---|---|---|
| Has a subscription? | Yes | No |
| Basis for OAT-level Revenue | Fixed-quantity subscription priced at customer's historical OAT with an escalator | Flat $/kWh adder to dynamic prices based on the rate schedule's seasonal average price paid per kWh |
| Ability to transact for fixed quantities at a guaranteed dynamic price?[12] | Yes, up to 6 days ahead | Yes, up to 7 days ahead |
| Recovery of non-marginal generation costs[13] | Dynamic and Flat $/kWh | Flat $/kWh |

Shadow Bill Credit Method

According to the Decision, the shadow bill approach was adopted "to address PG&E's and CLECA's objections about the revenue neutrality of the VCE Pilot rate."[14] Under this method, the customer continues to pay for its current usage at the OAT rates (e.g., Schedule AGC), which did not require changes to PG&E's billing systems for the Pilot. For each month and service account (pump), the difference between the OAT bill and the AgFIT (shadow) bill is recorded. At the end of the year, the monthly credits or debits are added up for each service account to determine whether a credit is paid to the customer. For any given service account, the customer is eligible to receive a credit if the sum of the shadow bills is less than the sum of the OAT bills. In contrast, if the sum of the shadow bills is greater than the sum of the OAT bills, the customer is not responsible for paying an additional amount beyond their OAT bills for that service account.

The equation below shows the calculation of the dynamic bill credit for service account *s* during months *m*.

$$\text{Dynamic Pilot Credit}_s = \text{MAX}\{\Sigma_m(\text{OAT Bill}_{s,m} - \text{Shadow Bill}_{s,m}), 0\}$$

[12] The change allowing customers to transact seven days ahead instead of six occurred at the time AgFIT 2.0 pricing was adopted but is not otherwise related to the removal of fixed-quantity subscription pricing.
[13] This change occurred at the time AgFIT 2.0 pricing was adopted but is not otherwise related to the removal of the subscription.
[14] CPUC Decision 21-12-015, p. 91.

In the equation, MAX is the maximum function, $\Sigma_m$ is the summation function, "OAT Bill$_{s,m}$" is service account *s*'s bill on their OAT using metered usage during month *m*, and "Shadow Bill$_{s,m}$" is service account *s*'s shadow bill during month *m*.

Note that service accounts belonging to a customer are treated distinctly for these calculations. That is, a customer could earn a credit for one service account that is not offset by a debit for another.

It is important to understand the shadow bill credit method as we discuss customer load and bill impacts during the Pilot. While a purported benefit of AgFIT pricing is that customers no longer need to consider the OAT demand charges[15], customers who increase their billed demand will pay the higher OAT bill associated with that change as they would have prior to the Pilot. At the end of a year, they will be eligible for a credit if their total shadow bills were less than the total OAT bills. This methodology may lead participants to view the Pilot negatively in real time (i.e., because they pay higher OAT bills relative to pre-Pilot months even as they are responding to dynamic prices). Perhaps more importantly, if the Pilot pricing method does not present the customer with sufficient opportunities to save each month (e.g., due to a lack of dynamic price variation), the customer could end up paying more by having ignored the OAT price signals.

Conversely, a customer who reduces their OAT bill relative to pre-Pilot levels by responding to dynamic prices may not receive a shadow bill credit even though responding to the Pilot prices benefited them. For example, if dynamic prices are consistently high during the peak pricing period, the customer may decrease its OAT billed demand by responding to dynamic prices which could result in reducing the OAT bill to a level lower than the shadow bill.[16] This is important to keep in mind when we examine bill impacts in Section 4. A customer who does not receive a Pilot credit still may have saved money relative to pre-Pilot levels.

[15] VCE's web page promoting AgFIT lists the following among the program benefits: "There are no penalties, no demand charges, and no clawbacks." https://valleycleanenergy.org/programs/a-flexible-irrigation-pilot-program-for-agriculture/

[16] The customer could have responded to the OAT prices to reduce their bills by the same amount. But perhaps the customer would be more engaged with prices during the pilot - their savings are due to paying attention more than to the dynamic prices or shadow billing process.

## 2.2 Observed Dynamic Prices

Figure 3 illustrates the average hourly "last rate" (the day-ahead dynamic tender price) by month since the beginning of the Pilot.[17] The vertical yellow line designates the change from the AgFIT 1.0 to 2.0 pricing method. The AgFIT 2.0 prices tended to have higher "troughs" and lower peaks compared to the AgFIT 1.0 prices. The shift from dynamic to flat recovery of non-marginal generation costs described in Section 2.1 is a contributing factor to the change in the daily price profile. AgFIT 2.0 prices are also shifted to reflect average OAT price levels, which is not a feature of AgFIT 1.0 prices.

**Figure 3: Average Hourly Day-Ahead Dynamic Prices by Month**

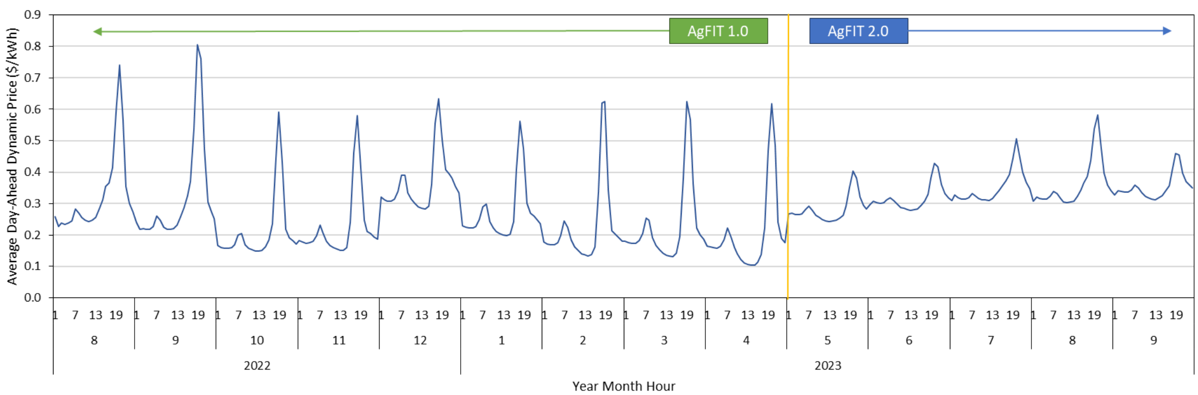



Figure 4 shows the hourly distribution of day-ahead dynamic tender prices for AgFIT 2.0 (May-September 2023). Each hour contains a box-whisker plot of the prices.[18] As expected, prices increase during evening hours. The variance on the upper bound is also largest during the early evening hours, peaking from 6 to 8 p.m. The morning hours exhibit lower prices and a reduced range relative to the evening hours.

[17] The higher average prices during December 2022 reflect much higher CAISO prices as a result of high natural gas prices used for generation. This had no significant effect on the pilot because of the very low pump usage during December.

[18] A box-whisker plot illustrates different elements regarding the distribution of prices. The shaded box area represents prices that fall within the 25th and 75th percentile of observations (i.e., the interquartile range). The horizontal line within the box indicates the median price. The "whiskers" represent the lower and upper bounds of prices that are not considered outliers – i.e., not more than 1.5 times the interquartile range away from the upper and lower bounds of the interquartile range.

**Figure 4: Distribution of Hourly Day-Ahead Dynamic Prices, May-Sep 2023**

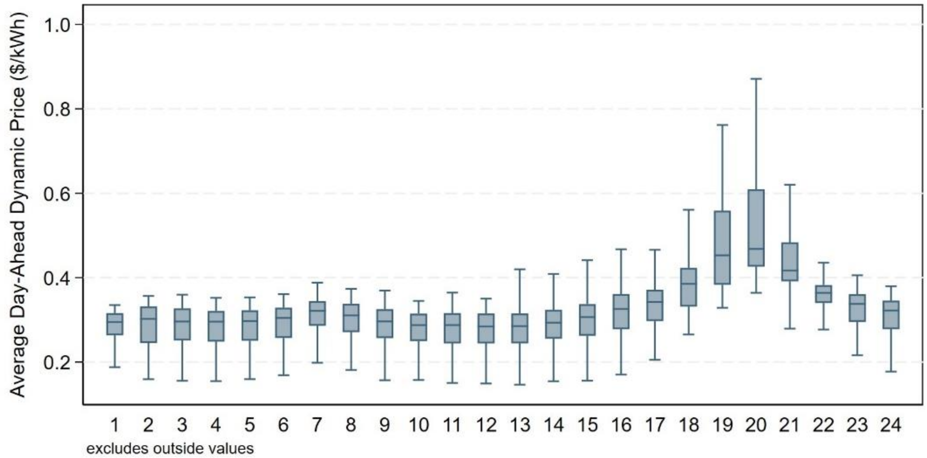
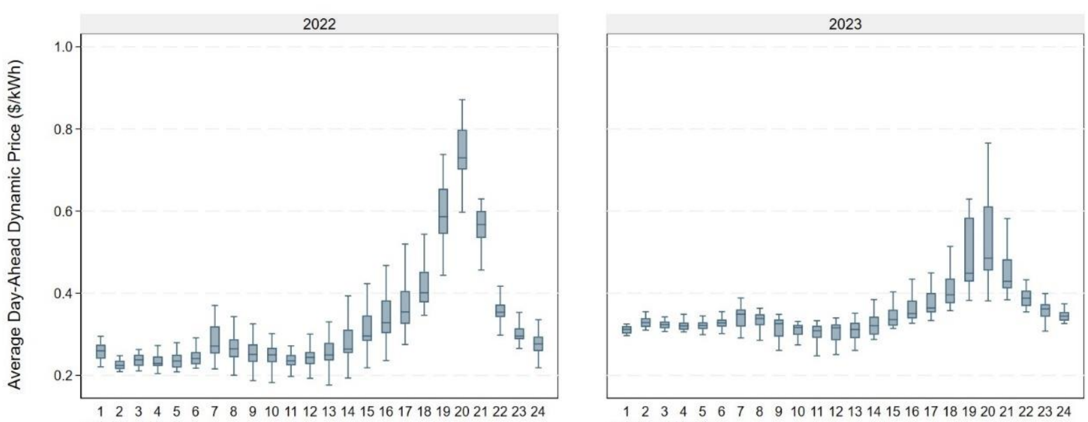



Figure 5 compares the distribution of hourly day-ahead dynamic tender prices between August 2022, which employed AgFIT 1.0 pricing, and August 2023, which employed AgFIT 2.0 pricing. The August 2023 AgFIT 2.0 prices are higher than August 2022 AgFIT 1.0 prices during the morning hours but lower during evening hours. The overall result is less intra-day price variation under AgFIT 2.0, resulting in a lower peak to off-peak period price differential relative to AgFIT 1.0. While the pricing method changed across the two periods, other factors also affected the price level and pattern. For example, the CAISO locational marginal prices (LMP) that serve as an input to the AgFIT prices were generally lower in 2023 than 2022, with lower price differentials. Figure 6 illustrates the distribution of CAISO LMPs for August 2022 and 2023.[19] (Please note the change in the y-axis scale relative to Figure 5 when making comparisons.)

**Figure 5: Distribution of Hourly Day-Ahead Dynamic Prices, August 2022 vs 2023**




[19] Specifically, the figure summarizes hourly real-time market prices for the Aggregated Pricing Node PGAE.

**Figure 6: Distribution of Hourly CAISO LMPs, August 2022 vs 2023**

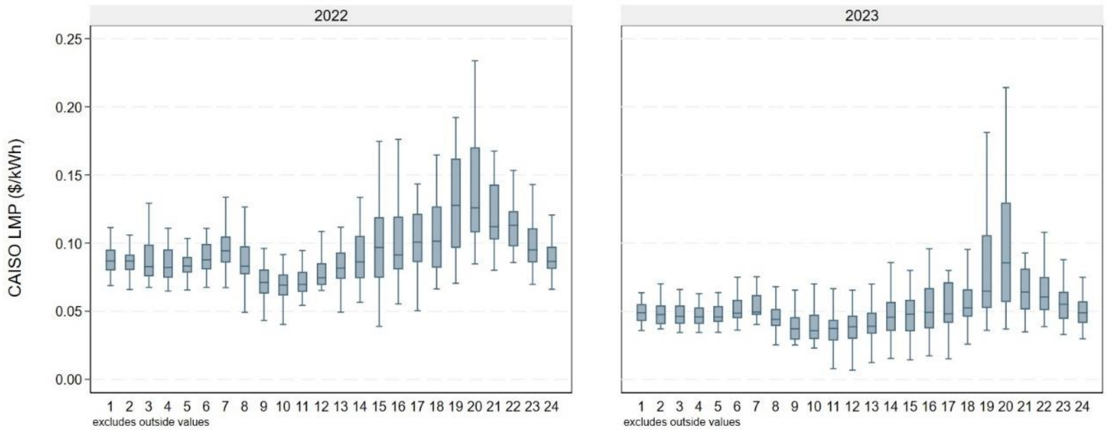
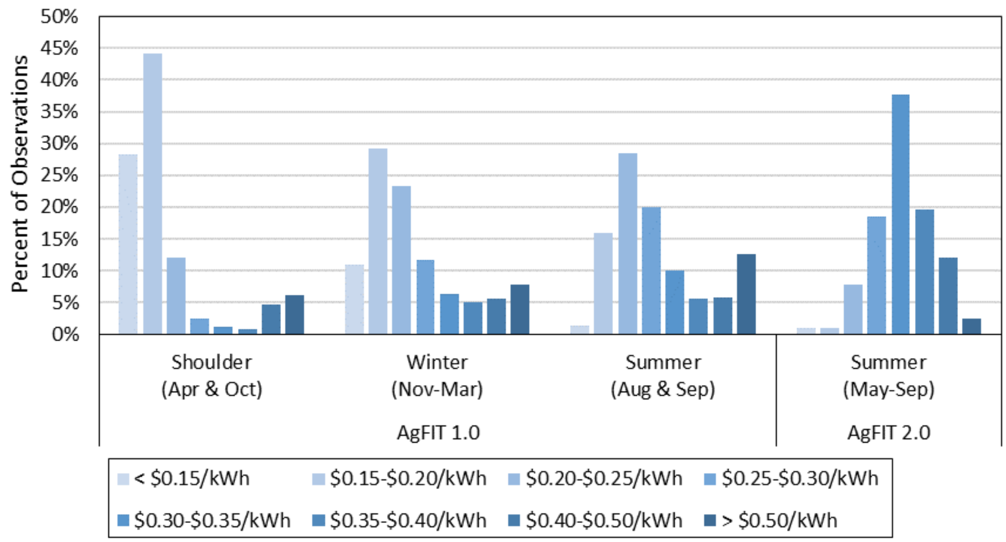



Figure 7 provides the distribution of day-ahead dynamic tender prices for three seasons (based on the seasonal usage pattern for the Pilot customers shown in Figure 10) and separately for AgFIT 1.0 and 2.0.[20] For each season and pricing method, the table contains the percentage of day-ahead prices that are in each pricing "bin".[21] For example, 28 percent of the Shoulder period day-ahead prices are less than $0.15/kWh. As expected, the AgFIT 1.0 Summer period has a greater proportion of prices in the higher price bins than the other AgFIT 1.0 seasons. Nevertheless, the Shoulder and Winter periods also contain prices that spike to more than $0.50/kWh (about 6% for the Shoulder and Winter period). Comparing the Summer AgFIT 1.0 and AgFIT 2.0 price distributions shows that AgFIT 1.0 had a greater proportion of prices that spike above $0.50/kWh, while also having a greater proportion of prices below $0.25/kWh. This illustrates the much greater price variation in AgFIT 1.0 prices compared to 2.0.

[20] Summer is May through September, Shoulder is April and October, and Winter is November through March.

[21] The Summer period is May through September; therefore, the period represented in the table is August and September 2022 for AgFIT 1.0 (due to the pilot start date) and May through September for AgFIT 2.0.

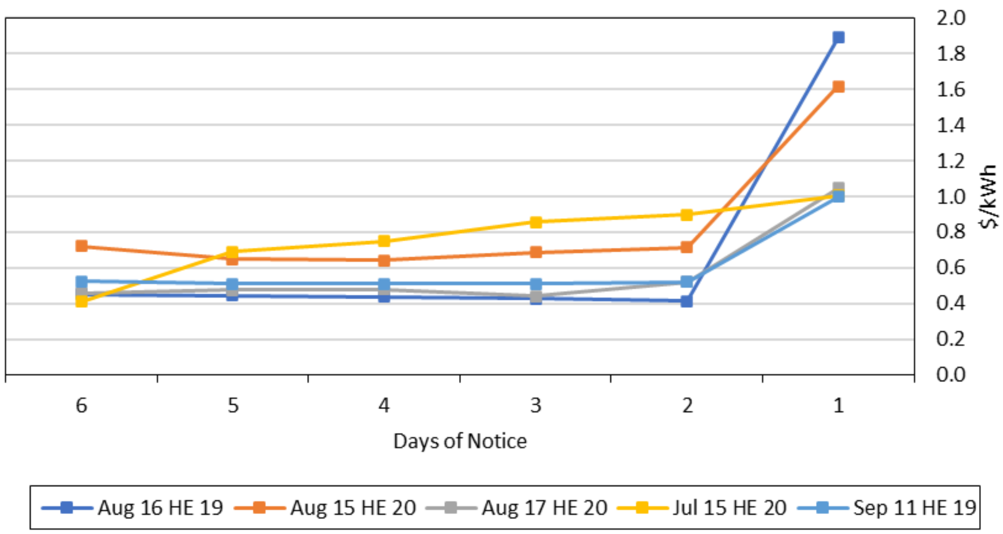
**Figure 7: Distribution of Day-Ahead Dynamic Prices**




While the discussion above focuses on day-ahead dynamic prices, customers were provided dynamic price tenders up to seven days ahead of time. It may be instructive to illustrate how the tenders for the highest priced hours changed over time. Figure 8 shows the tenders across notice levels for five high-priced hours during AgFIT 2.0.[22] Four of the five days exhibited a large increase in the tender price between the second and first day-ahead notice levels; the fifth day showed a more gradual progression across notice levels. A potential cause of the increase in the tenders in the day-ahead values is that the two-day and longer notice levels rely on third-party forecasts of CAISO prices, while the day-ahead prices reflect CAISO transactions.

[22] The figure shows prices for one of the circuits with Pilot participants. Only one hour per date (the highest-priced hour) was included in the figure. The seventh day of notice is excluded from the figure because that notice level was not consistently available in the data provided.

**Figure 8: Price Evolution for Select Days in 2023**




A potential implication of the figure is that customers who planned pump activity two or more days in advance (and did not revisit their decision later) may not have been aware of when prices were at their highest.

## 2.3 Participant Summary

The customers enrolled in the Pilot thus far are a mix of small, medium, and large agricultural customers that employ irrigation pumps to water different types of crops. The Pilot does not have a limit on the number of customers if the aggregate peak load of Pilot customers does not exceed 5 MW. Most enrolled Pilot customers have multiple pumps (service accounts). Figure 9 depicts the number of customers and pumps enrolled in the Pilot. There were two customers with a combined total of 17 pumps in September 2022. By September 2023, the enrollment count increased to five customers with a combined total of 33 pumps.

**Figure 9: Enrollment Customer and Pump Counts**

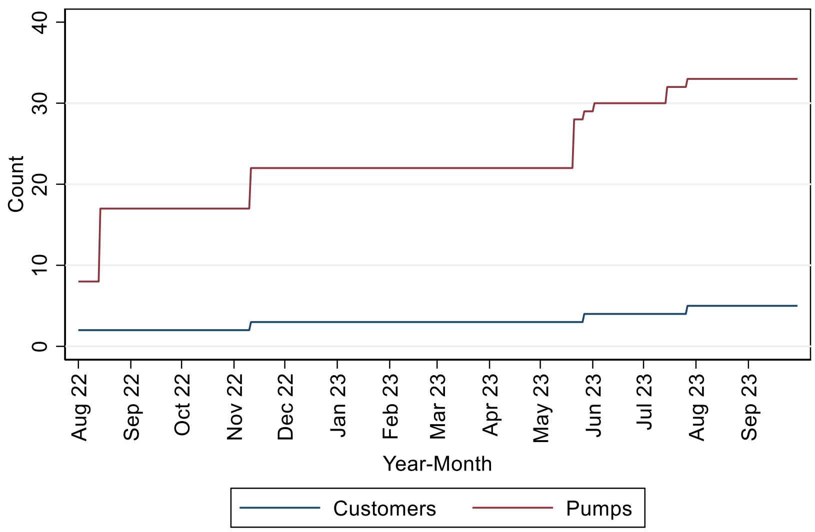



Table 3 provides characteristics information for each enrolled Pilot customer, including their start date, number of pumps, and usage. Note that we have anonymized the customer names in the interest of confidentiality. Of the two customers enrolled in both August 2022 and 2023, one customer increased the number of pumps in the Pilot while the other customer remained constant. The average kWh per pump indicates that usage was generally higher in August 2023 versus August 2022. The total Pilot demand grew from 602 kW to 1,840 kW between August 2022 and 2023.[23]

**Table 3: Pilot Customer Characteristics**

| | | August 2022 | | | August 2023 | | |
|---|---|---|---|---|---|---|---|
| Customer | Start Date[24] | N Pumps | Avg. kWh per Pump | kW | N Pumps | Avg. kWh per Pump | kW |
| C-001 | 7/31/2022 | 9 | 17.2 | 333.6 | 15 | 32.4 | 913.3 |
| C-002 | 7/31/2022 | 8 | 18.7 | 338.1 | 8 | 21.6 | 351.2 |
| C-003 | 11/11/2022 | n/a | n/a | n/a | 7 | 24.2 | 596.9 |
| C-004 | 7/27/2023 | n/a | n/a | n/a | 1 | 31.5 | 145.4 |
| C-005 | 5/27/2023 | n/a | n/a | n/a | 2 | 7.8 | 99.6 |
| **Total** | | **17** | **17.9** | **602** | **33** | **26.5** | **1,840** |

[23] The demand kW value indicates the monthly non-coincident peak (NCP) for each customer as well as for the Pilot total. Therefore, the sum of NCP kW values will not equal the Pilot total value. As of December 2023, VCE reports the aggregate enrolled load for these customers as 2.284 MW. This is based on a Peak Load Under Management (PLUM) methodology, calculated as the average load of each pump after removing hours when the pump is not running. The PLUM values can change over time.

[24] For customers C-001 and C-002, some of the pumps had a start date of 8/15/2022.

Agricultural pumping loads vary by season. Figure 10 depicts the average usage per pump for each month.[25] Energy use ramps up during May, is comparatively high from June through August, and then declines during September. April and October appear to be shoulder periods when relatively little pumping is employed. Customer energy use is minimal from November through March.

**Figure 10: Program Average Monthly Usage by Pump**

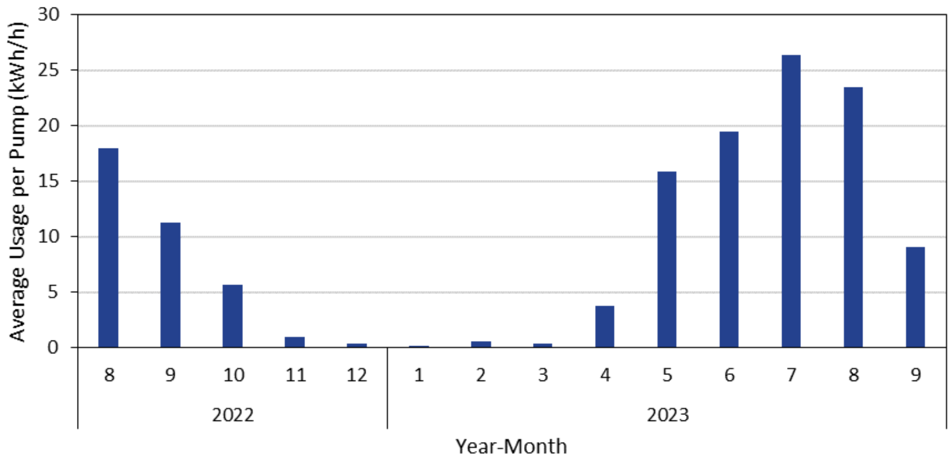
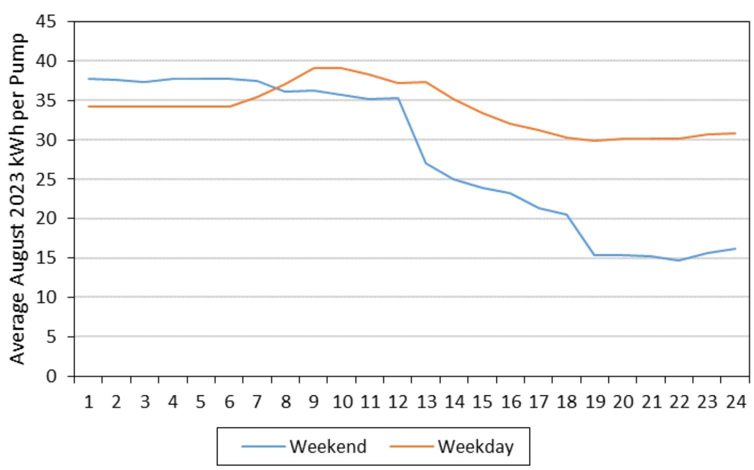



Figure 11 through Figure 15 illustrate the variation in hourly pumping demands across customers. Specifically, the figures show the average August 2023 weekday and weekend load profiles per pump for each customer. These figures help establish a reference point when comparing how loads change with respect to various Pilot prices as well as how pumping demands could be modeled in a regression analysis. For example, customer C-003 (Figure 13) does not have significantly different load profiles between weekdays and weekends. In addition, many of the customers have reduced usage during peak hours (HE 18-20) which limits the ability to reduce loads further when prices increase.

**Figure 11: Average Hourly Usage, August 2023, C-001**




[25] Because the composition of customers changes over time, the average usage per pump between months is not directly comparable in this figure.

**Figure 12: Average Hourly Usage, August 2023, C-002**

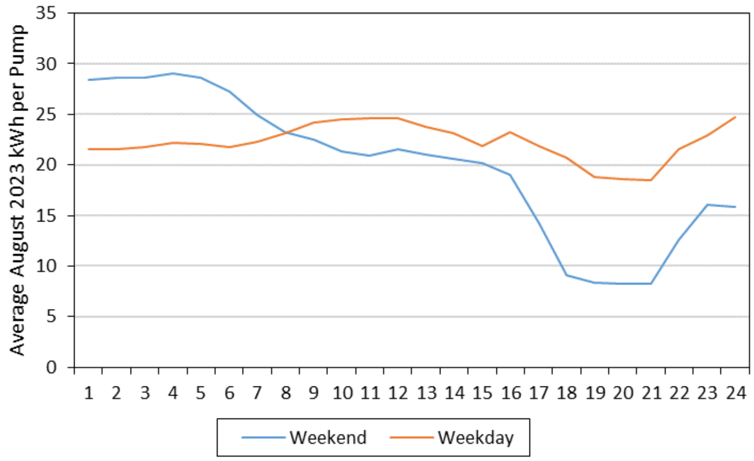



**Figure 13: Average Hourly Usage, August 2023, C-003**

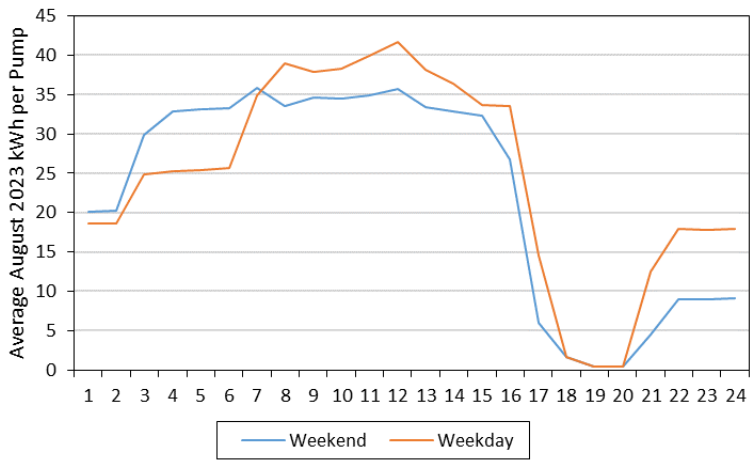



**Figure 14: Average Hourly Usage, August 2023, C-004**

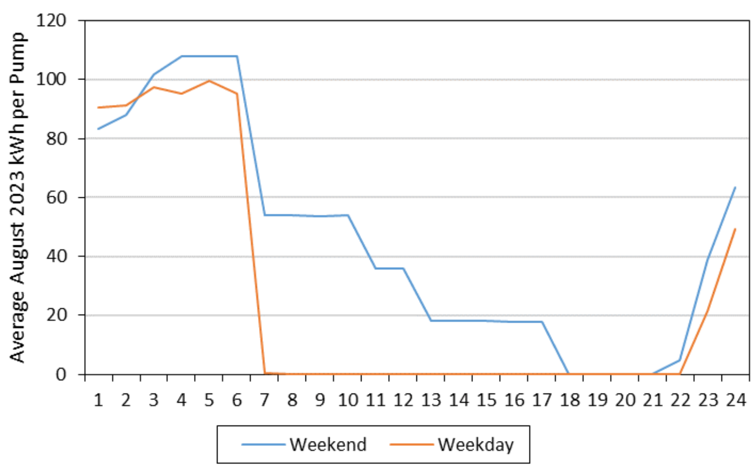
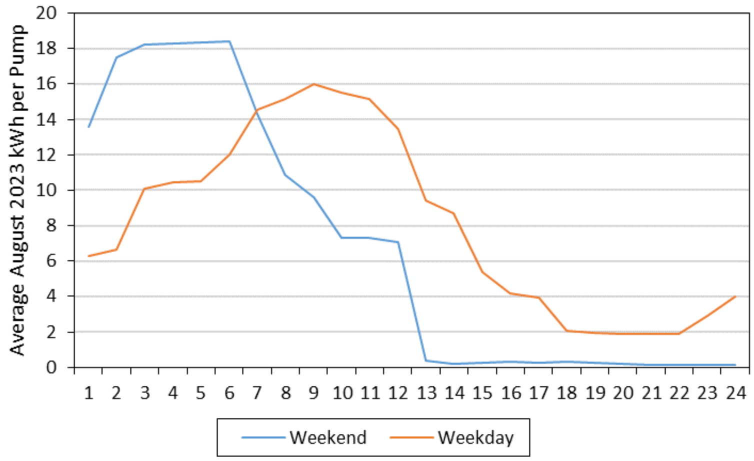


**Figure 15: Average Hourly Usage, August 2023, C-005**




# 3 EVALUATION OF LOAD RESPONSIVENESS

## 3.1 Overview of Methodologies and Results

In this section, we evaluate whether and how customers changed their usage while on the Pilot. Several methods are employed, including:

- Comparisons of pre-Pilot and Pilot loads;
- Comparisons of Pilot usage on high- and low-priced days; and
- Statistical analyses of changes in usage in response to dynamic prices.

The latter two analyses are carried out separately for AgFIT 1.0 and AgFIT 2.0 prices. The analyses are limited to months when Pilot customers have demand for pumping (August and September 2022 for AgFIT 1.0; and May through September for AgFIT 2.0).

The findings indicate the following:

- Comparisons of pre-Pilot to Pilot hourly usage profiles provide evidence of changes in typical customer usage patterns once automation is introduced, with the response occurring under both TOU and dynamic pricing.
- Comparisons of usage profiles on high- and low-priced days provide mixed evidence of larger price response on higher-priced days. Under AgFIT 1.0, one of the two participating customers showed a larger usage reduction during the highest-priced hours. During AgFIT 2.0, one of the five participating customers appeared to provide additional usage reductions during the highest-priced hours.
- The statistical analyses, which examine customer responses to Pilot dynamic prices, find that one of the two customers enrolled during AgFIT 1.0 responded to

dynamic prices. During AgFIT 2.0, three of the five participating customers responded to daily average price profiles but only one of those responded to the specific prices on a given day (i.e., responding more on a higher-priced day).

Note that one should be cautious in making inferences from comparing usage across years because there are external factors between growing seasons that cause usage changes. For example, a customer may change the crop type between growing seasons and have different pumping demands as a result.

## 3.2 Pre-Pilot Versus Pilot Usage Comparisons

In this section, we compare participants' pre-Pilot usage with usage after joining AgFIT. These simple comparisons can provide insight into how usage patterns may have changed in response to joining the Pilot.

Two Pilot customers, C-001 and C-002, had automation technology installed on pumps that were on Time-of-Use (TOU) pricing before being introduced to dynamic pricing.[26] This allowed us to compare how usage changed between technology and price regimes; first with no automation technology but TOU prices, second with automation technology and TOU prices, and third with automation technology but now with dynamic prices. The automation technology was installed in July 2022 while dynamic pricing went into effect in August 2022 for these customers' pumps. Therefore, the month of July between the years 2021 through 2023 can be used to compare usage under the different technology and price regimes. Again, it is important to note that other factors can affect usage levels and patterns across years, including variations in the planted crops and differences in hydrological conditions.

Table 4 summarizes the total usage (expressed as average daily kWh) and the share of usage during the TOU peak period (5 to 8 p.m.). As described above, the results for customers C-001 and C-002 reflect no automation with TOU pricing in 2021, automation with TOU pricing in 2022, and automation with AgFIT 2.0 dynamic pricing in 2023. For the other customers, the 2022 values represent pre-Pilot usage with no automation and TOU pricing, while the 2023 values reflect outcomes with automation and AgFIT 2.0 dynamic pricing. The table shows that the share of usage during the peak period is lower once automation is introduced, with or without AgFIT pricing. For customers C-003, C-004, and C-005, the share of peak usage may have been affected by an overall lower demand for pumping in 2023 versus 2022, as indicated by the lower Daily kWh values in 2022.

[26] There were eleven pumps between the two customers that fall into this category.

**Table 4: July Average Daily Load and Percentage of Load in the Peak TOU Period, by Year**

| Customer | 2021 | | 2022 | | 2023 | |
|---|---|---|---|---|---|---|
| | Daily kWh | % Peak (5-8 p.m.) | Daily kWh | % Peak (5-8 p.m.) | Daily kWh | % Peak (5-8 p.m.) |
| C-001 | 1,060 | 12.1% | 833 | 1.4% | 818 | 6.3% |
| C-002 | 535 | 12.2% | 606 | 7.7% | 553 | 8.9% |
| C-003 | N/A | N/A | 1,484 | 5.2% | 712 | 2.4% |
| C-004 | N/A | N/A | 3,167 | 12.1% | 1,374 | 1.0% |
| C-005 | N/A | N/A | 374 | 7.8% | 163 | 0.6% |

Figure 16 illustrates the average hourly usage for the C-001 pumps that had automated technology installed before receiving dynamic prices. July usage is shown for the years 2021 through 2023. The 2021 usage (blue line) remained relatively flat throughout the day and therefore did not include a reduction during the TOU peak period (HE 18-20). The 2022 usage (orange line) represents usage when the customer's pumps had automation technology but were still under TOU pricing. There is a noticeable decrease in 2022 usage during the peak TOU period relative to 2021. The comparison between 2021 without technology and 2022 with technology is suggestive that the automation technology helped the customer respond to the TOU peak period. The 2023 usage (green line) represents when the customer's pumps had automation technology and faced AgFIT 2.0 pricing. Compared to 2022, the usage in 2023 illustrates a wider reduction around and after the TOU peak period, though at a lower magnitude. The 2023 usage pattern aligns with the AgFIT 2.0 price pattern (see Figure 4).[27] Therefore, the automation technology appears to also have helped the customer respond to dynamic prices.

[27] From Figure 4, the highest average prices occurred about an hour later than the 5-8 p.m. Ag peak period (the highest prices were HE 19-21, e.g., 6-9 PM). Likewise, the usage reductions under AgFIT 2.0 pricing were shifted later in the day compared to the TOU-based reductions. Aggregate decreases below the mid-day "baseline" (i.e., total reductions over all hours from 2 p.m. to midnight) were also greater under AgFIT 2.0 than under TOU rates.

**Figure 16: Automation and Pricing Regime Usage, C-001**

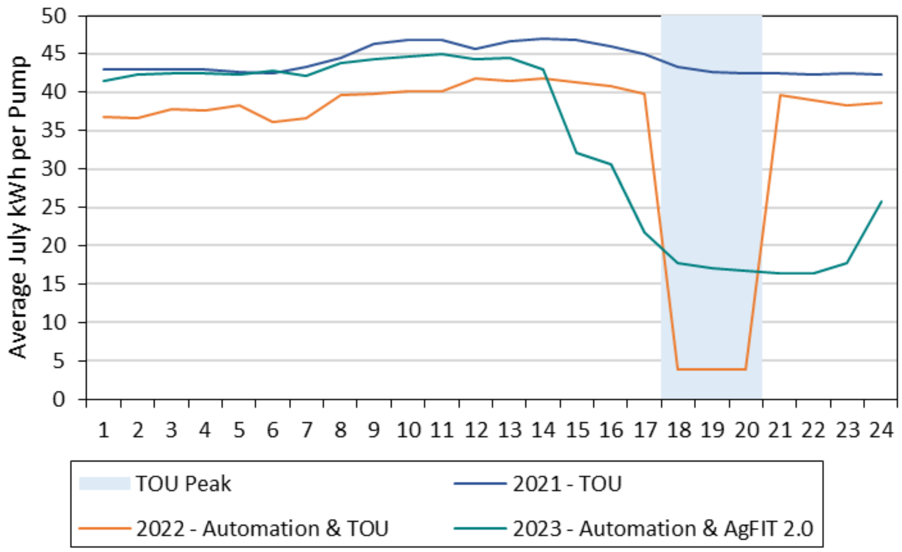
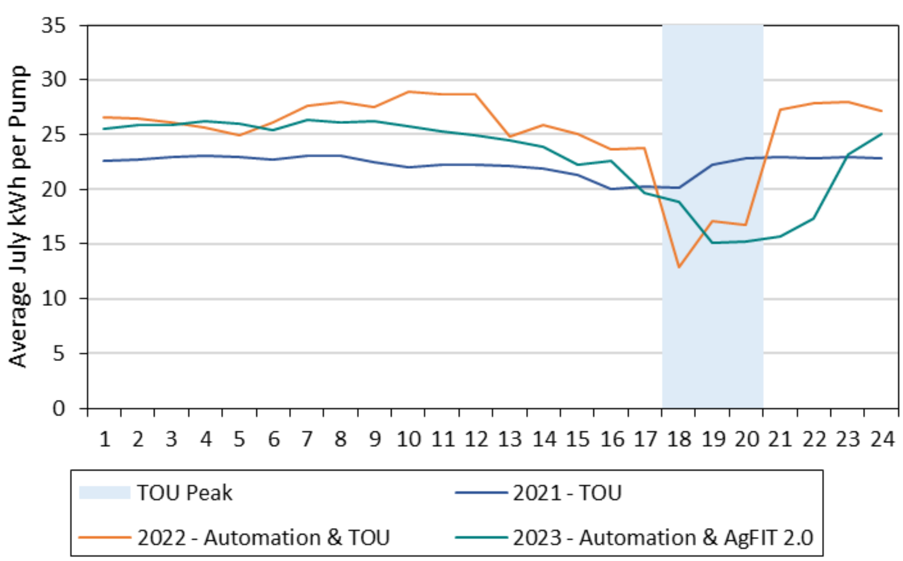



Figure 17 contains the same July comparisons for C-002's qualifying pumps. The 2021 usage without technology is relatively flat with no reduction during the TOU peak period. In contrast, the introduction of automation technology under TOU prices, reflected in the orange 2022 line, shows a reduction during the TOU peak period. The usage in 2023, when the customer faced AgFIT 2.0 prices, also exhibits a reduction during the TOU peak period but is again later, spread out in the surrounding hours, and greater in overall magnitude. The comparison between usage under the different technology and price regimes is suggestive that the automation technology was useful to enable load response to both TOU and dynamic pricing.

**Figure 17: Automation and Pricing Regime Usage, C-002**




The remaining customers were not enrolled in AgFIT during the Summer 2022 months but did have some pumps enrolled during the Summer 2023 months. Figure 18 through

Figure 20 display the per-pump average hourly pre-Pilot usage in July 2022 (orange line) and Pilot usage in July 2023 (green line) for each customer.[28] Figure 18 illustrates the average July pre-Pilot and Pilot usage for customer C-003. The pre-Pilot usage is higher than Pilot usage in all hours; however, overall differences in usage between years can be driven by external factors unrelated to the Pilot (e.g., crop rotation, water supply). Pre-Pilot and Pilot usage both include a significant reduction during the TOU peak period, with a moderate increase during the low-priced mid-day period. The 2023 reduction is wider than 2022 as load decreases slightly before and after the TOU peak period. The moderate response both mid-day and before and after the peak is suggestive of a response to the AgFIT 2.0 Pilot prices.

**Figure 18: Pre-Pilot vs. Pilot Usage, July 2022 & 2023, C-003**

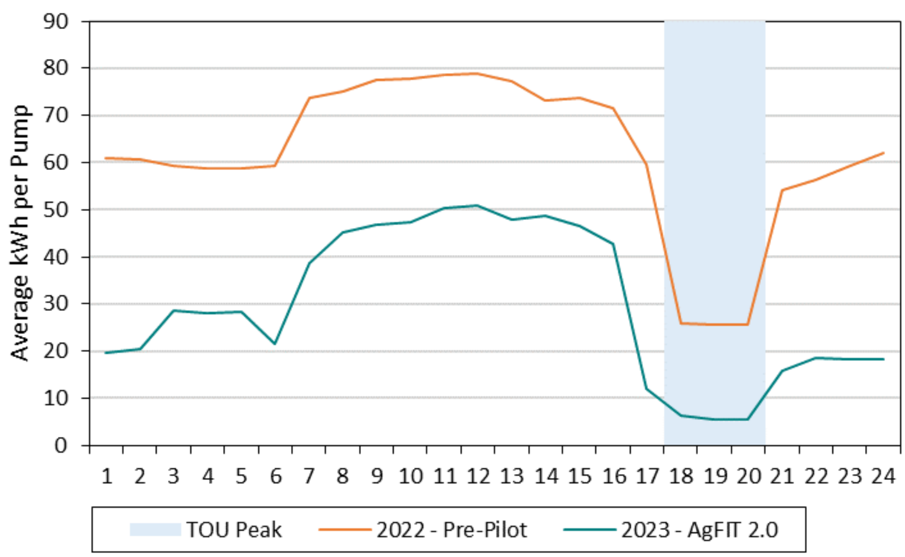



Figure 19 illustrates the average July pre-Pilot and Pilot usage for customer C-004. The 2023 Pilot usage is lower than 2022 usage for all hours. The hourly shape is significantly different between years as 2022 usage is relatively flat while the 2023 usage has relatively little pumping during the middle of the day (when, as shown in Figure 4, dynamic prices are actually the lowest). The lower usage in 2023 could be in response to dynamic prices considering that usage goes to zero during the peak hours, but the mid-day reduction does not fit that explanation. It seems likely that the differences between years are attributable to other factors affecting pumping demands between seasons.

[28] The average usage is shown for only pumps that exist in both periods. This prevents comparing usage between different sets of pumps.

**Figure 19: Pre-Pilot vs. Pilot Usage, July 2022 & 2023, C-004**

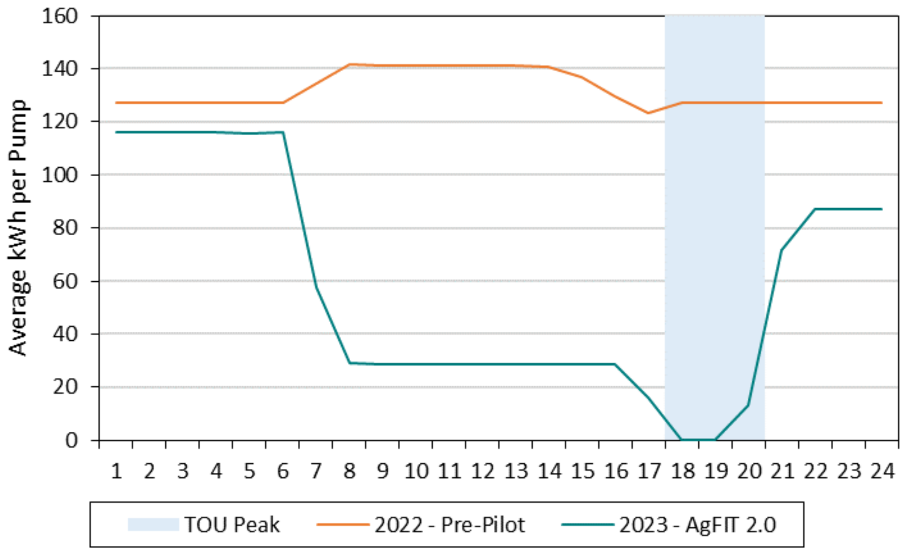
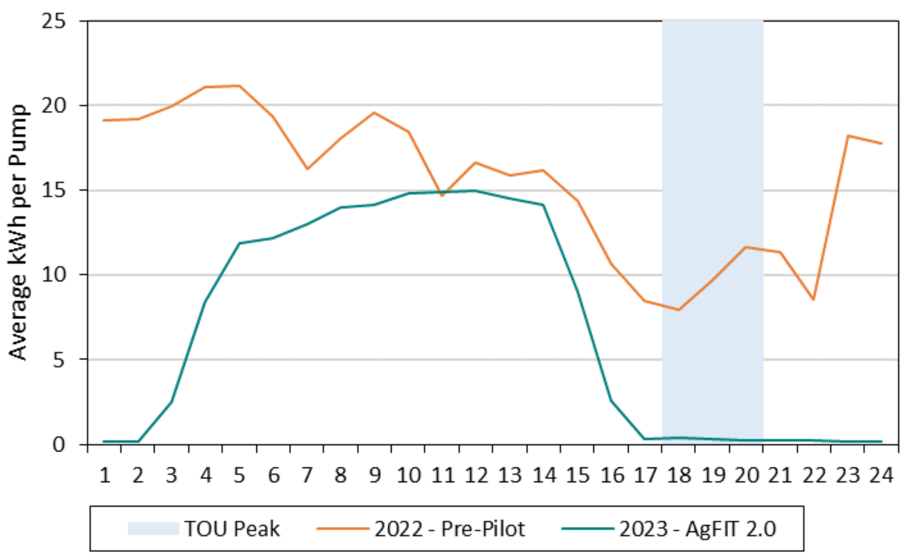



Figure 20 illustrates the average July pre-Pilot and Pilot usage for customer C-005. The hourly usage pattern in 2023 is very different from that of 2022, with usage highest mid-day when dynamic prices are lowest and dropping to nearly zero starting in hour-ending 17. C-005 is the only customer that not only reduced load significantly over the peak but took advantage of the lowest prices in the middle of the day.

**Figure 20: Pre-Pilot vs. Pilot Usage, July 2022 & 2023, C-005**




Taken together, these comparisons provide evidence of changes in typical customer usage patterns once automation is introduced, with the response occurring under both TOU and dynamic pricing.

## 3.3 Comparisons by Price Day Types

In this section we discuss results from comparisons between usage on high-price days and a set of low-price comparison days. The analysis is completed for the August and September 2022 period when AgFIT 1.0 was in place and then separately for the May through September 2023 period when AgFIT 2.0 prices were in place.

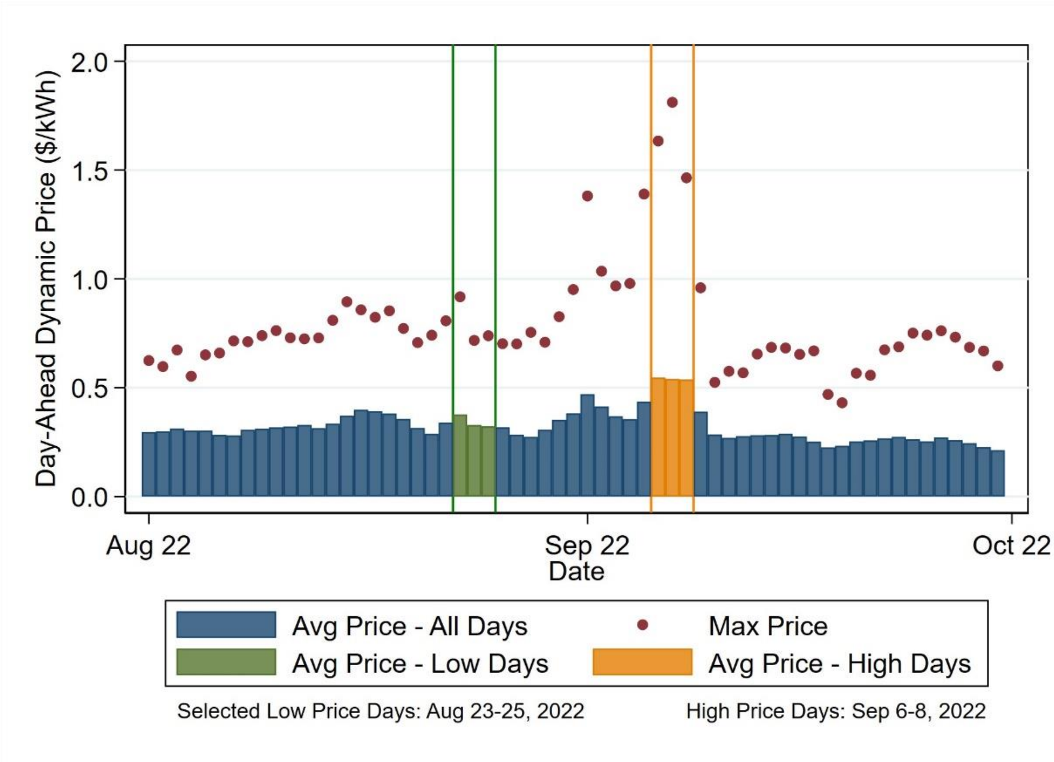
The set of low-price comparison days is intended to serve as a counterfactual and indicate what the customer loads would have been if the dynamic prices had not increased. Importantly, the two sets of days should be somewhat close to each other in time because the demand for pumping varies over the season. This comparison can illustrate the extent to which customer behavior changes across price day types.

### *3.3.1 AgFIT 1.0*

Figure 21 depicts daily average and maximum day-ahead dynamic tender prices from August and September 2022, which provides the basis for our selection of high- and low-price days to include in the comparisons. The blue bars represent the average daily price while the red dots represent a maximum price for each date. The orange bars mark the days that have the highest average prices during this period, September 6-8. Usage on high-priced days is compared with similar days that have relatively lower prices. The selected comparison group of low-priced days, August 23-25, are depicted by the green bars. Both the selected high- and low-priced days cover Tuesday through Thursday.[29] The days in later September were not selected as comparison days because customer usage was declining during this period as the growing season was coming to an end. As will be shown in the customer-specific hourly figures below, the two day types tend to have similar prices during the overnight and morning hours. The higher prices are limited to afternoon and evening hours.

[29] While pumps may operate on any day of the week, limiting our comparisons to the same weekdays helps control for any factors that may change by day of week. For example, a customer primarily scheduling usage during the weekend may affect the typical amount of notice at which the customer transacts by day of week.

**Figure 21: AgFIT 1.0 Daily Prices and Selected Comparison Days, Aug – Sep 2022**




Next, we compare the usage between the high- and low-priced days for each customer. Figure 22 and Figure 23 illustrate the average hourly prices and usage by day type for the two customers enrolled when AgFIT 1.0 pricing was in effect: customers C-001 and C-002, respectively. Each figure has a top and bottom panel. The top panel provides the average day-ahead dynamic tender prices. By design, the high-price day (dashed green line) has higher prices than the low-price day (solid green line). The higher prices are centered around 4 to 10 p.m. (HE 17-22). The lower panel in each figure illustrates the average customer usage on the selected high- (dashed blue line) and low-priced days (solid blue line).

Figure 22 appears to show sizeable demand response by customer C-001 on the high-price days. That is, their usage is lower than it is on the low-price comparison days during the same hours in which prices are higher. On similar low-priced days, usage remains around 15 kWh/hr during the peak hours.

**Figure 22: AgFIT 1.0 High vs Low Price Days, C-001**

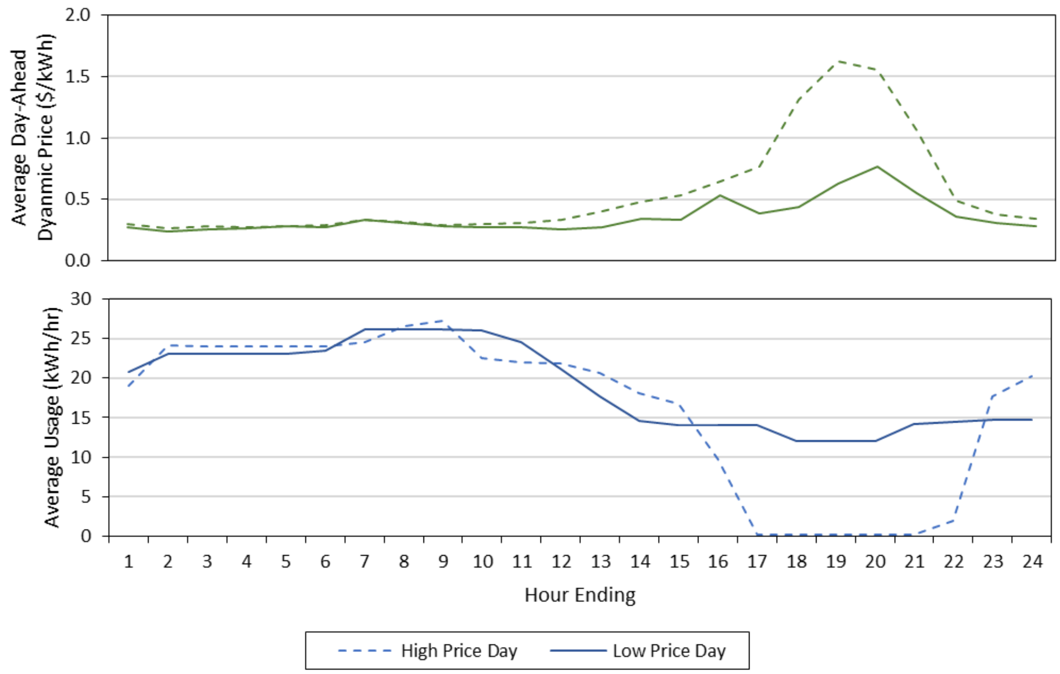
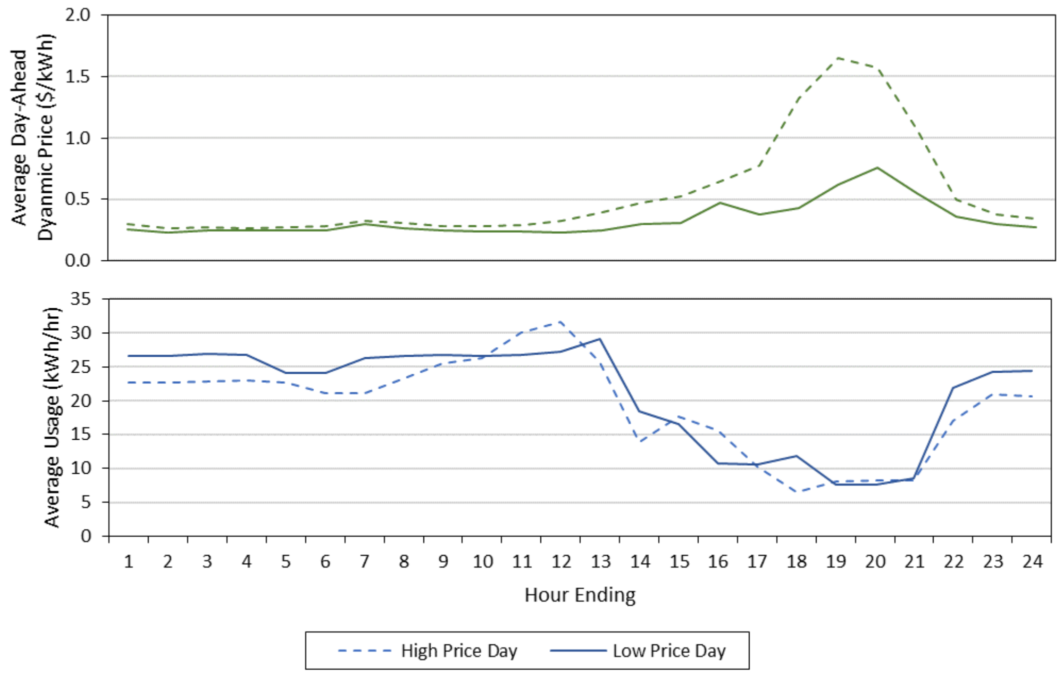



Figure 23 shows that customer C-002 didn't vary its response to AgFIT 1.0 prices on the selected high- and low-priced days. That is, they reduced usage during hours that tend to have higher prices, but the response didn't differ between the high- and low-price days. This indicates a response more akin to TOU demand response, in that they responded to typical price differences but not the date-specific prices that reflected current system conditions.

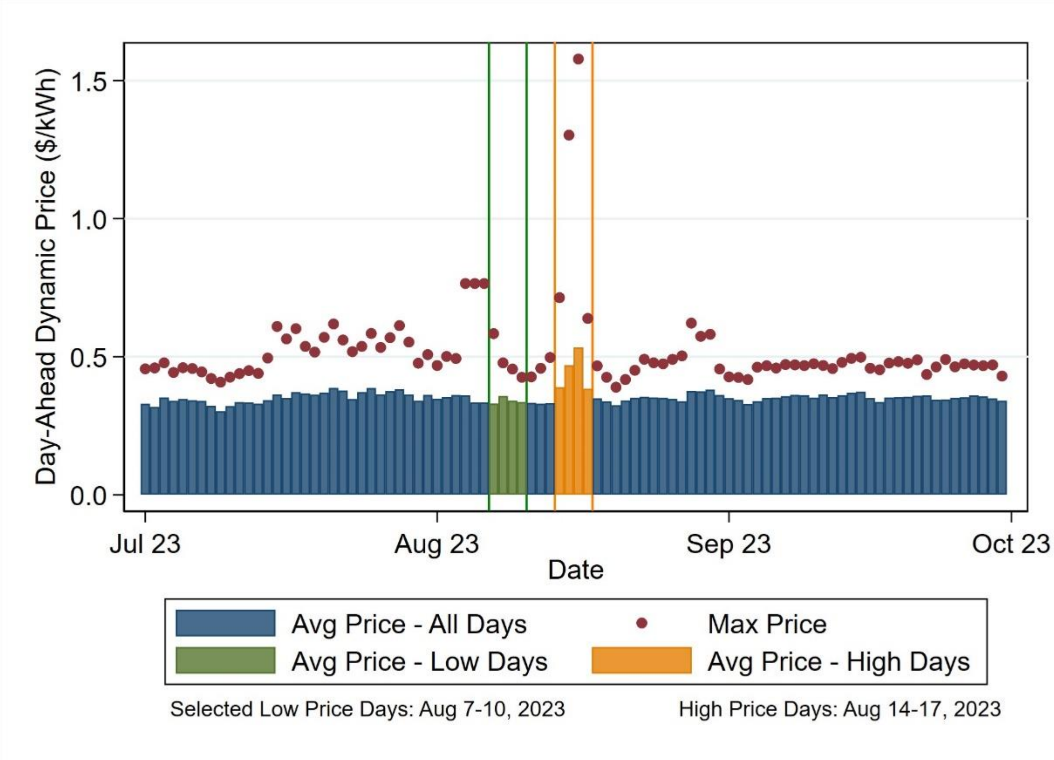
**Figure 23: AgFIT 1.0 High vs Low Price Days, C-002**




### *3.3.2 AgFIT 2.0*

Figure 24 depicts daily average and maximum day-ahead dynamic tender prices from July through September 2023 when AgFIT 2.0 pricing methods were in effect. The blue bars represent the average price while the red dots represent a maximum price for each date. The orange bars mark the days that have the highest average prices during this period, August 14-17. Usage on high-priced days is compared with similar days that have relatively low prices. The selected low-priced comparison days, August 7-10, are depicted by the green bars. Both the selected high- and low-priced days cover Monday through Thursday and are only a week apart.

**Figure 24: AgFIT 2.0 Daily Prices and Selected Comparison Days, Jul – Sep 2023**




We use these dates to compare usage on high- and low-priced days for each customer under AgFIT 2.0. Figure 27 through Figure 29 illustrate the average hourly day-ahead dynamic tender prices and usage by day type for the five customers enrolled during the period. As with the AgFIT 1.0 figures above, each figure has a top and bottom panel. The top panel provides the average day-ahead prices while the bottom panel shows the corresponding average hourly loads.

Figure 25 illustrates the average usage for customer C-001 on the selected high- and low-priced days during AgFIT 2.0. The average hourly usage is similar between the two day types, indicating that the customer did not respond differently to the higher dynamic prices. While there isn't load response under the select days for AgFIT 2.0, customer C-001 did exhibit load response under AgFIT 1.0. When interviewed by Polaris, the customer indicated that some crops require constant watering while others do not. In addition, the high-price days under AgFIT 2.0 (Aug. 14-17) were three weeks earlier than the high-price days under AgFIT 1.0 (Sep. 6-8). This could explain the more constant pumping usage observed under AgFIT 2.0 at different price levels.

**Figure 25: AgFIT 2.0 High vs Low Price Days, C-001**

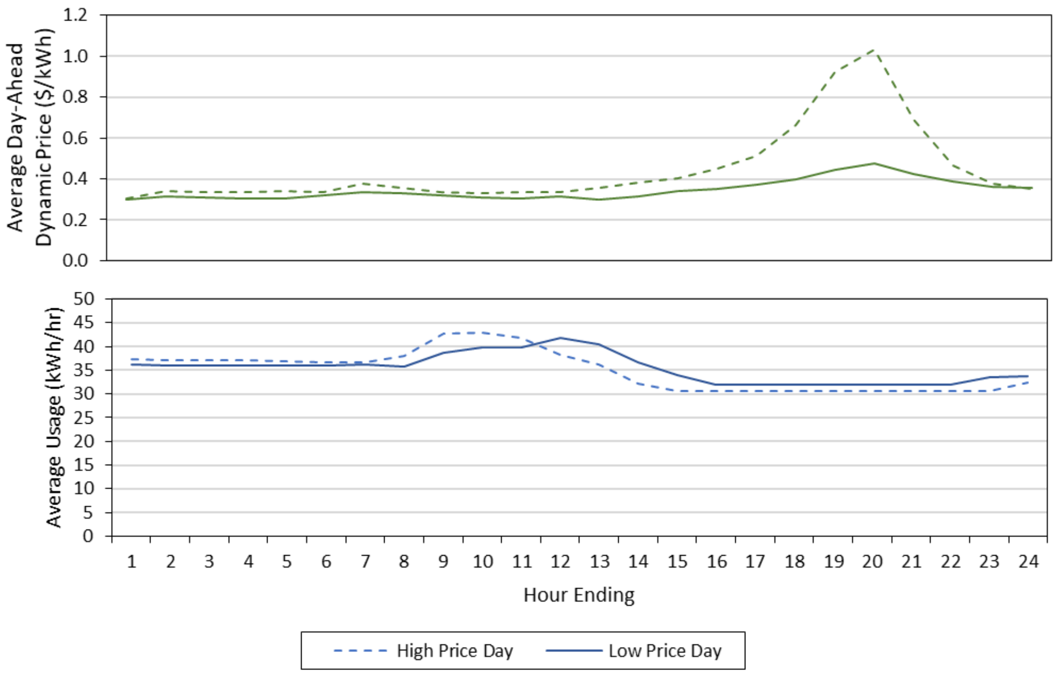



Figure 26 provides the average usage for customer C-002 on selected high- and low-priced days during AgFIT 2.0. Usage on the low-priced days exhibits a decrease during the peak hours even though prices displayed little variation within those days. In addition, usage from HE 17-21 was approximately the same on both day types despite the significant differences in prices. The differences in usage during the earlier hours of the day were likely due to factors we cannot observe. Recall that this customer also did not vary its peak-hour usage reductions across price day types under AgFIT 1.0 (see Figure 23).

**Figure 26: AgFIT 2.0 High vs Low Price Days, C-002**

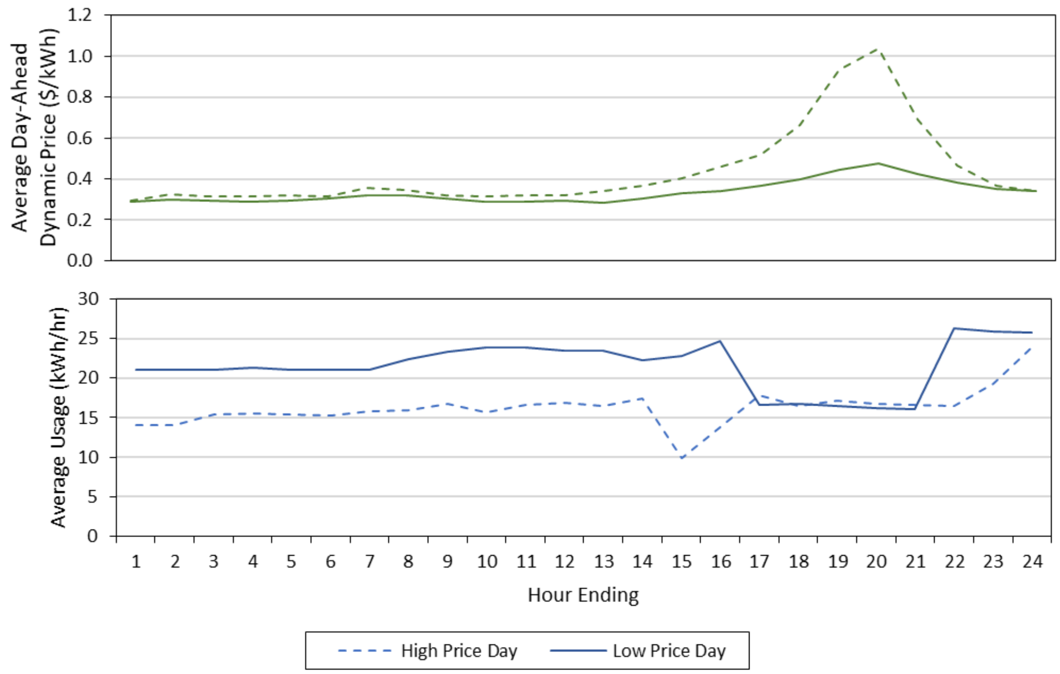



Figure 27 provides the average usage for customer C-003 on selected high- and low-priced days during AgFIT 2.0. Usage decreases begin at HE 17 on both day types, indicating that the customer did not change their pumping pattern in response to receiving higher dynamic prices. There are some usage differences during the early hours when prices are similar between day types, which likely reflects unexplained differences in pumping demand across day types.

**Figure 27: AgFIT 2.0 High vs Low Price Days, C-003**

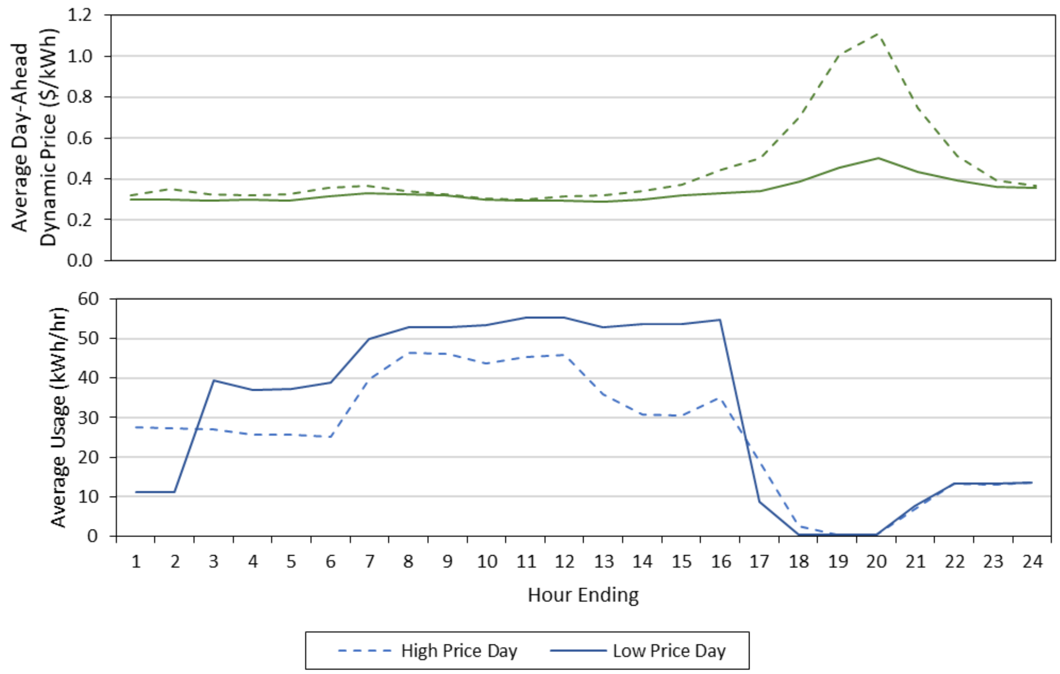



Figure 28 provides the average usage for customer C-004 on selected high- and low-priced days during AgFIT 2.0. For both day types, the customer has zero usage during the middle of the day (HE 7-22). Thus there was no ability for the customer to further reduce usage during the highest price hours reflected in these comparison dates.

**Figure 28: AgFIT 2.0 High vs Low Price Days, C-004**

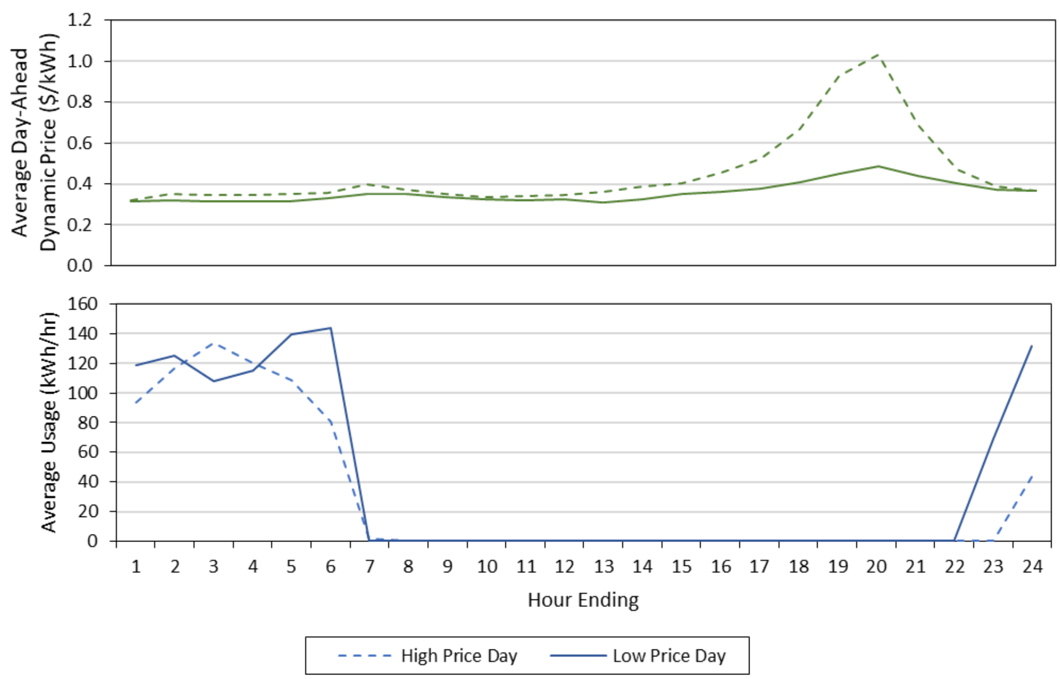
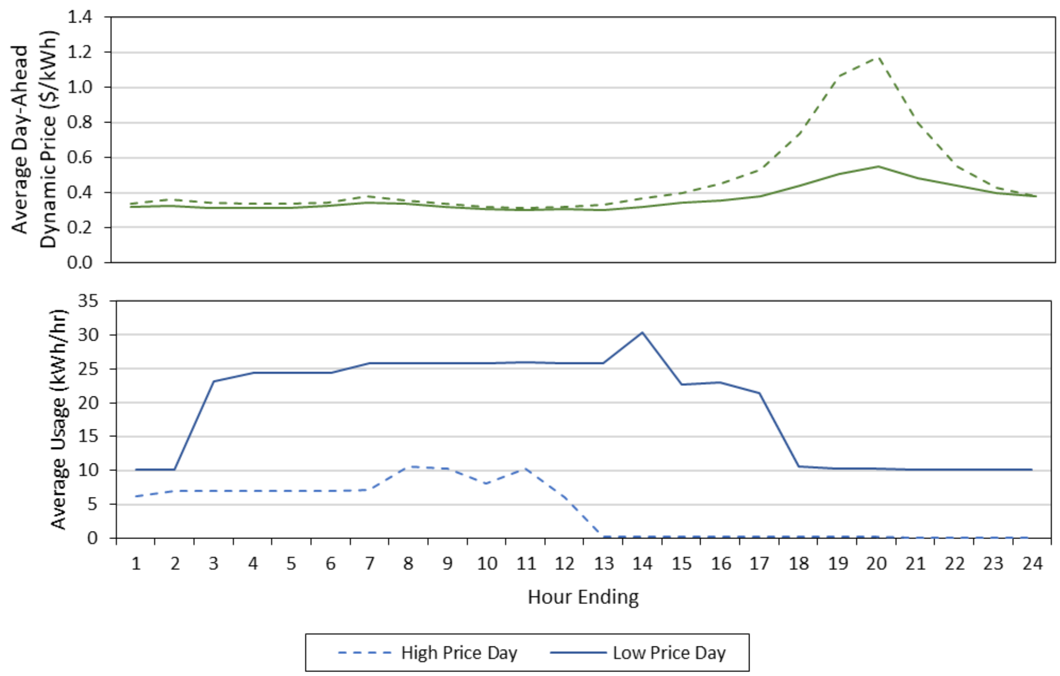


Figure 29 provides the average usage for customer C-005 on selected high- and low-priced days during AgFIT 2.0. Usage on high-price days is below the usage on low-priced days for all hours of the day. This is suggestive of price response, though it is not clear why the customer would have reduced usage during all hours when prices are only higher during some of the hours. It is possible that the customer makes daily pumping decisions based on the overall price profile, thus affecting usage in all hours. It is also possible that non-price factors affected pumping demand during the two day types.

**Figure 29: AgFIT 2.0 High vs Low Price Days, C-005**




In summary, the comparison of the average customer usage between days that exhibit large differences in day-ahead dynamic tender prices can provide an indication of customer's load response to the Pilot dynamic prices. Under AgFIT 1.0, one of the two enrolled customers exhibited load response by reducing usage when prices increased while the other customer did not. The single customer that had load response under AgFIT 1.0 did not respond during the AgFIT 2.0 period. Under AgFIT 2.0, there were five customers enrolled, one of which appeared to have responded differently to high- and low-priced days.

## 3.4 Statistical Estimates of Load Impacts

### *3.4.1 Methodology*

The statistical estimation of load impacts incorporates the full set of days in the analysis to model customer usage as a function of the hourly day-ahead dynamic tender prices. In contrast to the day-type comparisons that rely on a small set of days, the regression models are used to discover how customers' pumping behavior responds to Pilot prices over a longer period of time. The results presented below provide mixed evidence of customer response to dynamic prices. Estimates for some customers reflect the possibility that they respond on an everyday basis to the average price profile (similar to a TOU response), while others appear to differentiate their pumping use on high- versus low-priced days. Finally, there is little evidence that price response is consistently higher during peak hours.

The regression analysis uses the following specification:[30]

$$nkW_{it} = b^{Price} \times Price_{it} + b^{kW\_MA} \times nkW\_MA_{it} + b^{Price\_MA} \times Price\_MA_{it} + b^{Dtype\_Controls} \times Dtype\_Controls_t + \sum_{h=1}^{H} (b_h^{hour} \times Hour_{h,t}) + \sum_{p=1}^{P} (b_p^{Pump} \times Pump_{p,i}) + e_{it}$$

The variables and coefficients in the equation are described in Table 5:

**Table 5: Regression Variables**

| Symbol | Description |
|---|---|
| $nkW_{it}$ | the demand in hour *t* for a Pilot customer pump *i* divided by the pump's maximum observed hourly usage |
| *The various b's* | the estimated parameters |
| $Price_{it}$ | The Pilot program day-ahead tender price during hour *t* for pump *i*. |
| $nkW\_MA_{it}$ | the three-day moving average of daily usage for pump *i* during hour *t* divided by the pump's maximum observed hourly usage |
| $Price\_MA_{it}$ | the three-day moving average of day-ahead tender prices for pump *i* during hour *t* |
| $Dtype\_Controls_t$ | set of control variables for day type in hour *t.* The set includes year-month and day of week fixed effects. |
| $Hour_{h,t}$ | an indicator variable for hour *h*, equal to one when *t* corresponds to hour *h* of a given day |
| $Pump_{p,t}$ | an indicator variable for pump *p*, equal to one when *i* corresponds to pump *p* for a given observation |
| $e_{it}$ | error term for Pilot customer in hour *t* |

The dependent variable is normalized by dividing each hour's usage by the pump's maximum observed usage. This helps with the interpretation of the estimated coefficients. We model usage as a function of the day-ahead tender prices because they are the last prices presented to the customers before the usage hour in question. While the customer may have transacted at earlier dynamic tender prices (e.g., three days ahead) at a fixed quantity, the day-ahead price represents the customer's last transaction opportunity and the best estimate of the ex-post price used in AgFIT 1.0 settlement.

[30] A double log functional form provides the convenience of directly estimating the price elasticity; however, the double log functional form cannot be employed here because of the occurrence of zero usage. A double log specification would omit observations with zero usage because you cannot take the natural log of a zero value.

The estimated coefficient on price is the key parameter since it indicates the change in kWh associated with a change in price, all else equal. In other words, the price coefficient implies how much customers respond to the day-ahead dynamic prices. The three-day moving average of quantity is included to control for differences in pumping demand over the growing season.[31] The three-day moving average of the day-ahead tender price is included to control for substitution of pumping demand from previous days. For example, customers may substitute their usage from previous days to the current day if recent prices have been high, all else equal.

The model is estimated with and without hour fixed effects.[32] When the hour fixed effects are excluded from the model, the price coefficient includes the everyday coincidence of the pattern between prices and usage. For example, if a customer planned its usage pattern around the average hourly price profile but didn't respond to day-to-day price variations, we would find that the estimated price effect would be statistically significant with the correct negative sign when the hour fixed effects are excluded.

Alternatively, estimating a statistically significant price effect when hour fixed effects are included requires customers to use less when prices are higher *during a given hour*. That is, the customer would have to use less during relatively expensive peak hours versus less expensive peak hours. This type of effect is more closely related to the kind of response dynamic pricing programs are expected to produce, which is larger load reductions on days with higher prices.

The models are estimated using all hours of the day. However, we also investigate whether customers respond differently to prices during peak hours (5 to 8 p.m.). A potential reason for this to be the case is that the peak period tends to have higher and more volatile prices, increasing the potential benefits from paying attention to usage levels during those hours. To test this, the specification is modified to include an interaction between the price variable and the peak period indicator variable.[33] The interaction term is estimated in addition to the stand-alone price variable. The interaction coefficient therefore indicates whether customers respond to prices differently during the peak period relative to other hours.

The regression model is estimated separately for each customer. This allows us to control for unobservable differences between customers while also providing different estimates of price responsiveness. For customers with multiple pumps, we estimate the regression using a panel model containing all the pumps and include pump-specific fixed effects

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[31] Pumping demands generally increase over the summer period. A spurious positive correlation between usage and price occurs if AgFIT prices also increase over the same period. Controlling for changes in pumping demand over time prevents confounding usage changes from increased demands with increased prices. Another remedy would be to limit the analysis period to when pumping demand is relatively constant throughout. Robustness checks confirmed this to be the case.

[32] Hour fixed effects are implemented via hour-specific indicator variables. Each hour's variable estimates the customer's average usage in that hour, controlling for other included variables.

[33] This model specification includes the hour fixed effects.

while clustering the standard errors around the pump.[34] The models are separately estimated for the AgFIT 1.0 and 2.0 periods.

### 3.4.2 Results from Statistical Model

Table 6 provides the estimated price coefficients with p-values in parentheses from regression specifications described in 3.4.1.[35] The estimates are provided for two separate time periods: August and September 2022 (AgFIT 1.0) and May through September 2023 (AgFIT 2.0).[36] For each pricing method we present price coefficients from two different model specifications: excluding and including hour fixed effects. The estimated coefficients indicate customer price responsiveness. For example, a value of -0.5 would mean that the customer decreased their usage by 50 percent of their peak hourly usage when prices increased by $1/kWh. Therefore, greater negative coefficient values suggest higher response to prices. Positive values suggest that customers increased usage when prices increased. Such estimates likely indicate omitted variable bias (a factor unknown to the analyst that affects the customer's pumping demand). Different levels of statistical significance are represented by the number of stars ("*"). Negative and statistically significant estimates are highlighted in gray.

The price coefficients in Table 6 are estimated from the regression specification excluding and including hour fixed effects. When hour fixed effects are excluded, the price coefficient reflects customer response to the average daily price profile. Under AgFIT 1.0 pricing, both customers have the expected negative price coefficient, although only customer C-002's price response is statistically significant (with a point estimate of -0.219). The reduction in usage in response to higher dynamic prices is consistent with previously shown figures that illustrate decreased usage in hours that generally correspond to higher prices (e.g., Figure 22 and Figure 23).

When hour fixed effects are included, the estimated price coefficient reflects customer response to differences in prices across days (i.e., whether they reduced usage during hour-ending 17 by more when the price was 50 cents/kWh rather than 35 cents/kWh). While these estimates have the expected negative sign for both customers, once again only customer C-002's estimate is statistically significant. Recall that our day-type comparison for customer C-001 showed a response to high prices during peak hours (Figure 22), but these estimates reflect that the day-type comparison result does not generalize across a wider range of days.[37]

Under AgFIT 2.0 pricing (shown in the rightmost columns of Table 6), the price coefficient estimates from the specification without hour fixed effects are negative for all customers and statistically significant for three of the five customers. Customer C-004 has the

[34] We estimate a time series model for the single customer that has only one pump.

[35] Table A.1 in the appendix provides additional regression summary statistics, including the number of observations and $R^2$.

[36] The AgFIT 1.0 analysis end September 20, 2022, since the average usage is relatively low afterwards due to the end of the growing season.

[37] The $R^2$ values in Table A.1 demonstrate that the amount of variation in usage that is explained by the regression. A low $R^2$ value suggests that there is a lot of variation in usage not explained by the model. The short window for the AgFIT 1.0 model also contributes to difficulty in finding statistical significance.

largest relative decrease in usage, with an estimated coefficient of -0.816. The results are consistent with the graphical presentations we've provided that illustrate reduced loads during the hours in the day when dynamic prices are high (e.g., Figure 11 through Figure 15).

The price coefficient estimates from the specification that includes hour fixed effects indicate that only one of the five customers (C-004) had a statistically significant response to prices when accounting for the daily usage profile. That is, customer C-004 was the only customer that responded differently on high- versus low-priced days during the AgFIT 2.0 period.

**Table 6: Regression Results**

| Customer | AgFIT 1.0 (Aug-Sep 20, 2022) | | AgFIT 2.0 (May-Sep, 2023) | |
|---|---|---|---|---|
| | Without Hour FE | With Hour FE | Without Hour FE | With Hour FE |
| C-001 | -0.129<br>(0.072) | -0.010<br>(0.673) | -0.195*<br>(0.034) | 0.033<br>(0.654) |
| C-002 | -0.219*<br>(0.025) | -0.123*<br>(0.048) | -0.153<br>(0.342) | 0.028<br>(0.723) |
| C-003 | N/A<br>N/A | N/A<br>N/A | -0.380*<br>(0.010) | -0.090<br>(0.103) |
| C-004 | N/A<br>N/A | N/A<br>N/A | -0.816**<br>(0.000) | -0.351**<br>(0.000) |
| C-005 | N/A<br>N/A | N/A<br>N/A | -0.397<br>(0.325) | -0.295<br>(0.115) |

p-values in parentheses, ** p <0.01, * p<0.05

Table 7 contains the price coefficient estimates from the regression specification that interacts the price coefficient with the peak hours (HE 18-20). The estimated price coefficients reflect the average price responsiveness during all hours while the interacted price coefficient ("Price X Peak") reflects any incremental price response during peak hours. The models reflected in the table all include hour fixed effects. These models explore whether customers were more price responsive during peak hours, when prices tended to be higher and more variable.

The estimates in Table 7 don't show a consistent pattern of price response being higher during the peak period. In fact, the AgFIT 2.0 estimates for customer C-004 show the opposite effect: *less* price response during peak hours. This could be because their usage level is already low during those hours, so there is less room to further reduce usage as prices increase.

**Table 7: Regression Results with Peak Period Price Interaction**

| Customer | AgFIT 1.0 (Aug-Sep 20, 2022) | | AgFIT 2.0 (May-Sep, 2023) | |
|---|---|---|---|---|
| | Price | Price X Peak | Price | Price X Peak |
| C-001 | 0.011<br>(0.860) | -0.033<br>(0.641) | 0.008<br>(0.958) | 0.038<br>(0.776) |
| C-002 | -0.069<br>(0.507) | -0.069<br>(0.531) | 0.079<br>(0.592) | -0.081<br>(0.546) |
| C-003 | N/A<br>N/A | N/A<br>N/A | 0.023<br>(0.779) | -0.165<br>(0.077) |
| C-004 | N/A<br>N/A | N/A<br>N/A | -1.308**<br>(0.000) | 1.249**<br>(0.000) |
| C-005 | N/A<br>N/A | N/A<br>N/A | -0.544<br>(0.090) | 0.469<br>(0.088) |

p-values in parentheses, ** p <0.01, * p<0.05

Note that these models are attempting to identify changes in customer usage in response to changes in prices within the Pilot period. For example, we are looking to see whether customers use less when AgFIT prices are high, all else equal. While the models do not contain pre-Pilot data, the figures shown in Section 3.2 provide comparisons of pre-Pilot and Pilot usage profiles, indicating that some participants have changed their load profile while on the Pilot. Further evidence may help us attribute the usage changes to automation, Polaris's customer engagement efforts, or the dynamic prices. The low $R^2$ values in Appendix Table A.1 suggest that much of the customer usage is unexplained by the models,[38] which highlights the potential value in being able to evaluate more Pilot data over time.

# 4 MONTHLY BILL IMPACTS

As described in the introduction, Pilot participants continue to pay their OAT bill. Each month, a shadow bill is calculated representing what they would have paid under the AgFIT pricing model. At the end of a year, the customer is credited if their cumulative AgFIT bill is less than their cumulative OAT bill but does not pay more if the OAT bills are lower than the Pilot bills. In this section we compare AgFIT 1.0 and AgFIT 2.0 shadow bills with OAT bills for each pump and customer.

Note that final shadow bills are not yet available. The information shown in this section is based on the most recent information made available to the authors.

Table 8 provides a summary of the customer-level bill impacts. Each column represents a customer, with two of the customers participating in both AgFIT 1.0 and 2.0. The table shows both the simple difference between the OAT and shadow bills (row 5) as well as

[38] That is, the low-$R^2$ values reflect that it is difficult to explain the timing and level of customer pumping usage with dynamic prices and "regular profile" (e.g., time of day or day of week) variables.

the shadow billing credit (row 6), which omits pumps for which the total OAT bill is lower than the total shadow bill.

In all but one case (customer C-001 during AgFIT 2.0), the customers had aggregate shadow bills that were lower than the corresponding OAT bills. In most cases, the customers benefit from the shadow bill credit method. Only customers C-004 and C-005 do not benefit, which is partly due to those customers having fewer pumps than the other customers (and thus fewer opportunities for the "best bill" methodology to affect the credit).

**Table 8: Summary of Bill Impacts**

| Row # | Result Type | AgFIT 1.0 | | AgFIT 2.0 | | | | |
|---|---|---|---|---|---|---|---|---|
| | | C-001 | C-002 | C-001 | C-002 | C-003 | C-004 | C-005 |
| 1 | # Pumps | 9 | 8 | 15 | 8 | 7 | 1 | 2 |
| 2 | kWh | 142,140 | 239,872 | 1,429,756 | 456,862 | 342,897 | 4,231 | 27,377 |
| 3 | OAT Bill | $45,608 | $74,139 | $465,516 | $148,277 | $108,441 | $2,163 | $10,171 |
| 4 | Shadow Bill | $45,197 | $55,436 | $481,837 | $148,209 | $104,994 | $736 | $7,705 |
| 5 | OAT – Shadow Bill | $411 | $18,703 | -$16,321 | $68 | $3,447 | $1,427 | $2,466 |
| 6 | Shadow Billing Credit | $4,974 | $20,537 | $17,934 | $7,461 | $9,740 | $1,427 | $2,466 |
| 7 | OAT $/kWh (Row 3/Row 2) | $0.321 | $0.309 | $0.326 | $0.325 | $0.316 | $0.511 | $0.372 |
| 8 | Shadow $/kWh (Row 4/Row 2) | $0.318 | $0.231 | $0.337 | $0.324 | $0.306 | $0.174 | $0.281 |
| 9 | % Bill Difference (Row 5/Row 3) | 0.9% | 25.2% | -3.5% | 0.0% | 3.2% | 66.0% | 24.2% |
| 10 | Credit as % of OAT Bill (Row 6/Row 3) | 10.9% | 27.7% | 3.9% | 5.0% | 9.0% | 66.0% | 24.2% |

### *4.1.1 AgFIT 1.0*

Table 9 summarizes the OAT and shadow bills during the AgFIT 1.0 period for customer C-001. The table includes pump-specific amounts for AgFIT 1.0 billing periods that were provided to us by TeMix. The tables contain the total kWh consumed by the customer, the total OAT and shadow bill dollar amounts, the difference between the OAT and shadow bill, and the shadow bill credit (which is the greater of zero and the difference between the OAT and shadow bill). Four of the nine pumps received shadow bills that were lower than the corresponding OAT bill. The total shadow bill credit was $4,974.[39]

[39] For pump 5 the shadow bill was negative. This indicates that customer C-001 managed to "sell back" a significant amount of energy during high-priced periods. The relatively high average OAT price of $0.52/kWh indicates that most of the remaining pump energy was consumed on-peak.

**Table 9: OAT vs Shadow Bills, AgFIT 1.0, C-001**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 304 | $186 | $320 | -$134 | $0 |
| 2 | 28,488 | $7,900 | $8,407 | -$506 | $0 |
| 3 | 28,244 | $9,351 | $8,716 | $635 | $635 |
| 4 | 23,531 | $6,216 | $4,195 | $2,020 | $2,020 |
| 5 | 2,869 | $1,481 | -$751 | $2,231 | $2,231 |
| 6 | 26,452 | $8,877 | $8,789 | $87 | $87 |
| 7 | 7,104 | $2,835 | $5,163 | -$2,328 | $0 |
| 8 | 22,389 | $7,212 | $8,615 | -$1,403 | $0 |
| 9 | 2,759 | $1,550 | $1,743 | -$193 | $0 |
| **Total** | **142,140** | **$45,608** | **$45,197** | **$411** | **$4,974** |
| Billing Periods: Pumps 1-4: 8/1/22 – 1/20/23; Pumps 5-9: 8/15/22 – 1/20/23. | | | | | |

Table 10 shows how the total usage was divided between subscription purchases, net dynamic price transactions (purchases and sales in response to tenders), and the net ex-post transactions over the billing period. The dynamic and ex-post quantities represent the net amount after combining the purchases (i.e., buying more than their subscription quantity) and sales (selling unused subscription). For example, pump 3 had a subscription quantity of 28,616 kWh and transacted to sell a net amount of 345 kWh ahead of time, with an additional net 24 kWh sold at ex-post prices, resulting in a very small change in 2022 kWh from the 2023 kWh.

Table 10 also adds the average transaction price paid for these categories, thereby allowing comparisons to the average price for the OAT bill. The subscription price was higher than the average OAT price for four of the nine pumps. Differences between the subscription and OAT average prices do not necessarily indicate mispricing of the subscription. That is, the subscription price represents the customer's historical load profile and if that load profile changes while on the Pilot, the average OAT price paid may change as well. For example, a demand-billed customer who decreased its load factor across years (leading to relatively higher demand charges) would likely experience an average OAT price per kWh that is higher than the subscription price.

Note that the average transaction prices for dynamic and ex-post prices are calculated as the total net charges across all purchases and sales divided by the net kWh bought or sold. Therefore, they do not necessarily reflect the average dynamic or ex-post price at the time when the energy was being bought or sold. For example, for pump 3, the extremely negative average ex-post price is likely the result of selling slightly more kWh than the customer was buying (i.e., negative net ex-post kWh) but receiving less revenue from the sales than they paid for the purchases. In summary, when transactions can be purchases or sales, the average net price paid (or received) during an interval can be quite different from the simple average of the dynamic or ex-post prices during that same interval.

**Table 10: Comparison of Subscription, Dynamic, and Ex-Post Average Net Transaction Prices Paid, AgFIT 1.0, C-001**

| Pump | kWh | Subscription kWh | Dynamic kWh | Ex Post kWh | OAT $/kWh | Subscription $/kWh | Dynamic $/kWh | Ex Post $/kWh |
|---|---|---|---|---|---|---|---|---|
| 1 | 304 | 2,999 | 0 | -2,706 | $0.61 | $0.30 | N/A | $0.27 |
| 2 | 28,488 | 43,241 | -19,332 | 4,583 | $0.28 | $0.31 | $0.34 | $0.30 |
| 3 | 28,244 | 28,616 | -345 | -24 | $0.33 | $0.33 | $3.29 | -$6.27 |
| 4 | 23,531 | 37,167 | -16,214 | 2,569 | $0.26 | $0.24 | $0.36 | $0.37 |
| 5 | 2,869 | 33,138 | 0 | -30,261 | $0.52 | $0.29 | N/A | $0.35 |
| 6 | 26,452 | 23,369 | 0 | 3,083 | $0.34 | $0.32 | N/A | $0.39 |
| 7 | 7,104 | 2,045 | 4,475 | 579 | $0.40 | $0.64 | $0.77 | $0.34 |
| 8 | 22,389 | 8,641 | 0 | 13,748 | $0.32 | $0.43 | N/A | $0.34 |
| 9 | 2,759 | 2,454 | 0 | 310 | $0.56 | $0.55 | N/A | $0.68 |
| Billing Periods: Pumps 1-4: 8/1/22 – 1/20/23; Pumps 5-9: 8/15/22 – 1/20/23. | | | | | | | | |

It might be instructive to interpret the results for customer C-001's pump 2. Table 9 shows that the customer paid $506 more on its shadow bill versus its OAT bill. The information in Table 10 provides important context for that bill comparison. Notice that the subscription average price of $0.31 per kWh is above the current OAT average price of $0.28 per kWh. Because the subscription price reflects the customer's pre-Pilot OAT bill (with an escalator applied to account for current rate levels), this comparison indicates that the customer likely saved money on this pump relative to its pre-Pilot bills. The customer was able to benefit by selling much of the subscription it purchased at $0.31 per kWh for an average of $0.34 per kWh at dynamic prices. However, these gains from responding to dynamic prices were lower than the bill reduction the customer obtained from the OAT pricing. This example highlights the benefits a customer can obtain from continuing to respond to OAT price signals in the presence of the shadow bill credit methodology used in the Pilot and thus how the shadow bill methodology may diminish response to the dynamic prices.

Table 11 summarizes the OAT and shadow bills during the AgFIT 1.0 period for customer C-002. Six of the eight pumps received shadow bills that were lower than the corresponding OAT bill. The total shadow bill credit was $20,537.

**Table 11: OAT vs Shadow Bills, AgFIT 1.0, C-002**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 47,059 | 14,759 | 6,193 | $8,566 | $8,566 |
| 2 | 18,724 | 7,177 | 5,784 | $1,393 | $1,393 |
| 3 | 37,807 | 11,574 | 9,111 | $2,462 | $2,462 |
| 4 | 17,424 | 5,405 | 5,707 | -$302 | $0 |
| 5 | 30,708 | 9,296 | 5,992 | $3,304 | $3,304 |
| 6 | 33,892 | 10,963 | 8,676 | $2,287 | $2,287 |
| 7 | 26,378 | 6,601 | 8,133 | -$1,532 | $0 |
| 8 | 27,881 | 8,365 | 5,841 | $2,525 | $2,525 |
| **Total** | **239,872** | **$74,139** | **$55,436** | **$18,703** | **$20,537** |
| Billing Periods: Pumps 1-4: 8/1/22 – 1/20/23; Pumps 5-8: 8/15/22 – 1/20/23. | | | | | |

Table 12 shows how the total usage was divided between subscription purchases, dynamic price transactions, and the net ex-post kWh over the billing period for customer C-002. The subscription price was higher than the average OAT price for one of the eight pumps.

**Table 12: Comparison of Subscription, Dynamic, and Ex Post Price Paid, AgFIT 1.0, C-002**

| Pump | kWh | Subscription kWh | Dynamic kWh | Ex Post kWh | OAT $/kWh | Subscription $/kWh | Dynamic $/kWh | Ex Post $/kWh |
|---|---|---|---|---|---|---|---|---|
| 1 | 47,059 | 70,825 | -8,996 | -14,768 | $0.31 | $0.22 | $0.41 | $0.39 |
| 2 | 18,724 | 9,386 | 0 | 9,335 | $0.38 | $0.35 | N/A | $0.27 |
| 3 | 37,807 | 51,062 | -149 | -13,103 | $0.31 | $0.26 | $11.51 | $0.22 |
| 4 | 17,424 | 26,273 | -2,664 | -6,182 | $0.31 | $0.30 | $0.40 | $0.20 |
| 5 | 30,708 | 34,951 | -4,750 | 512 | $0.30 | $0.23 | $0.55 | $0.89 |
| 6 | 33,892 | 0 | 207 | 33,685 | $0.32 | N/A | $0.20 | $0.25 |
| 7 | 26,378 | 15,994 | -1,030 | 11,415 | $0.25 | $0.36 | $0.60 | $0.26 |
| 8 | 27,881 | 68,119 | 2,916 | -43,167 | $0.30 | $0.22 | $0.31 | $0.24 |
| Billing Periods: Pumps 1-4: 8/1/22 – 1/20/23; Pumps 5-8: 8/15/22 – 1/20/23. | | | | | | | | |

### *4.1.2 AgFIT 2.0*

Table 13 through Table 17 summarize the OAT and shadow bills during the AgFIT 2.0 period for each customer. Each table includes pump-specific amounts for billing periods that were fully served under AgFIT 2.0.[40] The tables contain the total kWh consumed by the customer, the total OAT and shadow bill dollar amounts, the difference between the

[40] Therefore, billing periods that were partially served under AgFIT 1.0 or when a customer was not completely enrolled in the pilot are excluded.

OAT and shadow bill, and the shadow bill credit (which is the greater of zero and the difference between the OAT and shadow bill).

Table 13 provides the comparison of OAT and shadow bills for each of customer C-001's pumps under the specified AgFIT 2.0 period. The shadow bill was lower than the corresponding OAT bill for eight of the fifteen pumps. The nine pumps that were also on the Pilot during AgFIT 1.0 had an aggregate shadow bill credit of $17,934 during AgFIT 2.0, which is significantly higher than the $4,973 credit during AgFIT 1.0. In contrast, none of the six pumps that only participated during AgFIT 2.0 earned a credit.

**Table 13: OAT vs Shadow Bills, AgFIT 2.0, C-001**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 14,736 | $4,996 | $4,444 | $552 | $552 |
| 2 | 87,454 | $29,552 | $25,059 | $4,493 | $4,493 |
| 3 | 93,686 | $31,475 | $29,360 | $2,115 | $2,115 |
| 4 | 39,828 | $11,633 | $12,143 | -$510 | $0 |
| 5 | 107,523 | $33,342 | $31,672 | $1,670 | $1,670 |
| 6 | 5,323 | $2,829 | $1,512 | $1,317 | $1,317 |
| 7 | 33,346 | $11,008 | $9,960 | $1,048 | $1,048 |
| 8 | 53,726 | $16,453 | $15,994 | $459 | $459 |
| 9 | 54,020 | $20,733 | $14,453 | $6,280 | $6,280 |
| 10 | 87,329 | $27,573 | $29,392 | -$1,819 | $0 |
| 11 | 106,902 | $34,032 | $36,151 | -$2,119 | $0 |
| 12 | 221,065 | $78,940 | $87,629 | -$8,688 | $0 |
| 13 | 258,760 | $74,388 | $86,583 | -$12,195 | $0 |
| 14 | 144,531 | $51,094 | $56,525 | -$5,431 | $0 |
| 15 | 121,526 | $37,469 | $40,962 | -$3,493 | $0 |
| **Total** | **1,429,756** | **$465,516** | **$481,837** | **-$16,321** | **$17,934** |
| Billing Periods: Pumps 1-15: 5/22/23 – 9/19/23. | | | | | |

Table 14 provides the comparison of OAT and shadow bills for each of customer C-002's pumps under the specified AgFIT 2.0 period. The shadow bill was lower than the corresponding OAT bill for four of the eight pumps. The aggregate shadow bill credit was $7,461, which is significantly lower than the $20,537 credit for the same pumps during AgFIT 1.0. For customer C-002, the sum of shadow bills is almost equal to the sum of the OAT bills; this customer only saves money because of the Pilot's shadow bill credit ("best-of billing") methodology.

**Table 14: OAT vs Shadow Bills, AgFIT 2.0, C-002**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 87,653 | $26,812 | $21,719 | $5,093 | $5,093 |
| 2 | 25,932 | $6,035 | $8,708 | -$2,672 | $0 |
| 3 | 76,416 | $25,073 | $23,642 | $1,432 | $1,432 |
| 4 | 32,233 | $9,960 | $10,780 | -$820 | $0 |
| 5 | 70,626 | $22,557 | $21,802 | $755 | $755 |
| 6 | 94,980 | $34,948 | $38,117 | -$3,169 | $0 |
| 7 | 819 | $417 | $236 | $181 | $181 |
| 8 | 68,202 | $22,473 | $23,205 | -$732 | $0 |
| **Total** | **456,862** | **$148,277** | **$148,209** | **$68** | **$7,461** |
| Billing Periods: Pumps 1,2,5: 5/18/23 – 9/17/23; Pumps 3, 4, 6-8: 5/22/23 – 9/19/23. | | | | | |

Table 15 provides the comparison of OAT and shadow bills for each of customer C-003's pumps under the specified AgFIT 2.0 period. The shadow bill was lower than the corresponding OAT bill for five of the seven pumps. Overall, the shadow bills for customer C-003 were only marginally lower than the OAT bills ($104,994 vs. $108,441), but because the "best-of" customer billing method used in the Pilot doesn't charge the shadow bill when it is higher than the OAT bill for each individual pump, C-003 will end up paying only $98,701 (the $108,441 OAT bill minus the $9,740 shadow billing credit).

**Table 15: OAT vs Shadow Bills, AgFIT 2.0, C-003**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 144,453 | $38,501 | $44,216 | -$5,715 | $0 |
| 2 | 16,155 | $7,723 | $4,464 | $3,259 | $3,259 |
| 3 | 115,244 | $38,275 | $35,038 | $3,237 | $3,237 |
| 4 | 4,942 | $1,938 | $1,273 | $665 | $665 |
| 5 | 19,367 | $8,454 | $6,501 | $1,953 | $1,953 |
| 6 | 21,158 | $7,320 | $6,694 | $626 | $626 |
| 7 | 21,578 | $6,230 | $6,808 | -$578 | $0 |
| **Total** | **342,897** | **$108,441** | **$104,994** | **$3,447** | **$9,740** |
| Billing Periods: Pumps 1-5: 5/10/23 – 9/7/23; Pumps 6-7: 8/9/23 – 9/7/23. | | | | | |

Table 16 provides the comparison of OAT and shadow bills for customer C-004's pump under the specified AgFIT 2.0 period. The shadow bill was $1,427 lower than the corresponding OAT bill for the single pump.

**Table 16: OAT vs Shadow Bills, AgFIT 2.0, C-004**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 4,231 | $2,163 | $736 | $1,427 | $1,427 |
| Billing Period: 8/24/23 – 9/24/23. | | | | | |

Table 17 provides the comparison of OAT and shadow bills for each of customer C-005's pumps under the specified AgFIT 2.0 period. The shadow bill was lower than the corresponding OAT bill for both pumps, with a combined shadow bill credit of $2,466.

**Table 17: OAT vs Shadow Bills, AgFIT 2.0, C-005**

| Pump | kWh | OAT Bill | Shadow Bill | OAT – Shadow Bill | Shadow Billing Credit |
|---|---|---|---|---|---|
| 1 | 2,923 | $2,143 | $1,145 | $999 | $999 |
| 2 | 24,454 | $8,027 | $6,561 | $1,467 | $1,467 |
| **Total** | **27,377** | **$10,171** | **$7,705** | **$2,466** | **$2,466** |
| Billing Periods: Pump 1: 6/26/23 – 9/24/23; Pump 2: 6/30/23 – 9/28/23. | | | | | |

Under AgFIT 2.0, some of the pumps show large differences between the average price paid under the OAT and shadow bills. For example, customer C-003's pump 2 shown in Table 15 has an OAT average price of $0.48 per kWh while its shadow bill averages $0.28 per kWh. Recall that AgFIT 2.0's pricing method scales the dynamic tenders to an OAT price level and there is no separate subscription (as in AgFIT 1.0). However, the OAT bills shown in these tables reflect the customer's current usage billed at its OAT rates while the class-average OAT price paid is used to scale dynamic tenders. Large differences between the OAT and shadow bills may simply reflect differences between the customer's load profile and the class average profile.

# 5 COST RECOVERY

The Decision requires an evaluation of the recovery of generation, resource adequacy (RA), and delivery costs by the Pilot rates. Stakeholder comments during the proceeding reflect concern that the Pilot could shift costs to other service classes. There is particular concern about the scarcity pricing concept used to allocate generation capacity, flexible capacity, and distribution capacity costs to hourly prices.[41]

One theory of dynamic pricing pilots is that the providers and customers can both win if load impacts produce changes in customer bills that are closely related to changes in avoided costs. For example, customers reducing usage during an hour with high CAISO LMPs will pay less on their bill and reduce generation costs for its load serving entity (LSE). However, AgFIT embeds a disconnect between the changes in bills and changes in

[41] E.g., Public Advocate's Office Opening Comments to the Proposed Phase 2 Decision at page 9, November 10, 2021.

energy costs because VCE uses the PG&E load profile for CAISO settlement. An example will illustrate the issue. An AgFIT customer that reduces its usage by 100 kWh when the CAISO LMP is $1,000/MWh ($1 per kWh) will reduce its bill by the amount of the LMP plus the other factors included in the AgFIT dynamic price. However, VCE's wholesale power costs will not be reduced by $1/kWh times 100 kWh because the 100 kWh reduction will be "spread" across all hours of the PG&E settlement profile (in proportion to the usage by hour in that profile). The reduction in VCE's CAISO energy costs will therefore be 100 kWh times the day's load weighted average LMP (where the load weights come from PG&E's settlement profile). As a result, in this example VCE will pay the customer more for its load reduction than it receives in energy cost savings from CAISO.[42]

Our understanding is that the use of PG&E's settlement profile is a common practice among Community Choice Aggregators (CCAs) such as VCE because PG&E's profile is less variable due to the large number of customers included in it. That is, using PG&E's settlement profile is perceived to be less risky for the CCAs. However, if dynamic pricing programs are going to scale to a significant share of a CCA's load, it seems that the settlement disconnect will need to be addressed.[43] Note that this settlement "mismatch" concern is not applicable to the capacity component of the dynamic prices.

Aside from that issue, the AgFIT 1.0 method would appear to produce prices that recover generation and delivery costs if the customer's actual load closely matches its subscription quantity.[44] That is, the subscription component prices the customer's historical usage level and profile at OAT rates. However, deviations from that level are priced using marginal energy costs (i.e., CAISO LMPs) and methods that allocate fixed capacity-related and other fixed costs to hours in proportion to their system net loads. When a customer changes their load under AgFIT 1.0, they therefore save based on marginal costs (which are also reduced for the Load Serving Entity, apart from the settlement profile issue discussed above). But the customer also saves on non-marginal costs, whereas the LSE doesn't see reduced non-marginal costs. Therefore, under AgFIT 1.0, customers that shift or reduce load significantly could shift some non-marginal costs to other customers. This may be mitigated when the pricing methods are recalibrated (perhaps annually) to recover sufficient revenues to cover costs.

The escalator method used in AgFIT 1.0 also had a potential problem in allocating revenue to PG&E vs. VCE. That is, the escalation factor method described in Section 2 (that translated 2022 OAT bills into 2023 price levels) implicitly assumed that the PG&E and VCE components of the bill would escalate at the same rate and that customers did

[42] Note that the ability of the Pilot to show prices in all 24 hours aligns with the CPUC's Slice of Day (SOD) RA structure that is scheduled to be implemented in 2025. The ability of VCE to incent customers to shift out of future high-priced overnight hours and reduce its RA buy during those hours could address the current energy-only savings calculations described above.

[43] The TeMix transactive platform used for this pilot can sum the forward transactions across all of a CCA's participants in CalFUSE so that as participation scales to a significant share of a CCA's load, the CCA can self-schedule and settle with the CAISO.

[44] For the two customers enrolled during AgFIT 1.0, there tended to be significant differences between the subscription kWh and the Pilot-year observed kWh at the pump level (as shown in the billing summary tables), but the aggregate difference across all pumps was lower (28 percent for customer C-001 and 15 percent for customer C-002). Some of this difference could be due to crop rotation, which may cause usage to shift across pumps from year to year.

not change their OAT rate from 2022 to 2023. However, this will not necessarily be the case for any one customer. For example, because the all-hours demand charge (versus the peak-period demand charge) is part of the distribution bill but not the generation bill, a customer with high all-hours demand relative to its other bill components could have a different PG&E bill impact than VCE bill impact as tariff rates change. This issue was not addressed by PG&E and VCE before August 1, 2022, but can be corrected by pricing each customer's historical loads at current OAT rates when creating subscription prices.

The AgFIT 2.0 pricing method introduces an additional complication, in that the dynamic tenders are adjusted to reflect OAT rate levels. That is, the flat $/kWh adder that is applied to all hours in a week to adjust the tenders so they match the OAT rate level drives a wedge between the dynamic price and the avoided costs they are intended to represent.[45] When dynamic prices are low relative to OAT levels, customer load reductions will be overcompensated relative to their avoided costs, all else equal. This concern is somewhat offset by the fact that all dynamic prices are adjusted to reflect OAT levels, so the overall bill level should also be reflective of OAT rates, which would seem to limit the possibility of under-recovery from the participating customers. In addition, the price differentials between hours in the same day (e.g., peak to off-peak) are not affected by the adjustment process; moving one kWh from peak to off-peak has the same impact – equal to the difference in marginal costs – before and after the adjustment process. The shadow bill impact of shifting load from one day to another within the same week is similar before and after the adjustment process, but not identical as the weekly averaging will be over different days.

# 6 PARTICIPANT AND STAKEHOLDER COMMENTS

<u>Participant Interviews</u>

Polaris provided us with video interviews of the two customers enrolled during AgFIT 1.0, customers C-001 and C-002. The interviews took place on December 15, 2022; therefore, the discussions focused on usage differences in 2022 versus 2021 due to installed automation technology more than due to dynamic pricing. There was only a limited period when customers were actively pumping and under AgFIT 1.0 pricing. Nevertheless, we summarize parts of the interview here since it provided insights into views regarding technology as well as factors that affect pumping behavior.

Customer C-001 had nine pumps installed during the AgFIT 1.0 summer period. While reviewing reductions during the TOU peak period for the months May through September in 2022, customer C-001 mentioned that the automation technology was the biggest factor contributing to the reduction. Higher prices were also a factor but not as much as the automation because by that point they had only received prices for a short period of time (August and September 2022) for a few of their pumps. Before having automation technology installed, customer C-001 knew when the TOU peak period was; however, it was difficult to avoid the peak period because it required sending out an employee to

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[45] Under AgFIT 2.0, the adjusted dynamic prices were almost always higher than the marginal-cost based tenders. On average, the adder applied to adjust the hourly prices to the OAT price level was 16 cents/kWh.

shut off the pump at the beginning and turn it back on at the end. Labor availability and additional overtime costs thus increased the costs to avoid the peak period.

During the interview, customer C-001 discussed pumping less in 2022 than the previous year. They indicated that the amount of surface water wasn't the cause of the difference, but crop rotation was. For example, the amount of TOU response is dependent on the crop type because specific crops need more water; therefore, the pump's response to TOU pricing is not as steep. In discussing the upcoming year (2023 at the time), customer C-001 indicated that the coming year's crops would require more irrigation. The anticipated higher pumping demands in 2023 may be a reason for the differences in the high- versus low-priced days response between AgFIT 1.0 and 2.0 (compare Figure 22 with Figure 25).

Customer C-002 had eight pumps on the Pilot during the 2022 period. Customer C-002 indicated that in 2021, before installing automation technology, they would run their pumps regardless of the TOU peak period because of the labor challenges associated with changing employees in and out. In general pump usage was less in 2022 than in 2021 but there was also a TOU peak period reduction because of the automation. Customer C-002 suggested that the reduced usage in 2022 was due to having more control over when pumping was dispatched.[46] The automation technology allowed the ability to track pumps without having to send laborers out to the locations. This ability helped reduce errors due to not knowing whether the pump was incorrectly on/off.

Similar to the customer C-001 interview, customer C-002 indicated that the automation technology was convenient for employees to not have to go out there to turn pumps on/off. TOU without automation was inconvenient and not worth the savings to avoid the peak period because of the additional labor costs. Customer C-002 indicated that there can be a negative side to the automation technology, that is, employees can become comfortable with the technology and assume it is working without checking it.

Customer C-002 mentioned some things that were instructive regarding how they respond to dynamic pricing and the platform. First, they indicated that they wanted the scheduling platform to have the ability to view weeks Monday through Sunday to better match their planning period. Second, customer C-002 indicated that while some pumps run all the time, their plan was still to avoid specific high price thresholds (e.g., $0.30/kWh). However, if overall price levels increased, the customer's price threshold would also increase if there was a need to get a certain number of pumping hours – in other words, the price threshold was essentially a way to get the pumps to run during the lowest-priced hours while still pumping the required hours per week. This provides evidence that price thresholds are used by the customer to manage price responsiveness.

<u>VCE Comments</u>

VCE's original concept to use price signals to help customers shift agricultural load has shown encouraging results. Given the opportunity, ability, and support needed to respond to market-based price signals, agricultural customers have shown a willingness to do so. Our observations to date indicate that this is appealing to the customer when the signal is

[46] Customer C-002 indicated that crop rotation and surface water levels wouldn't have been the cause of the reduction.

clear, simple, actionable, and support is provided by trusted partners. It is VCE's opinion that it is the role of the AgFIT team (VCE, consultants, PG&E, regulatory agencies) to translate the complexity of dynamic pricing to the customer to incent mutually beneficial outcomes for the customer, LSE/IOU, and the grid. Based on mid-term results, VCE makes two high-level observations: (1) agricultural customers are willing to respond to market based dynamic pricing, and (2) further calibration of the rate design is necessary to achieve durable results.

In general, we would encourage policy makers to consider the assumptions that were made in designing the Pilot, as represented in the regulatory filings and in developing the program. It is, of course, important to measure results (mid-term and final), but it is also important to identify where they meet and diverge from expectations.

More detailed comments/observations include:

- Throughout implementation of the pilot, there has been tension between recovering the "correct" amount of revenue and calibrating pricing to provide predictable bill savings for any given level of response. Just as TOU rates do not guarantee precisely correct revenue recovery, VCE believes that dynamic rates should first deliver load shift and customer savings—which help the grid and spur wider adoption–and then be calibrated and adjusted over time.
- There are a wide variety of customer behaviors, non-energy costs and benefits, etc. that influenced program design– we believe that these can be accounted for through rate design calibration.
- Automation is one key to responding to price signals and there is usage evidence that indicates similar response to TOU vs. dynamic pricing. However, we would like to emphasize the significant impact of the customer engagement element to the AgFIT formula, which was a catalyst of formation of the program. As observed by VCE's consultants, automation incentives and TOU savings have been available for years and yet most of these customers had not taken advantage of them until engaged and coached on the utility and use of the tools.
- 'Price type days' - it should be noted that these results align closely with the hypothesis that once customers are responding, they will choose the least expensive schedule that meets their operational needs without radically changing operating practices (e.g., multiple start/stops in a week). We did not necessarily expect significantly greater response on more expensive days because many factors affect customer usage levels. For example, customers may have needed to pump on the high-priced day, or the prices on the "low-priced" day may have been high enough to elicit customer response.
- Similarly, the goal of the program was to provide savings correlated with shift (as measured by the % of load in the peak-period hours vs. before the program). There is evidence in Table 4 that the peak-period usage share is reduced during the Pilot. It would be informative to incorporate that change in the bill comparisons.
- The role of customer engagement/support/success should be evaluated since it is a critical component to the success of the program. This can be

accomplished via customer interviews conducted after the growing season. Customer education and coaching has a strong influence on how customers perceive the pilot tariff and we have seen them willing to respond (up to a point), even before rate costs were available. In addition, we should note that customer participation in 2023 took place in the absence of expected results (shadow bills and incentive payments) from 2022. It cannot and should not be assumed that only quantitative factors (prices and irrigation requirements) drive customer response.

Additionally, CA Energy Consulting conducted a "learnings to date" call on February 24, 2023, which is summarized below:

VCE and Polaris were interviewed to obtain their thoughts on the early stages of the pilot. They focused on selecting early adopters with a high profile in the farming community because success with those customers could help spread the word about the benefits of the pilot. They noted that many agricultural customers are hesitant to adopt changes as large as the AgFIT pilot entailed, so an endorsement for their community would be valuable.

VCE emphasized the need to "meet the customers where they are", meaning that pilot success depended on accommodating customer preferences and behaviors to the extent practicable. Accommodating the planning schedule of customer C-002 is an example of this.

<u>Polaris Comments</u>

1. We are pleased to see demonstrated load shift in this pilot. It is important to note that customer support has proven critical in delivering load shift in each "transitional" phase of the program:

    a. Time-of-use without automation
    b. Time-of-use with automation
    c. Dynamic rates with automation

    Participants in AgFIT received high touch training and support across each of these phases, and we believe that it has proven to be potentially as impactful as automation and price signals in encouraging load shift.

2. Ideas about how to improve the communication of energy bill savings to farmers beyond the "monthly bill impacts of the pilot dynamic rate in comparison to a customer's otherwise applicable tariff (OAT)," as specified in the Decision, should be further developed. We believe that it is important to provide energy bill savings that correlate with the value of load shifting, and the evaluation (as well as anecdotal evidence from the field) points to instances where comparisons of shadow bill savings versus the OAT wouldn't make this value clear to farmers.

3. From an aggregate level, the pilot appears to be on track to deliver promising results in terms of energy bill savings for farmers based on the program

outcomes data that is currently under review. There are near-term opportunities to refine the program calibration and deliver even more positive results on top of what's been achieved to date. These include:

a. Continued exploration of nuances at the service account level (the main area of concern for farmers – in this case, individual pumps) in order to better handle months with low or no usage.
b. Refining 7-day price forecasting so that the forecasted prices are more representative of what the day-ahead and day-of prices are likely to reflect near the hour of consumption.
c. Making sure price signals are strong enough to incentivize desired load shift behavior.

<u>TeMix Comments</u>

TeMix is pleased with the accomplishments of the entire VCE, PG&E, Polaris, and TeMix AgFIT team in the first two years of this pilot. The response of the customers to highly dynamic forward binding prices is clearly demonstrated even as we seek to improve the systems and processes the team has deployed.

Recalibration of the pricing formulas is necessary for 2024:

- The Decision requires the use of scarcity pricing for the pilot.[47]
- Calibration of the scarcity pricing functions needs the best available data.
- Both the two-part and one-part models need the same calibrated scarcity pricing models.

The two-part subscription and dynamic pricing method in 2022 was paused to experiment with a one-part dynamic price averaging method for 2023, with the decision between one-part and two-part price to be reviewed for 2024. The considerations for this 2024 decision review include:

- For the two customers that participated on both the two-part and one-part price methods, the two-part method showed substantially higher percentage credits (see Table 8). When examining pump-specific bill impacts for these customers, there are fewer cases where the credits are very negative, but for the "best-of" bill limiters. (I.e, comparing Table 9 and Table 13 for customer C-001 and Table 11 and Table 14 for customer C-002.)
- One-part pricing introduced new issues in selecting the average reference prices.
- Two-part pricing was deployed for August and September of 2022 for two customers with 17 pumps and 850 kW of capacity. The one-part pricing was deployed for at least five months from May 1, 2023, to October 2023 for five customers with 33 pumps and 1,844 kW of capacity. The two-part pricing clearly needs more pilot time to achieve the objectives of this pilot.
- The two-part pricing can be improved with modest changes to the subscription price and quantity calibration.
- The infrastructure for the two-part pricing is still in place with all six steps of the CalFUSE vision and has been operating the background providing the tender

[47] CPUC Decision 21-12-015, Attachment 1, p. 8

prices to Polaris and recording the transactions during the operation of the one-part pricing in 2023.

- The one-part pricing was primarily for week-ahead pricing and is not widely applicable.
- We need to address both the effect of demand charges on subscriptions and demand charges on the OAT used to compute credits.

There are several issues needing deeper discussion, such as the interpretation of scarcity pricing and its effect on price response, customer and utility investments, and cost recovery. Scarcity pricing can best deal with extreme loads where there is no more supply, and the response and price is the result of some customers being willing to use less so that others can use more. At the same time, subscriptions provide for relatively stable bills and supplier cost recovery and equity among customers.

TeMix looks forward to the successful completion of this pilot and its extension and expansion and the deployment of CalFUSE as an opt-in tariff without shadow billing for all customers.

# 7 SUMMARY AND CONCLUSIONS

Customers began taking service on the AgFIT Pilot in August 2022. Two customers were participating during the 2022 growing season, which ended in September 2022. Three additional customers joined the Pilot by the time the 2023 growing season arrived. An important caveat to this mid-term evaluation is that the analyses are based on a small sample of customers. It is not clear whether or how the load and bill impact findings would generalize to a larger sample of customers.

That said, we believe some important lessons have been learned thus far that may help guide the Pilot going forward.

<u>Automation helps agricultural pumping customers respond to all price signals.</u>

The technology includes the MyPolaris interface that allows Pilot participants to schedule pump usage for up to a week in advance, transacting at the dynamic price tenders at the time of scheduling. Based on customer interviews and the quantitative evidence, the automation introduced in AgFIT (along with the Pilot's customer education and engagement efforts) enables participants to respond to price signals in a way they had not previously done. We have a limited sample of data indicating TOU response prior to the introduction of dynamic pricing, and additional evidence of response to dynamic prices in one form or another. There is more to be learned about the best pricing method to combine with the automation to elicit the most (and most economically beneficial) load response from agricultural pumping customers.

<u>Pilot participants reduced their share of usage during the peak pricing period (5 to 8 p.m.) relative to pre-Pilot levels.</u>

Two of the five participants reduced the peak usage share by half, while another two reduced the peak share to nearly zero. In some of these cases, the peak share reduction was accompanied by significant reductions in overall usage, which may reflect a change in overall pumping needs rather than a Pilot response.

<u>There is mixed evidence that the Pilot customers responded to dynamic price differences across days.</u>

Under AgFIT 1.0, one of the two customers responded differently to the set of high-priced days compared to a similar set of low-priced days. Under AgFIT 2.0, one of five customers responded differently on the high-price days, while three of the five customers responded to the daily average price profile (i.e., using less during hours that tended to have the highest prices, but not necessarily differentiating across days with different price levels). Additional pilot experience and customer interviews will provide information to better understand whether and how customers respond to dynamic prices. For example, the amount of shifting a customer can do may be limited by the need to pump enough to satisfy the irrigation needs for a day, and the needs on high-price and low-price days may be similar.

<u>It has been difficult to find an appropriate method for anchoring AgFIT bills to OAT revenue recovery levels.</u>

Under AgFIT 1.0, subscription pricing was used to ensure that OAT-level revenues were recovered for the customer's historical load profile. In theory this method works well and has been applied elsewhere, but the unpredictable loads of agricultural pumping customers presented challenges. If the historical year used to price the subscription had an unusually poor load factor (possibly because of crop rotation), the customer's shadow bill would reflect something akin to a 100 percent, 12-month demand ratchet for that month, which may make it difficult to realize Pilot savings that are as high as customers could obtain by improving their load factor under the OAT.[48] Conversely, a customer with a subscription priced based on an unusually high load factor would be more likely to realize Pilot savings, perhaps even in the absence of a response to the dynamic prices.

AgFIT 2.0 attempted to solve this problem by adopting a one-part pricing method that removed the subscription pricing element and in exchange adjusted the dynamic prices to reflect OAT price levels. However, this change traded one problem for another closely related problem: selecting the OAT price level to be used for the price adjustment. The selection of the PG&E seasonal class-average price paid by rate schedule ensured that customers with less favorable load profiles than average would be "instant winners" (i.e., their overall price level was scaled to a level they would not receive based on their own load profile), while those with more favorable load profiles than average would be "instant losers."

[48] Under a demand ratchet, the customer's billing demand is a function of both its demand in the current month and that of previous months. For example, a tariff might read "the billing demand shall be the greater of the 15-minute maximum demand in the current month or 50 percent of the highest billed demand in the previous 11 months." While demand ratchets can be effective at recovering fixed costs, customers tend to dislike them due to the potential long-term bill impacts associated with a single high-demand hour (or sub-hourly period). Note that we introduce the concept here for illustrative purpose and not because it's a feature of pilot participant bills.

VCE's CAISO settlement method creates a mismatch between changes in customer bills and changes in VCE's energy costs.

While the dynamic prices appear to provide incentives to reduce both customer bills and VCE *capacity* costs, there is a disconnect between the dynamic prices paid to customers and the marginal *energy* costs for VCE. That is, because VCE's CAISO settlement is based on PG&E's load profile, using dynamic pricing to induce customers to use less during the costliest hours is unlikely to result in corresponding energy cost savings for VCE. For example, a customer's usage reduction of 100 kWh during a single hour will translate to the CAISO settlement load as a 100 kWh reduction spread across all hours of the day (in proportion to PG&E's load profile). The revenue and energy cost implications of this disconnect are probably not significant during a small pilot program but may present issues as dynamic pricing scales to higher participation levels. Another issue that will become significant at higher participation levels is that the AgFIT 1.0 non-marginal price scaling can result in customers saving more than VCE or PG&E save when they shift load from high-priced to low-priced hours.

The shadow bill credit method gives customers a strong incentive to continue to respond to OAT price signals while participating in AgFIT.

While on AgFIT, the customer pays its current OAT bill and will receive a credit each year if the sum of its OAT bills is greater than the sum of its shadow (Pilot) bills. However, those OAT bills may be higher than their pre-Pilot OAT bills if the customers stop managing their billed demand and instead focus on the dynamic prices. Therefore, the presence or absence of an AgFIT credit is not necessarily indicative of whether the customer benefited from Pilot participation. A customer who used the automation technology to reduce their OAT bill would receive that benefit in the current month's bill and could further benefit by trying to respond to dynamic prices to earn an AgFIT credit, provided the response did not conflict with the incentives embedded in the OAT rates. In other words, a profit-maximizing customer may focus mostly on its OAT bill, which could reduce dynamic load response compared to what the customer would have done in the absence of the shadow bill credit methodology.

## APPENDIX

**Table A.1: Regression Model Statistics**

| Customer | Period | Model | Coef | P-Value | N | $R^2$ |
|---|---|---|---|---|---|---|
| C-001 | AgFIT 1.0 | Without Hour FE | -0.129 | (0.072) | 9,154 | 0.318 |
| | | With Hour FE | -0.010 | (0.673) | 9,154 | 0.337 |
| | AgFIT 2.0 | Without Hour FE | -0.195* | (0.034) | 52,200 | 0.363 |
| | | With Hour FE | 0.033 | (0.654) | 52,200 | 0.368 |
| C-002 | AgFIT 1.0 | Without Hour FE | -0.219* | (0.025) | 8,530 | 0.206 |
| | | With Hour FE | -0.123* | (0.048) | 8,530 | 0.212 |
| | AgFIT 2.0 | Without Hour FE | -0.153 | (0.342) | 29,376 | 0.212 |
| | | With Hour FE | 0.028 | (0.723) | 29,376 | 0.214 |
| C-003 | AgFIT 1.0 | Without Hour FE | N/A | N/A | N/A | N/A |
| | | With Hour FE | N/A | N/A | N/A | N/A |
| | AgFIT 2.0 | Without Hour FE | -0.380* | (0.010) | 22,104 | 0.263 |
| | | With Hour FE | -0.090 | (0.103) | 22,104 | 0.306 |
| C-004 | AgFIT 1.0 | Without Hour FE | N/A | N/A | N/A | N/A |
| | | With Hour FE | N/A | N/A | N/A | N/A |
| | AgFIT 2.0 | Without Hour FE | -0.816** | (0.000) | 1,440 | 0.180 |
| | | With Hour FE | -0.351** | (0.000) | 1,440 | 0.393 |
| C-005 | AgFIT 1.0 | Without Hour FE | N/A | N/A | N/A | N/A |
| | | With Hour FE | N/A | N/A | N/A | N/A |
| | AgFIT 2.0 | Without Hour FE | -0.397 | (0.325) | 5,760 | 0.134 |
| | | With Hour FE | -0.295 | (0.115) | 5,760 | 0.172 |

p-values in parentheses, ** p <0.01, * p<0.05