California ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

ENERGY RESEARCH AND DEVELOPMENT DIVISION

FINAL PROJECT REPORT

Permanent Load Shifting to Increase Grid Stability and to Reduce the Cost of Agricultural Water in California

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We want to recognize the dedication of the educators at California State University, Fresno, including Bill Green, and at West Hills College Coalinga, including Terry Brase, for helping the project during the COVID-19 pandemic. They provided online classes and helped the growers and students.

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency; renewable energy and advanced clean generation; energy-related environmental protection; transportation; and energy transmission and distribution.

In 2011, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The EPIC Program is funded by California utility customers under the auspices of the California Public Utilities Commission. The CEC and the state's three largest investor-owned electric utilities — Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company — were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs to promote greater reliability, affordability, and safety for California electric ratepayers. EPIC investments advance these values by:

- Providing societal benefits.
- Reducing greenhouse gas emissions in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs, first with energy efficiency and demand response, next with renewable energy (distributed generation and utility-scale projects), and finally with a clean electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

Permanent Load Shifting to Increase Grid Stability and to Reduce the Cost of Agricultural Water in California is the final report for EPC-20-036 conducted by AgMonitor Inc. The information from this project contributes to the CEC Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

Load shifting, which refers to the coordinated, targeted modification of the timing of power consumption by utility customers to better align with the daily cycles in power generation, has emerged as a primary strategy to address the challenges posed by incorporating large amounts of variable renewable generation resources into the power grid. The project team augmented AgMonitor's existing programmable irrigation software platform – which utilizes Smart Meter data to provide water, energy, fertilizer, and crop management tools to farms – by adding a feature that enables growers to shift large electrical loads for agricultural water pumping outside of peak demand hours without adversely affecting farming operations.

Over 3 megawatts were shifted from peak demand hours in the summer of 2021 and over 10 megawatts in the summers of 2022 and 2023 across more than 100 power meters covering 18,500 acres of croplands. Summer savings of $50 per acre or $75 per kilowatt of pump load were achieved consistently. The project accounted for 1 percent of the total power load shed statewide during the Governor's declared emergency event on September 6 during the summer of 2022. The grid was under extreme strain at the onset of the wildfire season that coincided with a heat wave and high winds.

The project also demonstrated that diverting flood waters for groundwater recharge can shift the energy load of well pumps from dry to wet years by restoring the level of the water table.

Applying permanent load shifting programs to farms covered by Pacific Gas and Electric Company and Southern California Edison Company territories, which include over 5 million acres of irrigated land, has the potential to shift 1500 megawatts of power load from peak demand periods. Benefits include greater grid stability during the critical summer season, the ability to incorporate more renewable resources into California's energy portfolio, reduction of greenhouse gas emissions, and lower energy costs for ratepayers.

Keywords: permanent load shifting, crop management tools, farm irrigation software, Smart Meter data

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EXECUTIVE SUMMARY

Background

The Clean Energy and Pollution Reduction Act (Senate Bill 350) established goals for reducing greenhouse gas emissions to 40 percent below 1990 levels by 2030 and to 80 percent below 1990 levels by 2050. Senate Bill 100 increased the targets of the California Renewables Portfolio Standard to require 60 percent of electricity retail sales to be served by renewable resources by 2030 and for 100 percent of the state's electricity to come from carbon-free resources by 2045. This must be achieved within the overarching mandates of the California Independent System Operator, the California Public Utility Commission, and the California Energy Commission to ensure a safe and reliable supply of power to all Californians under changing climate conditions, which are expected to produce more frequent extreme weather events.

To achieve these goals, large amounts of new renewable energy generation must be brought online while maintaining the stability of the state's power grid. This presents significant challenges due to the variable nature of solar power generation, which is the predominant source of renewable energy in many areas. Load shifting, which refers to the coordinated, targeted modification of the timing of power consumption by utility customers to better align with the daily cycles in power generation, has emerged as a primary strategy to address these challenges. Existing incentives provide customers with the means to utilize more power during periods of surplus renewable generation and reduce power utilization during periods of scarcity in renewable generation. While load shifting in agriculture is not a new idea, adoption by farmers has been limited due to concerns about the cost and complexity of implementation, the need for confidence that changing their irrigation practices will not put their crops at risk, and a lack of clear understanding of the savings they can achieve in their utility bills.

Project Purpose and Approach

The project's objective was to augment AgMonitor's existing programmable irrigation software platform – which utilizes Smart Meter data to provide water, energy, fertilizer, and crop management tools to farms – by adding a feature that enables growers to shift large electrical loads for agricultural water pumping outside of peak demand hours without adversely affecting farming operations. The expanded software platform helps growers to set irrigation schedules that avoid peak demand hours and to visualize the corresponding savings in their power costs.

The target market for this technology consisted of the farms in the region served by investor-owned utilities, which represent 5 million acres of irrigated land and approximately 3,000 megawatts (MW) in power load. Benefits resulting from the successful implementation of the project include greater grid stability during the critical summer season, the ability to incorporate more renewable resources into California's energy portfolio, reduction of greenhouse gas emissions, and lower energy costs for agricultural ratepayers.

The goals of the project were to apply the technology to at least 10,000 acres of farmland and achieve at least 7 MW of load shifting over the two-year duration of the project, with at least 3

MW of load shifting achieved by August 1, 2021, at farms with which the project team had existing relationships. The project's success was assessed using the following set of specific quantifiable metrics for the farm sites enrolled in the program:

- Percentages of energy use that occurred during peak demand hours and off-peak hours
- Amount of load shifted consistently outside of peak demand hours
- Precision in following manual and automated irrigation plans (comparison of actual pumping hours to scheduled pumping hours)
- Post-savings in terms of dollar per acre of farmland covered by the technology and dollars per kilowatt (kW) of pump capacity

Key Results

Enrolling Farms in the Load Shifting Program

By the end of the project, there were 148 active power meters in the program across 16 sites in 11 counties that covered 18,500 acres of croplands. The project team recommends that growers begin implementing new irrigation schedules in May, before peak demand penalties in the summer months start.

Measurement and Verification

Load shifting programs quantify the amount of load shifted consistently from peak demand hours daily. The project team developed a measure of load shifting based on the difference between a farm's maximum power load during a defined window of peak demand hours and the maximum power load that occurred at any time during the billing month. This is an indicator of how successfully a utility customer avoided high rates and penalties associated with power use during peak demand periods. This metric was used to assess the project's load shifting goals and included it in the new software feature to give farmers a clear, simple measure of the cost savings they could achieve by turning their irrigation pumps off during peak demand hours and making up for it by running the pumps at all other times.

Load Shifting Summary

In 2021, a limited number of sites were enrolled because the project did not start until spring 2021 and had limited time to promote the new program. The project team was still able to meet its initial target of 3 MW of load shifting during the summer months.

In 2022, the project team initially attained 8 MW of load shifting, which then reached over 10 MW after human and equipment errors were analyzed and more power meters were enrolled in the program. Peak drought conditions were present in September 2022, and the wildfire season began with extreme temperatures and high winds, which placed exceptionally high stress on the grid. During the emergency event declared by Governor Newsom on September 6, 2022, to avoid widespread power shutoffs, the load shifting from the program was around 5.3 MW, which represented 1 percent of the total load reduction achieved statewide. Our load shifting was relatively low on that day because some of the customers did not operate their

pumps at all during the crisis event. During the rest of the month of September, the project consistently shifted 10 MW of load during peak demand hours.

The year 2023 was a wet year that presented a very different set of circumstances. Exceptional rainfall during the spring led to farms receiving 100 percent of surface water allocations, resulting in most well pumps not being used. Consequently, a similar amount of load shifting was achieved in 2023 as in 2022 (10 to 11 MW), even though more power meters were registered. At one of the project sites, the team documented recharge of the aquifer with over 18,000 acre-feet of diverted flood waters. This restored the level of the water table in July 2023 to where it had been in July 2019. It was estimated that restoring the water table to its pre-drought level would result in the ranch reducing its energy consumed for groundwater pumping by 1000 megawatt-hours and saving $200,000 on its electricity bill per year. The savings occur because the energy required to pump groundwater is a function of how far the pump must lift the water — a higher water table means less vertical distance (lift), and therefore lower energy use per unit of water pumped.

Attainment of Project Metrics

AgMonitor met or exceeded all the objectives defined for the Permanent Load Shifting (PLS) project (see Table 1).

Table 1: Results of PLS Project Against Performance Metrics

Performance Metric	Bench-mark	Current	Low Target	High Target	Evaluation Method	Significance of Metric
Percentage of irrigation during off-peak hours	89%	96%	98%	100%	Analysis of Smart Meter data	Reduction of energy during ramp-up period when sun sets
Amount of load shifted	1 MW	11 MW	7 MW	10 MW	Max Peak Demand* during peak hours subtracted from Max Demand** during month	Amount of load shifted (kW) and persistence of reductions to strain on grid
Precision in following irrigation plan (manual)	70%	80%	85%	90%	Comparison of actual pump hours to scheduled hours of irrigation	Improvement of temporal resolution to increase water use efficiency and reduce peak power load
Precision in following irrigation plan (automated)	80%	90%	95%	100%	Comparison of actual pump hours to scheduled hours of irrigation	Improvement of temporal resolution to increase water use efficiency and reduce peak power load
Cost savings ($/acre)	$30	$50	$40	$70	Analysis of utility bills	Cost savings to farmers

Performance Metric	Bench-mark	Current	Low Target	High Target	Evaluation Method	Significance of Metric
Cost savings ($/kW)	$40	$75	$50	$90	Analysis of utility bills	Cost savings to farmers

*The maximum power load during peak demand hours
**The maximum power load that occurred at any time during the billing month

Cost Savings for Farms With and Without Solar Power

It is often confusing for farms to determine their cost savings from load shifting programs for pumps connected to power meters that are part of a Net Energy Metering Aggregation (NEMA) group. AgMonitor worked with three sites that installed solar power generation resources during the course of the project to evaluate the cost savings from participation in load shifting programs with and without the availability of solar power. The addition makes it more complicated because part of the energy savings is already offset by solar generation. However, demand charges remain and load shifting can generate savings. The project team improved the software platform to help farmers with rate recommendations in situations where solar power generation complicates the interplay between offsetting energy charges and demand charges.

Knowledge Transfer and Next Steps

The project team organized classes on energy, irrigation, and load shifting with the Center for Irrigation Technology at California State University, Fresno. These included online webinars offered during the COVID-19 pandemic to reach a wider audience. It also worked with several farms and food processors to engage the community during field day events.

Farms are under a lot of pressure from groundwater use restrictions, new labor regulations, an increase of electricity rates by 40 percent from 2021 to 2023, and an increase in fertilizer costs by 80 percent in the same period. The project team recommends that permanent load shifting be widely deployed in tandem with other energy efficiency measures (installation of variable frequency drives, pump efficiency tests, conversion to micro-irrigation, etc.) and that agricultural rate payers have access to on-bill financial, paying for energy-efficiency upgrades through their monthly utility bills.

At one of the project sites, the project team demonstrated that electrical pumps can be cheaper to operate than diesel pumps in terms of dollar per acre-feet of water if PLS is deployed in conjunction with solar power generation.

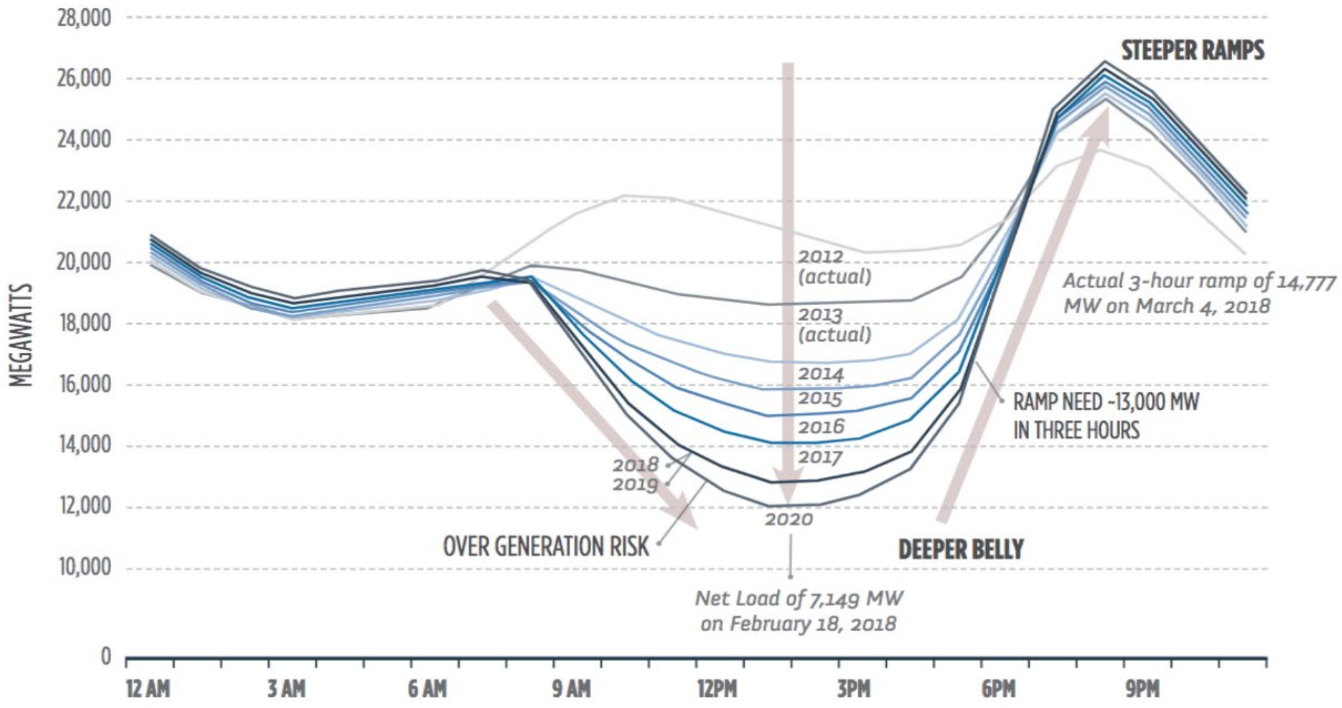
The project team estimates conservatively that applying PLS to half the agricultural load covered by Pacific Gas and Electric Company and Southern California Edison Company territories has the potential to shift 1,500 MW of power load during peak demand hours during droughts. Some farms, and most districts that can release water only in 24-hour intervals, cannot participate. Demand response programs such as Emergency Load Reduction Programs can help for those cases. The project's immediate goal was to manage 500,000 acres of farmland by the end of 2026 and have 100,000 acres enlisted in PLS programs, which would be able to provide at least 60 MW of load shifting during the next drought.

The project also demonstrated that banking water underground not only improves water security but can also shift the energy load for well pumps from dry to wet years by diverting flood waters towards restoration of the water table. The energy and water data collected during the project will help growers and food processors to comply with the new Senate Bill 253 (Climate Corporate Data Accountability Act) and Senate Bill 261 (Climate-Related Financial Risk Act).

CHAPTER 1:
Introduction

In order for California to achieve its goals for greenhouse gas reduction and incorporation of carbon-free resources into its energy portfolio, large amounts of new renewable energy generation must be brought online while maintaining the stability of the state's power grid. This presents significant challenges due to the variable nature of solar power generation, which is the predominant source of renewable energy in many areas. The Independent System Operator (ISO) managing the power grid must respond rapidly to changes in the net electricity load (i.e., total electricity demand from consumers minus the power supplied by renewable generation resources) by adjusting the amount of generation from conventional power facilities (Figure 1). When the net load ramps up as the sun sets and solar generation is lost, the grid can become unstable, leading to rolling blackouts and other power disruptions. Conversely, when the net load drops during the middle of the day in association with maximum solar generation, oversupply and curtailment of renewable generation can occur.

Figure 1: Net Load on the California Power Grid on a Typical Spring Day



Source: California ISO, 2016

Load shifting has emerged as a primary strategy to address the challenges posed by incorporating large amounts of variable renewable generation resources into the power grid. Load shifting refers to the coordinated, targeted modification of the timing of power consumption by utility customers to better align with the daily cycles in power generation. Existing incentives provide customers the means to utilize more power during periods of surplus renewable generation and reduce power utilization during periods of scarcity.

In addition to relieving stress on the grid, this approach can lower energy costs for customers and reduce greenhouse gas emissions by shifting power consumption to periods when more of the total power demand can be met by renewable generation resources. The purpose of this project was to expand AgMonitor's software platform to achieve load shifting in the agricultural sector. AgMonitor's Software as a Service (SaaS) platform was used to help farmers reduce the power demand placed on the grid by their irrigation pumps during net peak demand hours during the critical summer season without adversely affecting farming operations. The goal of the project was to apply the technology to at least 10,000 acres of farmland and to achieve at least 7 megawatts (MW) of load shifting over the duration of the project, with at least 3 MW of load shifting achieved by August 1, 2021, at farms with which the project team had an existing relationship.

Success in attaining the project objectives was assessed by a set of specific quantifiable metrics (Table 2). Benefits of the project include greater grid stability, the ability to incorporate more renewable resources into California's energy portfolio, reduction of greenhouse gas emissions, and lower power costs for agricultural ratepayers.

Table 2: Metrics for Assessing Attainment of Project Objectives

Performance Metric	Bench-mark	Current	Low Target	High Target	Evaluation Method	Significance of Metric
Percentage of irrigation during off-peak hours (manual and automated)	89%	96%	98%	100%	Comparison of meters under PLS program with other meters	Reduction of grid load during ramp-up period when sun sets (5 pm-8 pm)
Maximum peak power during 5 pm-8 pm window	100%	50%	25%	0%	Peak power normalized to max power during month	Transition of irriga-tion from 12 pm-6 pm peak period to 5 pm-8 pm period
Precision in following irrigation plan (manual)	70%	85%	85%	90%	Comparison of actual pump hours vs scheduled hours of irrigation	Improvement of temporal resolution, water use efficiency and reduction of max power
Precision in following irrigation plan (automated)	90%	97%	95%	100%	Comparison of actual pump hours vs scheduled hours of irrigation	Improvement of temporal resolution, water use efficiency and reduction of max power

Source: AgMonitor, follow-on proposal in 2020 to EPIC project EPC-16-051 from 2017 to 2019.
PLS: permanent load shifting

The target market consisted of the farms in the region served by Pacific Gas & Electric Company (PG&E) and Southern California Edison Company (SCE), which represent over 5 million acres of irrigated land and approximately 6 percent of the grid power load. That represents about 3,000 MW in the summer. Demand response and load shifting in agriculture

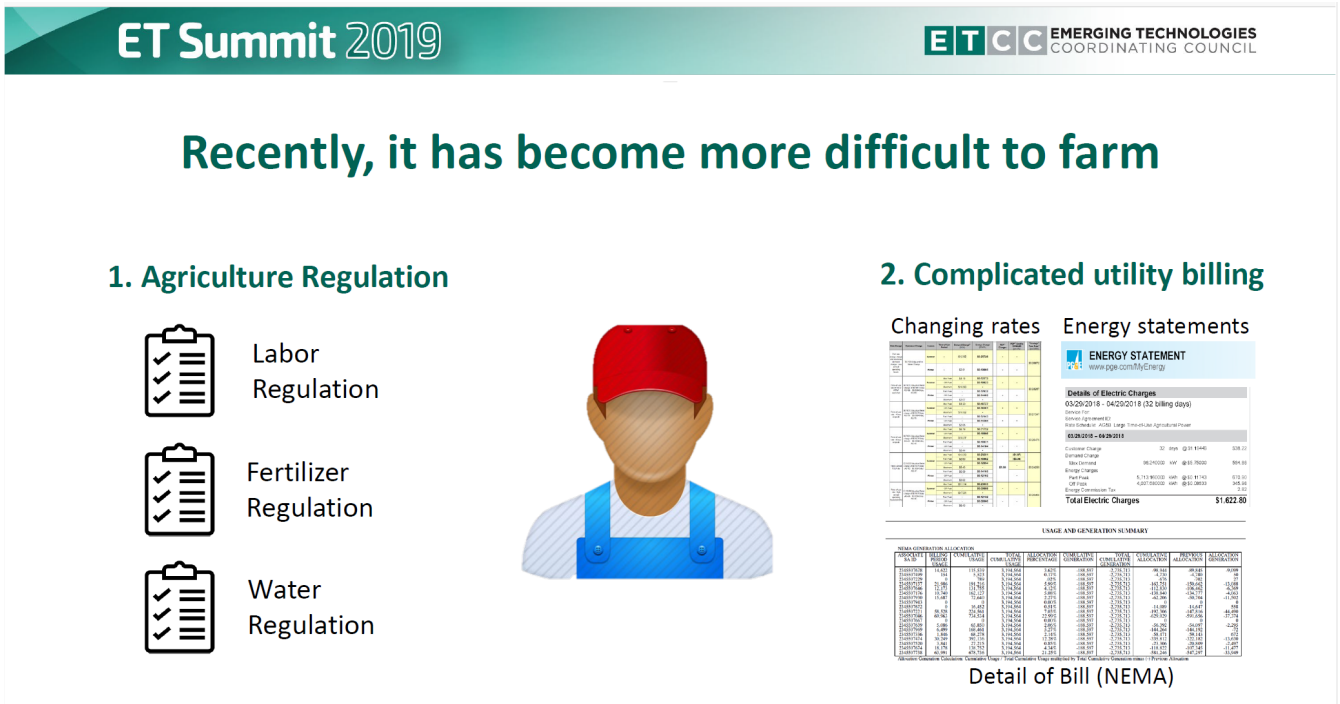
are not new ideas, but adoption has been limited due to three major hurdles that have not been addressed until now: (1) the integration of smart meter data into simple reports that can be used by both the field crew that operates the irrigation system and the accountant who enrolls in the load shifting program; (2) the ability to irrigate off-peak using irrigation scheduling software that can be applied to both manually and automatically controlled systems; and (3) the ability to perform rate recommendation and reporting when on-farm solar generation resources are present.

CHAPTER 2:
Project Approach

Demand response (DR) and permanent load shifting (PLS) are strategies (Marks et al. 2013) that have been applied to reducing power consumption for water conveyance in the agricultural sector during peak demand times. DR programs are actively managed by power suppliers, who provide customers with relatively short notice of an anticipated critical event (e.g., the afternoon of a day during a summer heatwave when extreme temperatures are forecast) and offer financial incentives. This is accomplished by offering customers reduced power rates outside of a defined daily peak demand period (e.g., between 5 pm and 8 pm on weekdays), which allows customers to reduce their bills by not operating their irrigation pumps at times of the day when the grid is under high stress, especially during summer. Participating farms (customers of the investor-owned utilities [IOUs]) receive a check at the end of the year for not operating their irrigation pumps during those periods. PLS programs aim to shift load consistently from peak demand hours on a daily basis).

While power utilities have tried DR and PLS approaches in the past, there has been little success to date with commercial efforts to implement DR or PLS solutions for agricultural customers. The primary factors contributing to lack of acceptance of the technology by farmers are the costs and complexity of implementation, the confidence that changing their irrigation practices will not put their crops at risk, and a clear understanding of the savings they can achieve in their utility bills (Figure 2).

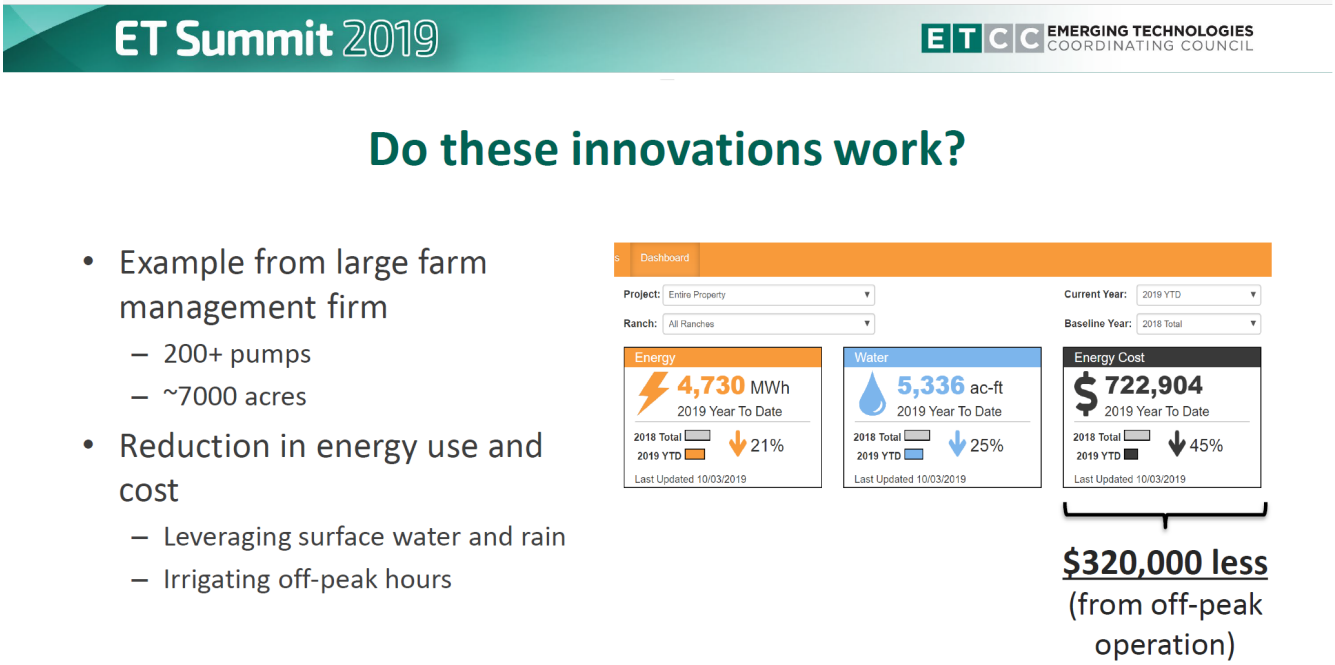
Figure 2: Farming Is Under Regulatory Constraints and Utility Bills Are Complicated



Source: AgMonitor at Emerging Technology Coordinating Council, 2019

The project team addressed these issues by having agronomists and software developers (AgMonitor and Naico ITS Inc. [USA]), educators (Center for Irrigation Technology at California State University [CSU], Fresno, and West Hills College in Coalinga), and automation equipment experts (WiseConn Engineering) on the same team to scale the early pilots at Bowles Farming (PG&E) and Ag-Wise Enterprises (PG&E and SCE) to more than 10,000 acres. The results were presented at the Emerging Technology Coordinating Council in 2019 (Figure 3).

Figure 3: Impact of Off-Peak Irrigation at a Farm in San Joaquin Valley



Source: AgMonitor at Emerging Technology Coordinating Council, 2019

AgMonitor's existing programmable irrigation software platform — which utilizes Smart Meter data to provide water, energy, fertilizer, and crop management tools to farms — was augmented by the addition of a load shifting feature that will enable growers to understand the energy-water nexus that is evolving with the increasing penetration of renewable energy into the state's power supply. The technology provides a comprehensive solution that avoids the expense and management of installing new equipment and presents a clear return-on-investment (ROI) to farmers.

The timing has been favorable for implementation of this project because it has coincided with recent changes in electricity rate structures that have been imposed on agricultural customers. Legacy rates had assigned the period from noon to 6 pm as peak demand hours, while the new rates define peak demand hours as 5 pm to 8 pm (PG&E) or 4 pm to 9 pm (SCE) during weekdays. Growers have often asked us to help them understand the new rate structures and find ways to lower their power costs, which indicates their recognition of the financial incentive to participate in load shifting efforts.

The overarching objective of the project was to shift large electrical loads for agricultural water pumping outside of peak demand hours to reduce strain on the grid in the summer. The approach is simpler than previous DR and PLS efforts for two main reasons:

- **Reducing the disconnect between the accounting office and the field crew.** Often, controllers or financial officers will sign DR contracts across several power meters. They do not operate the pumps, however — that is the responsibility of ranch managers and foremen, who are put in a difficult situation when they receive 24-hour notifications to shift their pump usage and must adjust their irrigation schedules quickly while still meeting the water needs of their crops. In the PLS approach, the project team reviewed a seasonal plan with the entire farm staff that allowed them to balance the water needs of their crops and lower energy costs.
- **Providing implementation options based on the education level of the field crew and the complexity of the irrigation system.** The software platform supports manual operation of pumps combined with weekly reports, the use of timers to automatically shut off power before the onset of the peak demand period (4 pm for SCE territory and 5 pm for PG&E territory), or a fully automated system to control the valves and the pump (resulting in savings in energy and labor). Farms were able to optimize their daily operations in accordance with their existing practices and available resources. Once a decision was made, the same irrigation schedule was followed for the rest of the summer except if there was a pump failure.

In all cases, the project team provided a weekly report to growers that closed the loop between the accounting office and the field operations and verified that no power was used during peak hours. Some errors occurred at the beginning of the growing season (e.g., May) but the field crews settled into the new irrigation routines and could subsequently focus on other aspects of their farming operations. This is why the project approach represents a fundamental behavioral change (energy efficiency) rather than a response to a power dispatch (demand response).

There were three components of the project's approach: seasonal planning, daily operations, and weekly reporting.

Seasonal Planning

AgMonitor developed a new "Energy Assets" page on its website to help farms plan for the season and evaluate different scenarios (Figure 4). There are three important factors:

1. **Energy load:** The total energy load on a farm varies due to several factors, but power consumption for water conveyance (lifting of surface water or pumping of groundwater) is the main factor. It can change by a factor of 3 between a dry year (e.g., 2022) and a wet year (e.g., 2023). A farm could choose a historical load from previous years. For instance, 2019 was the last wet year, 2020 was the last average year, etc.
2. **Solar co-generation:** Many farms have deployed large solar arrays to offset the electricity consumption of multiple pumps under Net Energy Metering Aggregation

(NEMA). This makes the calculations for utility billing more complicated because solar credits offset energy charges but not demand charges. The platform tracks participation in NEMA by meter and displays results from billing calculations done across a true-up period.

3. **Load shifting option:** An analysis is performed for a baseline year to determine whether PLS is possible at a farm. If so, the option "PLS" can be selected in the "Load Shifting" column and the grower can select a threshold. This is particularly useful when a single meter serves both a large well pump (e.g., 200 horsepower [HP]) and a smaller lift pump (e.g., 50 HP), and only the well pump can be shut off, since the lift pump must operate continuously to receive district water. In this case, the threshold is set at 50 HP, reflecting the non-shiftable lift pump load, and the remaining 200 HP associated with the well pump is treated as shiftable load.

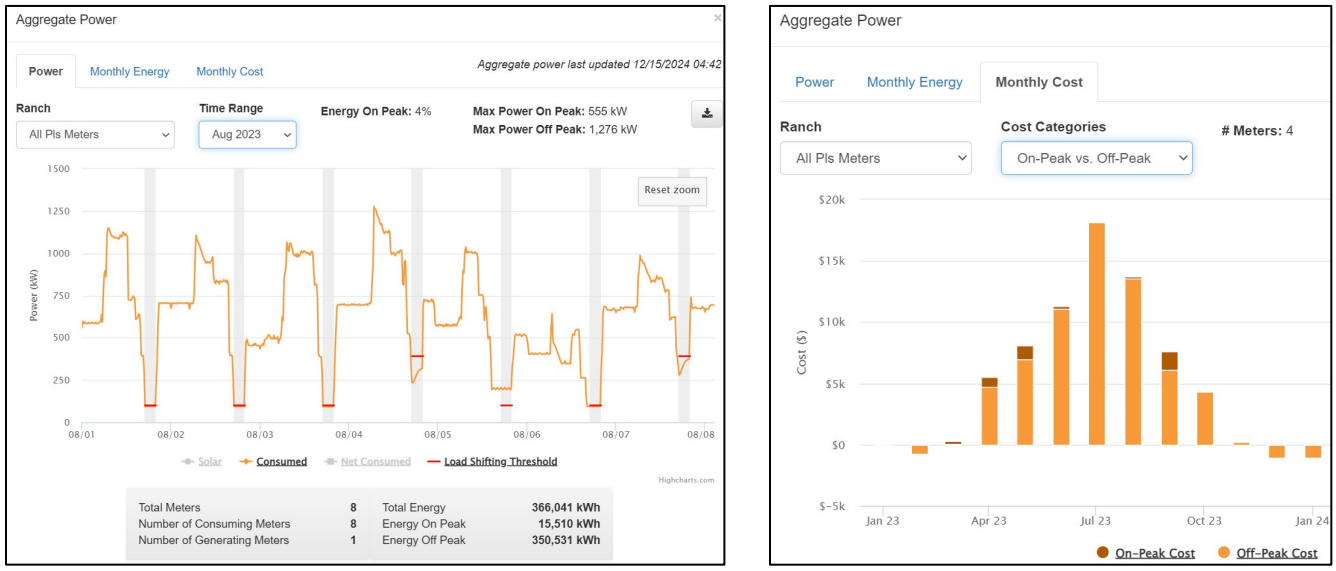
Figure 4: Energy Assets Page to Evaluate Impact of PLS and Explore the Different Power Utility Rates Available to Agricultural Load

Service Acct ID	Ranch	Assets	Current Rate	New Rate: Cost Change	Annual Use (kWh)	Annual Peak (%)	Annual Cost ($)	Annual Peak Charge ($)	NEMA Group	Load Shifting	Status	Actions
0263835009	Hawkins	Hawkins LP5	AGC	AGC: $8,670.42	96,525	13%	$35,965.0	$10,269.09		PLS	Purchased	
0262170168	Hawkins	Hawkins River Pump	AGC	AGC: $2,997.22	30,173	11%	$12,420.7	$3,228.71		PLS	Purchased	
0263344888	Hawkins	SW2 Floater	AGB	AGC: $2,069.67	39,866	2%	$17,152.0	$361.33		ELRP	Purchased	

Source: AgMonitor

The project team also developed a performance visualization tool to better understand PLS implementation (see Figure 5). The tool allows adjustments to be made from year to year. For example, a solar generator was installed at a site in Tehama County in late 2022 and rate adjustments were required in 2023.

Figure 5: Visualization of Aggregated Power for Meters Enrolled in the PLS Program (left) and Peak Demand Charges (right)

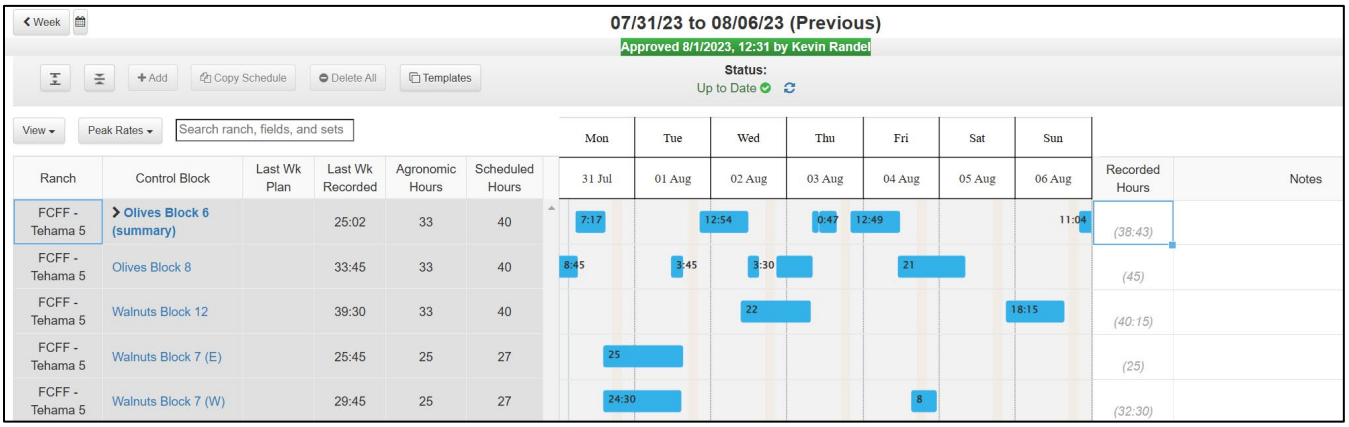


Source: AgMonitor

Daily Operation

AgMonitor developed software features to make it easier for field crews to implement PLS. These includes a "Calendar" webpage that lays out a weekly schedule showing how the irrigation events will meet the irrigation targets during times outside of peak hours. It can get complicated, as some crops with deep root zones have heavier soil and need longer irrigation events (24 hours or more), while other crops have a shallow root zone in medium soil. The example shown in Figure 6 is for a ranch in Tehama County where walnut fields needed two long irrigation events per week and the grower selected the flexible rate "AGFC-MonFri," which does not have peak penalties on Monday evening and Friday evening. Irrigation events for the walnut trees are scheduled during those times, while the pumps are used for shorter durations for olive trees the rest of the week. The grower decided to install pressure sensors for tracking irrigation events to make sure that PLS is correctly implemented every day and to improve irrigation precision.

Figure 6: Calendar Webpage to Visualize Irrigation Events Against Peak Periods



Source: AgMonitor

The project team included a software feature that sent daily text alerts to field crews. This was a result of observations that it could take several weeks for a crew to get used to a new irrigation schedule. It's recommended that growers begin implementing new irrigation schedules in May, before peak demand penalties in the summer months start. The text alerts help the crews to familiarize themselves with the new irrigation schedule so that they are ready for the summer season, which starts on June 1 and ends on September 30 for PG&E.

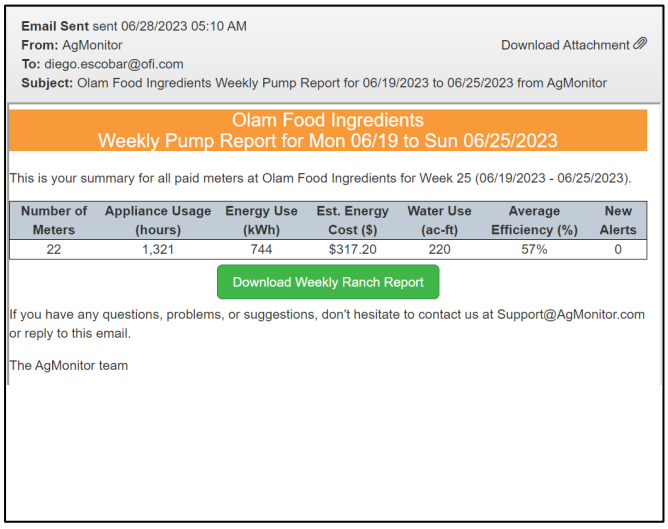
A downside of using Smart Meters as a source of information is that there is a 24-hour lag period before receiving the data from the utility (this data is provided on a "next-day" basis, so yesterday's data is available today, as the utility usually needs time to validate, edit, and estimate the data before using it for billing). This delay can be too long in cases where a ranch manager wants to check if an irrigator has set the proper schedule. This can be overcome by using a fully automated irrigation system, which is one of the options supported by the software.

Weekly Reporting

The key to the project was to connect the accounting staff who pay the bills and the ranch crew who operate the pumps. What is a dollar amount for some boils down to hours of labor for others. A weekly reporting feature was developed that summarized pump activity, in particular on-peak and off-peak hours of operation. This was built on the weekly pump report feature developed for a previous project, which documented how many hours a pump was used, overall pumping efficiency, whether the pump was used during peak demand hours, the energy cost of pumping the water per acre-foot, and the occurrence of any alert conditions. The project team added the peak operation cost in terms of dollars so the farming operation could discuss the impact of errors and the benefit of staying on schedule, and it created a new class of meter alerts for peak usage.

This worked very well for some small operations, which contacted us quickly after receiving an email alert notification to better understand the utility rates or to check what happened using the pump records. One ranch manager helped us identify a problem with Smart Meter data in situations when utilities initially generate "estimated data" and later update them with "revenue quality" data. AgMonitor learned not to send alerts right away in those cases and waited to receive the correct data from PG&E or SCE via Green Button.

Figure 7: Weekly Report to Ranch Managers in Firebaugh (left) and in Bakersfield (right)



Email Sent sent 06/28/2023 05:10 AM
From: AgMonitor
Download Attachment
To: diego.escobar@ofi.com
Subject: Olam Food Ingredients Weekly Pump Report for 06/19/2023 to 06/25/2023 from AgMonitor

Olam Food Ingredients
Weekly Pump Report for Mon 06/19 to Sun 06/25/2023

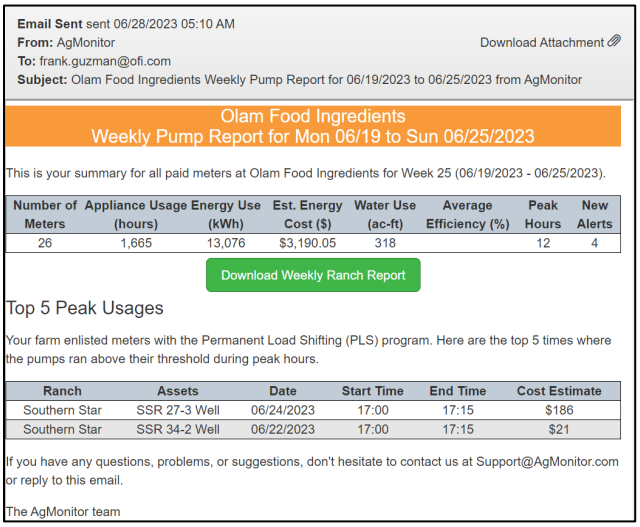
This is your summary for all paid meters at Olam Food Ingredients for Week 25 (06/19/2023 - 06/25/2023).

Number of Meters	Appliance Usage (hours)	Energy Use (kWh)	Est. Energy Cost ($)	Water Use (ac-ft)	Average Efficiency (%)	New Alerts
22	1,321	744	$317.20	220	57%	0

Download Weekly Ranch Report

If you have any questions, problems, or suggestions, don't hesitate to contact us at Support@AgMonitor.com or reply to this email.

The AgMonitor team



Email Sent sent 06/28/2023 05:10 AM
From: AgMonitor
Download Attachment
To: frank.guzman@ofi.com
Subject: Olam Food Ingredients Weekly Pump Report for 06/19/2023 to 06/25/2023 from AgMonitor

Olam Food Ingredients
Weekly Pump Report for Mon 06/19 to Sun 06/25/2023

This is your summary for all paid meters at Olam Food Ingredients for Week 25 (06/19/2023 - 06/25/2023).

Number of Meters	Appliance Usage (hours)	Energy Use (kWh)	Est. Energy Cost ($)	Water Use (ac-ft)	Average Efficiency (%)	Peak Hours	New Alerts
26	1,665	13,076	$3,190.05	318		12	4

Download Weekly Ranch Report

Top 5 Peak Usages

Your farm enlisted meters with the Permanent Load Shifting (PLS) program. Here are the top 5 times where the pumps ran above their threshold during peak hours.

Ranch	Assets	Date	Start Time	End Time	Cost Estimate
Southern Star	SSR 27-3 Well	06/24/2023	17:00	17:15	$186
Southern Star	SSR 34-2 Well	06/22/2023	17:00	17:15	$21

If you have any questions, problems, or suggestions, don't hesitate to contact us at Support@AgMonitor.com or reply to this email.

The AgMonitor team

Source: AgMonitor

It was more challenging for larger operations, which had as many as 53 meters signed up across multiple ranches. To simplify the reports, the project team decided to highlight the top five peak-demand-period alerts in terms of penalty costs to be avoided. This was especially useful for the accounting staff. Reports by ranch were also sent to each ranch manager. In the examples shown in Figure 7, one ranch manager made no mistakes with timers on pumps (left), while another ranch manager realized that the irrigators working with him were 15 minutes late in turning off two pumps (right). That mistake resulted in over $200 of peak demand penalties that week on Agricultural B (AGB) rates. The penalty is much higher when

meters are on Agricultural C (AGC) rates because there is an additional demand charge called "Max Peak Demand." Even a single 1-minute spike within a 15-minute interval will have an impact on the entire monthly bill. Peak demand penalties on energy charges (e.g., 45 cents per kilowatt-hour (kWh) during peak demand periods as opposed to 15 cents during off-peak periods) are commensurate with the size and the frequency of the errors.

The project team used the new tools summarized above to achieve the following milestones:

- Enlist farms to the PLS program; the goal was to enlist at least 10,000 acres.
- Develop a new method of measurement and verification adapted to PLS that tracks the performance of load shifting and provides simple cost-saving metrics for farms.
- Shift significant amounts of power load during the summer months of 2021 and 2022 to reduce strain on the grid at a critical time when solar penetration surpassed demand and wildfires raged. The goal was to shift at least 3 MW in 2021 and 7 MW in 2022.
- Develop new online class materials with educational partners and participate in outreach and technology transfer events with representatives of PG&E and SCE.

The results are summarized in the next section. The project resulted in lower costs and greater electricity reliability to agricultural ratepayers. The farms that participated in the project saw significant savings on their utility bills from reduced peak energy charges ($ per kWh) and peak demand charges ($ per kilowatt [kW]).

CHAPTER 3:
Results

Enrolling Farms for PLS

The project's first task was to enroll farm sites and power meters in the PLS program. By the end of the project, it had registered 177 power meters across 16 sites in 11 counties (Table 3).

Table 3: List of Farm Sites and Numbers of Power Meters Enrolled in the PLS Program Over the Course of the Project

Organization	Type	2020	2021	2022	2023
Site #1	Family Farm & Custom Farming (1)			4	8
Site #2 (Ag-Wise)	Family Farm & Custom Farming (2)	18	34	26	26
Site #3 (AgIS Capital)	Institutional Farm (1)			2	2
Site #4	Institutional Farm (2)		4	2	2
Site #5	Small & Medium Farm			2	2
Site #6 (Bowles Farming)	Family Farm & Custom Farming (3)	2	2	2	2
Site #7	Family Farm & Custom Farming (4)		2	2	2
Site #8 (CSU Fresno)	Experimental Farm			1	1
Site #9	Family Farm & Custom Farming (5)			2	9
Site #10 (JJS Corp.)	Family Farm & Dairy			2	2
Site #11	Institutional Farm (3)			48	53
Site #12 (Olam)	Corporate Farm & Processor			22	39
Site #13	Family Farm & Nut Processor (1)		3	3	3
Site #14	Family Farm & Custom Farming (6)			3	8
Site #15 (Terranova)	Family Farm & Custom Farming (7)			2	2
Site #16	Family Farm & Nut Processor (2)		11	18	16
Total meters on PLS		20	56	137	177

Source: AgMonitor

Family farms had more difficulty accessing capital as prices of nuts went down. The project team used some of its hardware funding to help one site install automation equipment (JJS Corporation, Site #10). The site at CSU Fresno (Site #8) was kept for demonstration and for online classes with PG&E. One institutional portfolio reached a much higher level of scaling, with 53 meters.

Measurement and Verification

In contrast to the DR approach of quantifying episodic load reductions during one-time events, PLS aims at quantifying the amount of load shifted consistently from peak demand hours on a daily basis. This can be done by comparing the customer's power load during a regularly occurring high-demand period (e.g., between 5 pm and 8 pm on weekdays) to a measure of the customer's typical power load outside of the peak demand period. A critical task for the project was to define the metrics for the PLS program in a way that would provide farmers with incentive to turn their irrigation pumps off during the peak demand period and make up for it by running the pumps at all other times.

From discussions with farmers, it was evident that the most effective metrics would be to provide them with a clear, simple measure of how much they could save on their power costs. An analysis of their utility bills showed that their costs were dependent on two primary factors:

- **The percentages of on-peak and off-peak energy use.** Energy used during peak demand hours is charged at a higher rate in $/kWh. On-peak and off-peak energy use are independent of the rate structure, and these metrics were added to the information provided to the project customers. An analysis of historical data from the Smart Meters at the beginning of the project, compared with data obtained from the Smart Meters over the course of the project, would demonstrate the extent to which the PLS program allowed customers to avoid high costs for power used during peak demand periods.
- **The maximum power load during peak demand hours compared to the maximum power load during the month.** The difference between the maximum power load during peak demand hours (Max Peak Demand) and the maximum power load that occurred at any time during the billing month (Max Demand) provides a measure of the load shifted consistently out of peak demand hours. This is an indicator of how successfully a customer has avoided high rates and penalties associated with power use during peak demand periods. The project team selected this metric as the basis of assessing its goals of 3 MW of load shifting in 2021 and 7 MW in 2022.

Load Shifting Summary

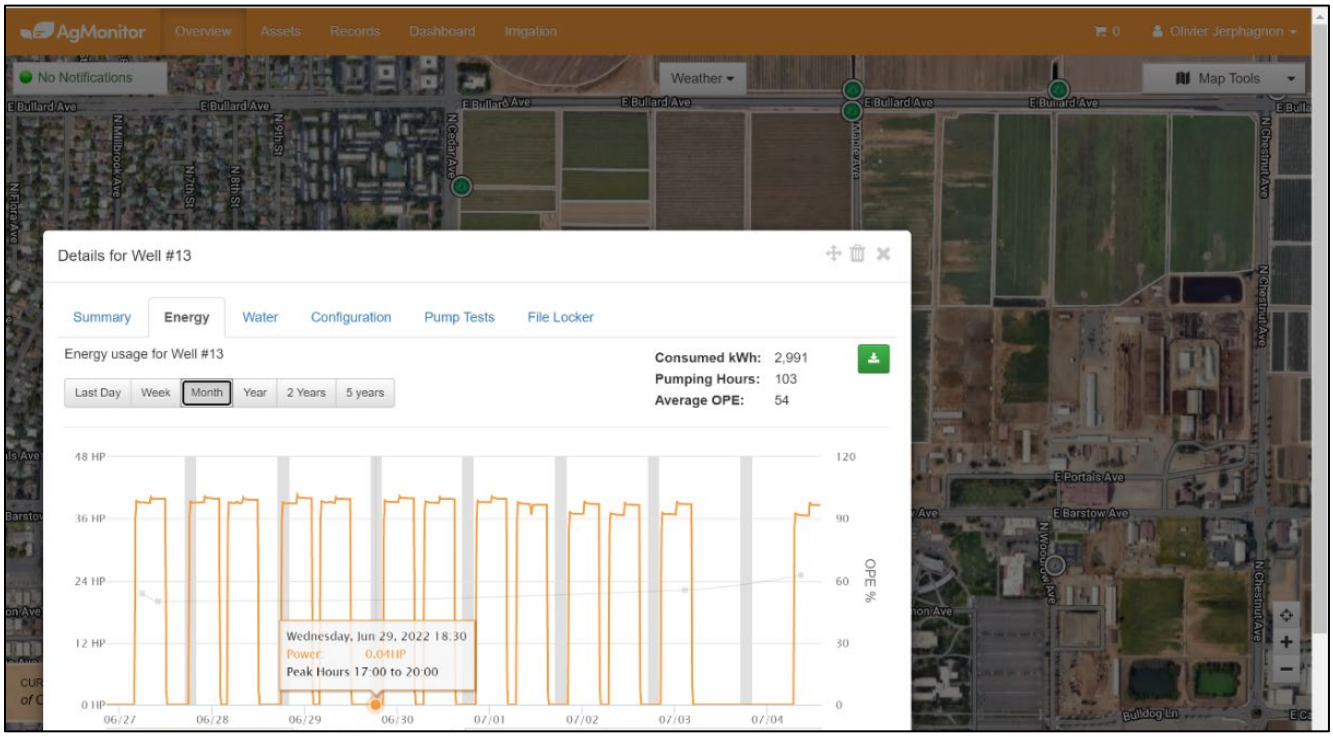
Summers of 2021 and 2022: Height of the Drought

After a wet year in 2019, drought returned to California in spring 2020 after little rain was received in February and March. Dry conditions persisted and intensified in 2021 and 2022. The summer of 2022 was particularly hot, with a series of days in late June and early September when there were high winds and dry vegetation and an extreme risk of fires. This means that PG&E had to shut down some transmission lines and fewer resources were available to keep the lights on in several parts of California (CBS News 2022). There were a limited number of sites enrolled in summer 2021 because the project did not start until spring 2021 and there was limited time to promote the new program. But a lot was learned during the process.

- The project team reviewed available electricity rates and the potential for cost savings with Bill Green of the Center for Irrigation Technology (CIT) and the farming staff. They decided to operate wells off-peak (Figure 8).

- The project team observed at the demo site at CSU Fresno that it was easy for a farm manager or irrigator to make a mistake when irrigation was done manually, so it used the pump at the demo site for education. The personnel still made a few mistakes, so, in addition to generating text alerts for the irrigators (similar to the pump alert feature developed previously for the software platform), the team included weekly summaries for management that contained information about penalties incurred for pumping during peak periods.
- The project team learned that it could take a utility one or two billing months to process a rate change (e.g., requests made late May might not manifest until July). This led to false alerts in some cases, and, in one case, it even resulted in an extra charge to the customer. The team decided to filter out "estimated data" received from Green Button.

Figure 8: Power Usage at Site 8 (CSU Fresno) Following a Change in Irrigation Schedule on June 29, 2022, to Avoid Peak Demand Hours



Source: AgMonitor

In 2021, the project achieved its goal of shifting at least 3 MW during the summer months (Table 4). It was not easy to achieve the minimum target of 7 MW of load shifting across all the summer months in 2022. One factor was that the power consumption at the farms started to go down in August with the beginning of the harvest, and a reduction in the maximum power load during the billing month resulted in lower values for the calculated amount of load shifting.

Table 4: Calculations of Power Shed Across All Enrolled Sites in 2021 and by Month

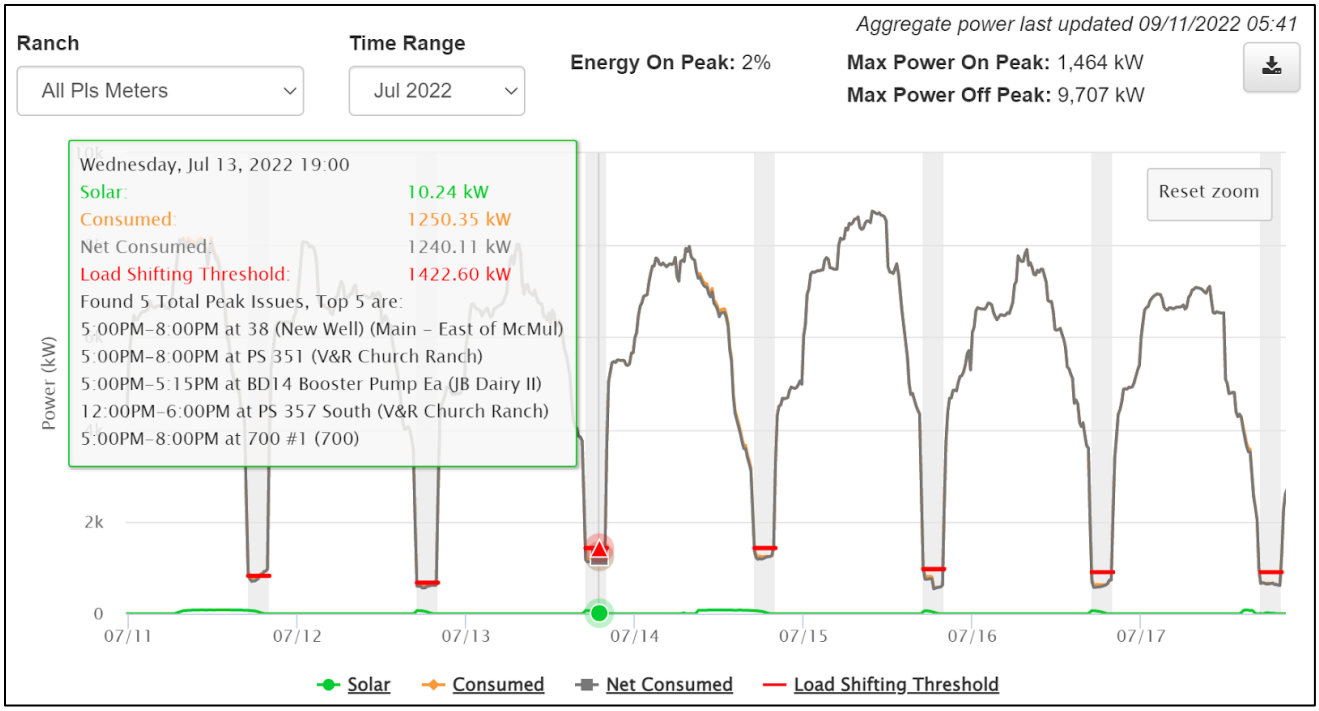
	Total	Ag-Wise Ent.	Bowles Farming	Agriculture Cap.	P-R Farms	Vann Brothers	C&G
Nameplate power (kW)	8,498	5,999	39	398	144	767	225
Power shed in June (kW)	4,824	3,580	38	298	136	766	7
Power shed in July (kW)	4,222	2,966	38	330	137	747	4
Power shed in August (kW)	3,472	2,148	-	294	131	677	222

The total power shed in July-August 2021 (3.4 to 4.8 MW) is lower than the sum of the nameplate values (8.5 MW) because not all of the pumps enrolled are turned on.

Source: AgMonitor, progress report in 2021

Utilities increased their rates in 2021 and 2022. As the drought intensified and rates kept climbing, more farms showed interest in PLS. The project saw significant increases in the number of participating sites (6 to 16) and power meters enrolled (56 to 137) from 2021 to 2022. The aggregated load for July 2022 is shown in Figure 9. In addition, the project team observed that errors would routinely occur that resulted in pumps being operated during peak demand periods. To gain a better understanding of what was happening, it decided to track the top five alerts every day from the aggregated load display, which allowed it to engage with the specific sites where errors were occurring and help the staff at those farms improve their results.

Figure 9: Power Aggregated From Meters Enrolled in the PLS Program in July 2022



The technical support engineer could see the main PLS alerts by hovering over a specific day of the week. The display for July 13 is shown, on which date five substantial alerts occurred for conditions resulting in peak cost penalties.

Source: AgMonitor, progress report in 2022

The project team performed an in-depth analysis of the data from July and called the farming staff at the sites associated with the alerts to discuss why they had operated their pumps

during peak demand hours. Surprisingly, alerts were due to roughly equal occurrences of human errors (on the farm side) and equipment errors (on the utility side). On average, out of every 10 errors, the following were identified.

- 4 errors related to water needs (farming): This was expected, because irrigation needs drive pump use. For example, one rancher reported that the crews would not irrigate off-peak until mid-August on three pumps because they needed to repair their piping.
- 3.6 errors due to metering issues (utility): The release of estimated meter data via Green Button led to false alerts and, in some cases, errors in the bills. This was particularly a problem at Olam and led the project team to adjust its alert system to filter estimated data. Also, some meters were still processing rate changes in July, and the team worked with customers to make sure they were not penalized on their power bills.
- 1.7 errors due to human interaction: This could include entering bad information into automation systems (this rarely occurred and improved when alerts were issued) or a field irrigator was late/early to turn a pump off/on (this was more common).
- 0.7 errors due to power shutoffs: When the grid became unstable and power was shut off, equipment got reset. It happened at a farm in Firebaugh. It missed one peak period on an AGC rate (and incurred a one-time penalty). The project team talked to the PG&E representative, so the farm was not penalized because the grid service was interrupted.

The improvements resulting from this analysis allowed the project team to meet and exceed its load shifting target of 7 MW in summer 2022. It first reached 8 MW and subsequently reached over 10 MW after more power meters were enrolled in the program. The AgMonitor dashboard reporting results for September 2022 is shown in Figure 10.

Figure 10: Aggregated Power From 136 Active Meters in September 2022, with a Max Peak Demand of 1.028 MW and a Max Demand of 12.419 MW

Source: AgMonitor, progress report in 2022

Results from the summer of 2022 are provided in Table 5. The project achieved at least 11 MW of power shifting from June 1 to September 30. On-peak energy varied from 1 percent to 2 percent. The increase in August was due to the start of harvest, which makes irrigation scheduling more difficult to plan.

Table 5: Summary of Measurement and Verification Method to Quantify the Power Consistently Shifted in Summer of 2022

Month	June	July	August	September
Max Demand (kW)	14,969	15,110	12,717	12,419
Max Peak Demand (kW)	1,486	1,461	1,751	1,028
Shifted Load (kW)	13,483	13,649	10,966	11,391
On-Peak Energy (%)	1%	1%	2%	1%

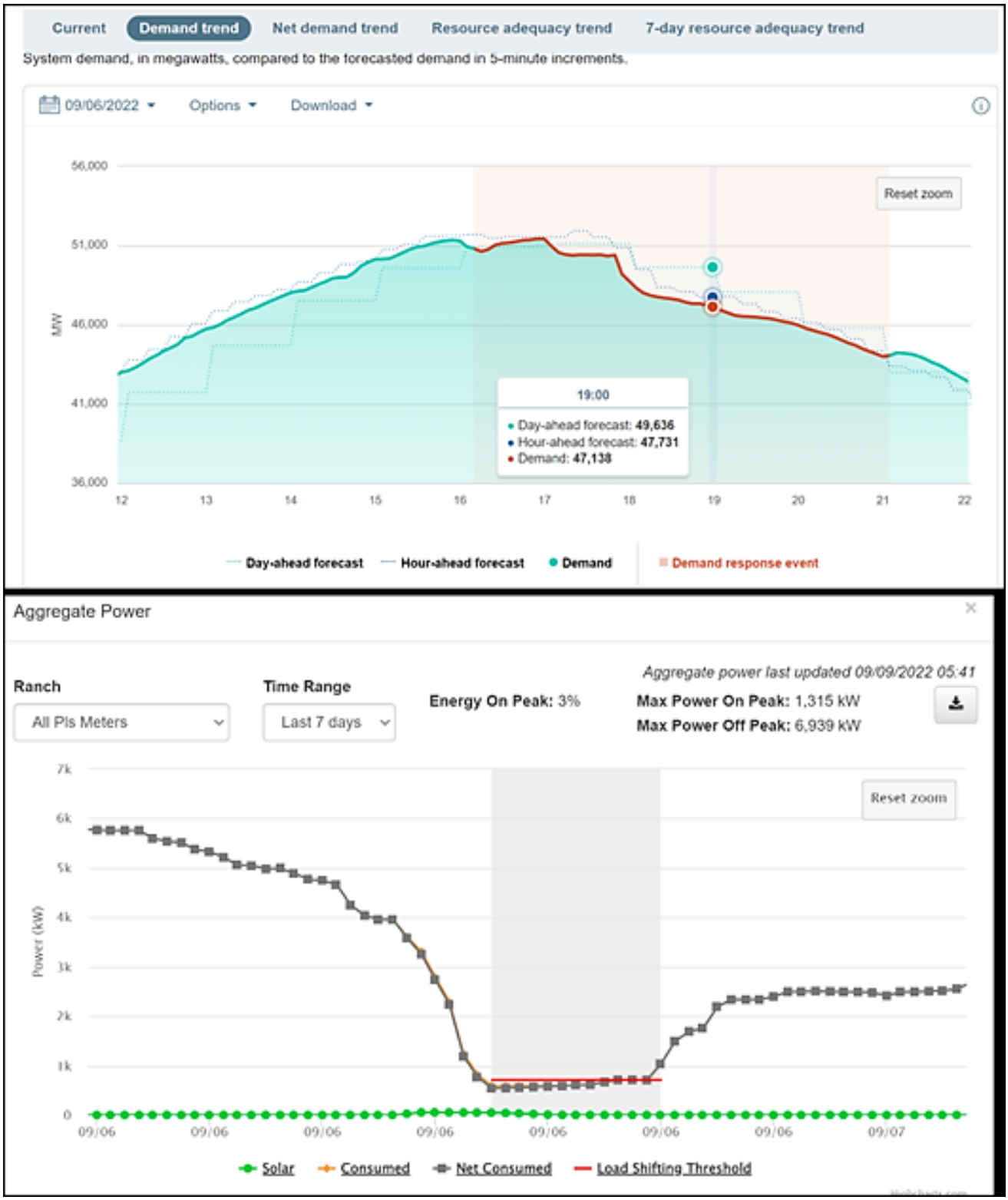
Source: AgMonitor, progress report in 2022

Emergency Events in Summer 2022

Peak drought conditions were present in September 2022 and the fire season began with high winds, which placed high stress on the grid, as predicted in 2020. On September 6, Governor Newsom extended the emergency response to avoid massive power shutoffs and the event was announced on television (Newsom 2022). The crisis was met with multiple programs and technologies, including battery systems. At 7 pm on September 6, the total estimated power load shed throughout California was 593 MW. The impact from the project's PLS program was around 5.3 MW, which represented 1 percent of the total load reduction statewide, demonstrating the potential to relieve stress on the California grid.

Figure 11 compares the total power load shed statewide and the load shifted by the project's implementation of the PLS program during the emergency event of California ISO on September 6, 2022, between 4 pm and 9 pm.

Figure 11: Total Power Load Shed Statewide (top) Versus Load Shifted by Implementation of the PLS Program (bottom) During the Emergency Event of California ISO on September 6, 2022



The reduction in California at 7 pm was 593 MW and under PLS was 5.3 MW.

Source: AgMonitor, progress report in 2022

The load shifted by the project's PLS program was relatively low on September 6 because some of the project's customers did not operate their pumps at all on that day. During the rest of the month of September, project customers consistently shifted 10 MW of load during peak demand hours.

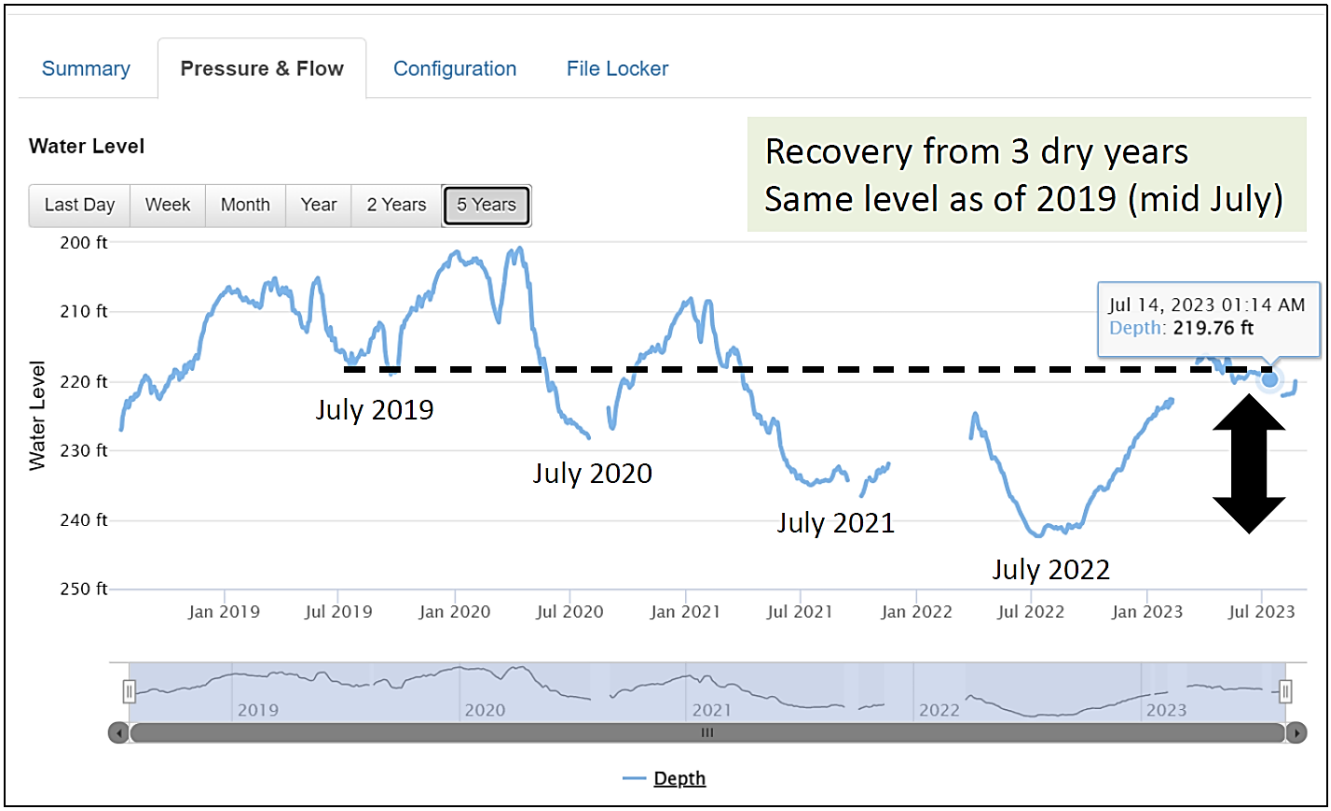
Spring and Summer of 2023: Risks of Flood and Groundwater Recharge

While the original project scope covered only the years 2021 and 2022, the project team decided to include results from 2023 as well because it was a wet year that presented a very different set of circumstances. Farms received 100 percent of surface water allocations and most well pumps were not used. This explains why the project achieved a similar amount of load shifting in 2023 as in 2020 (approximately 11 MW) even though there were more meters registered in 2023. Starting from 20 meters before the beginning of the follow-on project, the number reached 137 meters in 2022 and 177 meters in 2023. Only 148 meters were active and drew power.

The project team met with Terranova Ranch, with whom it had been working since the EPIC project EPC-14-081 in 2016, to discuss other ways of realizing energy savings. The team had studied the increase of energy intensity (and cost) per acre-feet (Ac-Ft) of water pumped at the ranch during the dry years of 2021 and 2022. In winter 2023, additional pump tests were performed to document the impact of the 20-foot drop in the level of the water table that had occurred during the drought years. It was estimated that restoring the water table to its pre-drought level would result in savings of 1,000 megawatt-hours (MWh) and $200,000 per year.

In response to Governor Newsom's emergency order to divert flood water, issued in April 2023, Terranova Ranch was able to turn on the 150-CFS (cubic feet per second) lift pump in Helm, California, to recharge the aquifer with flood water. The project team worked with Terranova Ranch to document the amount of water recharged (over 18,000 Ac-Ft) (Jerphagnon 2024a). The water table in July 2023 returned to the same level as it had been in July 2019 (Figure 12).

Figure 12: Impact of Groundwater Recharge at Terranova Ranch on the Water Table



Source: Terranova Ranch, 2023

Project Metrics

AgMonitor met and exceeded the main project goal of achieving 3 MW of load shifting during the first summer (2021) and more than 7 MW of load shifting during the second summer (2022). It also met all of the other project objectives quantified by metrics defined in the original proposal. In addition, it added a cost metric after meeting with Glenda Humiston, Vice President for Agriculture & Natural Resources at the University of California. It is critical for growers to get a sense of how much money they can save with respect to their operational budgets ($/acre) or relative to DR programs ($/kW) (Table 6).

Table 6: Performance Metrics at the End of the Project in 2023

Performance Metric	Bench-mark	Current	Low Target	High Target	Evaluation Method	Significance of Metric
Percentage of irrigation during off-peak hours (manual and automated)	89%	96%	98%	100%	Analysis of Smart Meter data	Reduction of energy during ramp-up period when sun sets (5 pm-8 pm)

Performance Metric	Bench-mark	Current	Low Target	High Target	Evaluation Method	Significance of Metric
Maximum peak power during 5 pm-8 pm window compared to maximum power during month	1MW	11MW	7MW	10MW	Analysis of Smart Meter data to subtract peak power during 5 pm-8 pm from max power during month	Amount of power (kW) shed and persistence of PLS program to reduce strain on grid
Precision in following irrigation plan (manual)	70%	85%	85%	90%	Comparison of actual pump hours vs scheduled hours of irrigation	Improvement of temporal resolution to increase water use efficiency and reduction of max power
Precision in following irrigation plan (automated)	80%	97%	95%	100%	Comparison of actual pump hours vs scheduled hours of irrigation	Improvement of temporal resolution to increase water use efficiency and reduction of max power
Savings per acre	$31	$50	$40	$70	Analysis of utility bills	Cost saving to farmers
Savings per kW	$40	$75	$50	$90	Analysis of utility bills	Cost saving to farmers

Source: AgMonitor, benefits questionnaire for 2024

Cost Savings to Farms With and Without Solar Power

Another challenge during the project was to calculate the savings for farms with pumps on power meters that are part of a NEMA group. This creates a lot of confusion for the accounting staff, who often find it difficult to understand the utility bills. If the energy charges in a bill are already offset by solar generation, it may not be clear how additional savings can be achieved by irrigating outside of peak demand periods (the key is the reduction in demand charges that can be realized by off-peak irrigation). More than half of the sites that the project team worked with during the project had existing solar power generation systems or were in the process of installing one, which introduced a major complication to the project. As a result, the team decided to improve its RanchMonitor™ software module to help with rate recommendations, as it found that the situation was counter intuitive. For example, a grower would put a large pump in PG&E territory with significant load on an AGC rate (low energy charge and high demand charge) to reduce costs. However, the lowest cost would result from placing the pump on an AGB rate after the interconnection of a solar array (higher energy charge and lower demand charge) because the residual charge was dominated by the demand charge.

Figure 13: Overview of Site #3 With Well Pumps Operating on Solar Power in 2023

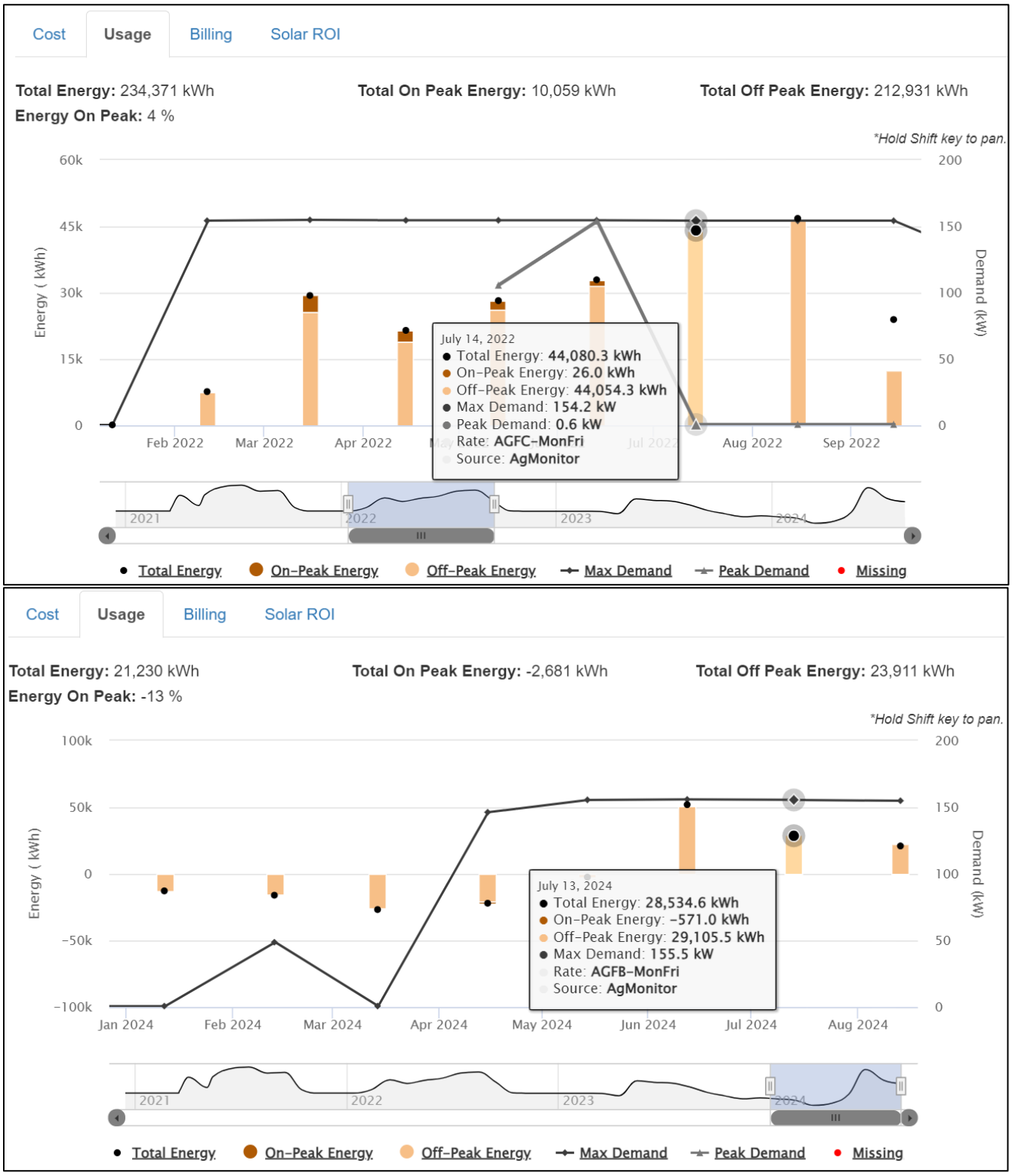
Source: AgMonitor

That is what happened at Site #3 in Tehama County (Figure 13). Its solar power project was interconnected in 2023, so the team was able to compare the cost savings of irrigating off-peak without solar in 2022 and with solar in 2023. Two additional examples, described in the following sections, provide more nuance on the actual benefits of the PLS program: a ranch manager for an institutional fund (Basco Farming for AgIS Capital), and a family farm and dairy (JJS Corporation).

Example of Basco Farming in Tehama County

A ranch manager worked with AgMonitor to implement a PLS program at a property in Tehama County at the request of the owner, an institutional fund (AgIS Capital). The property, located south of Red Bluff along Highway 5, has two electric well pumps. There is also one diesel well pump available in case there is a power shutoff. The Director of Sustainability at AgIS Capital was interested in improving irrigation precision and reducing energy costs. He also wanted to compare the cost of pumping water (in $/Ac-Ft) for the electric pumps and the diesel pump. AgMonitor met with the ranch manager, who had been irrigating his olive orchards off-peak each day but not his walnut orchards, which require longer irrigation events. After reviewing the water requirements for walnut trees and the existing irrigation schedule, he opted to start irrigating the walnut orchards off-peak all day except for Monday evening and Friday evening. The program was implemented across two power meters starting in July 2022, and the farm saved $17,200 over the summer, compared to summer 2021 (Figure 14).

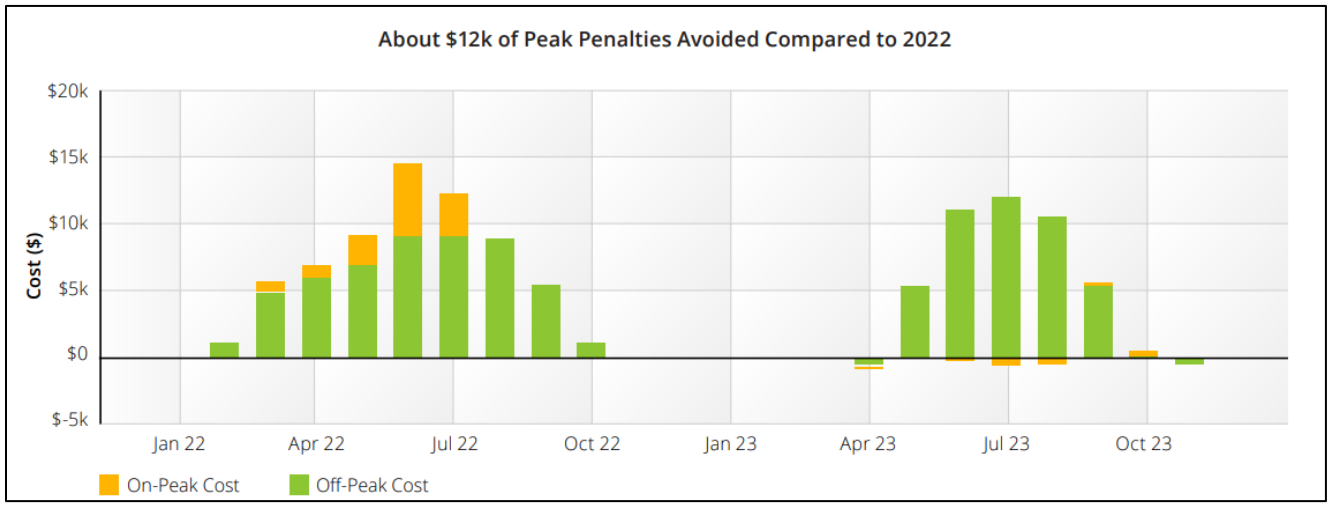
Figure 14: Power Usage of a Well Pump on a Meter Rate of AGFC-MonFri in 2022 (left) and a Rate of AGFB-MonFri in 2024 After Solar Power Installation (right)



Source: AgMonitor, 2024

In 2023, no on-peak irrigation occurred over the entire summer. The farm saved $12,000 more in peak charges and achieved a total saving of $29,300 compared to 2021 (Figure 15). The ROI over two years was 310 percent and AgIS Capital implemented the system at other farming properties.

Figure 15: Monthly Utility Bills in 2022 and 2023 With On-Peak and Off-Peak Costs

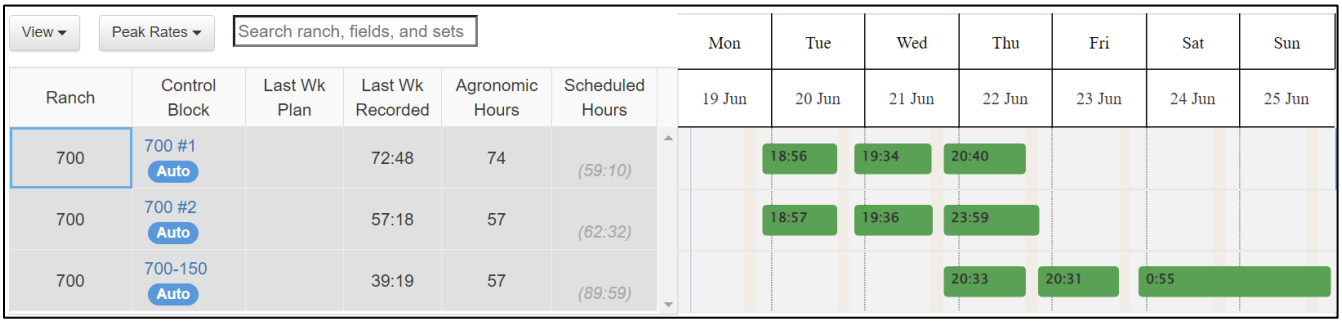


Source: AgIS Capital, 2023

Example of JJS Corporation in Merced County

At Site #10 in Merced County, the CFO of JJS Corporation decided that using solar power was too complicated. Instead, he invested in setting up automated off-peak irrigation (for almond and alfalfa fields on the farming side of the business) using AgMonitor technology (Figure 16), while also installing a bio-digester for a dairy on the processing side of the business. JJS Corporation deployed automation equipment from WiseConn Engineering provided by a local dealer. AgMonitor provided a one-time incentive of $50 per kW for the pumps enrolled in the program. The owner agreed to host a field day in conjunction with PG&E and the University of California, Merced to promote PLS.

Figure 16: Off-Peak Irrigation With Loads Scheduled Into an Automation System

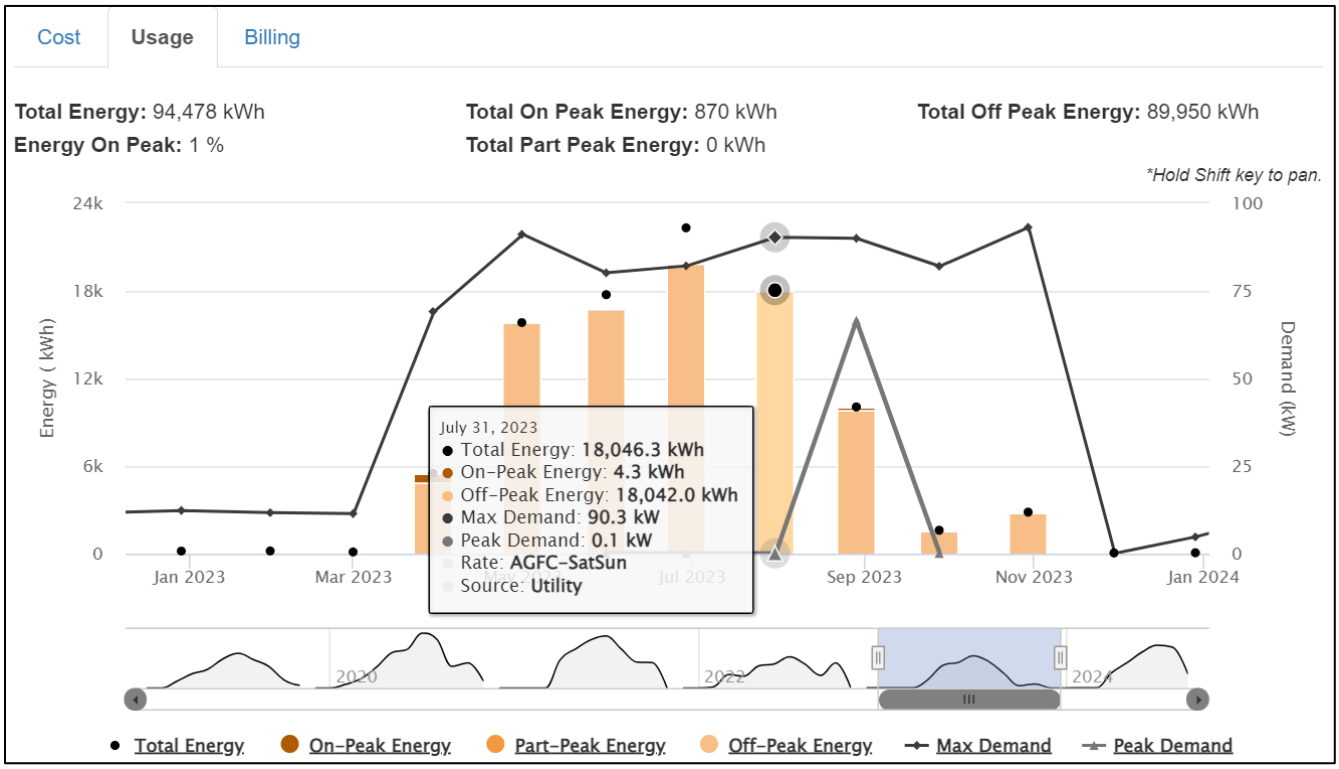


Source: AgMonitor, 2023

The project team did not observe any errors during normal automated operations in 2023. Errors could occur, however, when the automated mode was turned off. An example of this

was observed in August, which led to a one-time Max Peak Demand charge (Figure 17). Overall, the project was a success, and the farm expanded PLS to a second orchard.

Figure 17: Power Usage of a Well Pump on a Meter Rate of AGFC-SatSun



Source: AgMonitor, 2023

Technology Transfer

The project team organized classes on energy, irrigation, and load shifting with CIT at CSU Fresno for farms in PG&E and SCE territory (Figure 18). It also worked with several farms and food processors (almond and tomato) to engage the community. The staff of PG&E participated in two field day events in Merced County. Unfortunately, the Energy Education Center in Tulare was not open during the project due to the COVID-19 pandemic. So, team members had a meeting with only a team from SCE to explain PLS and how complimentary it is to Emergency Load Reduction Programs (ELRP).

Figure 18: Online Classes Organized by CIT, With Collaboration From PG&E and SCE, During COVID-19 Reached a Wide Audience

Source: Center of Irrigation Technology at CSU Fresno, 2022

Comparison of PLS (Energy Efficiency) and ELRP (Demand Response)

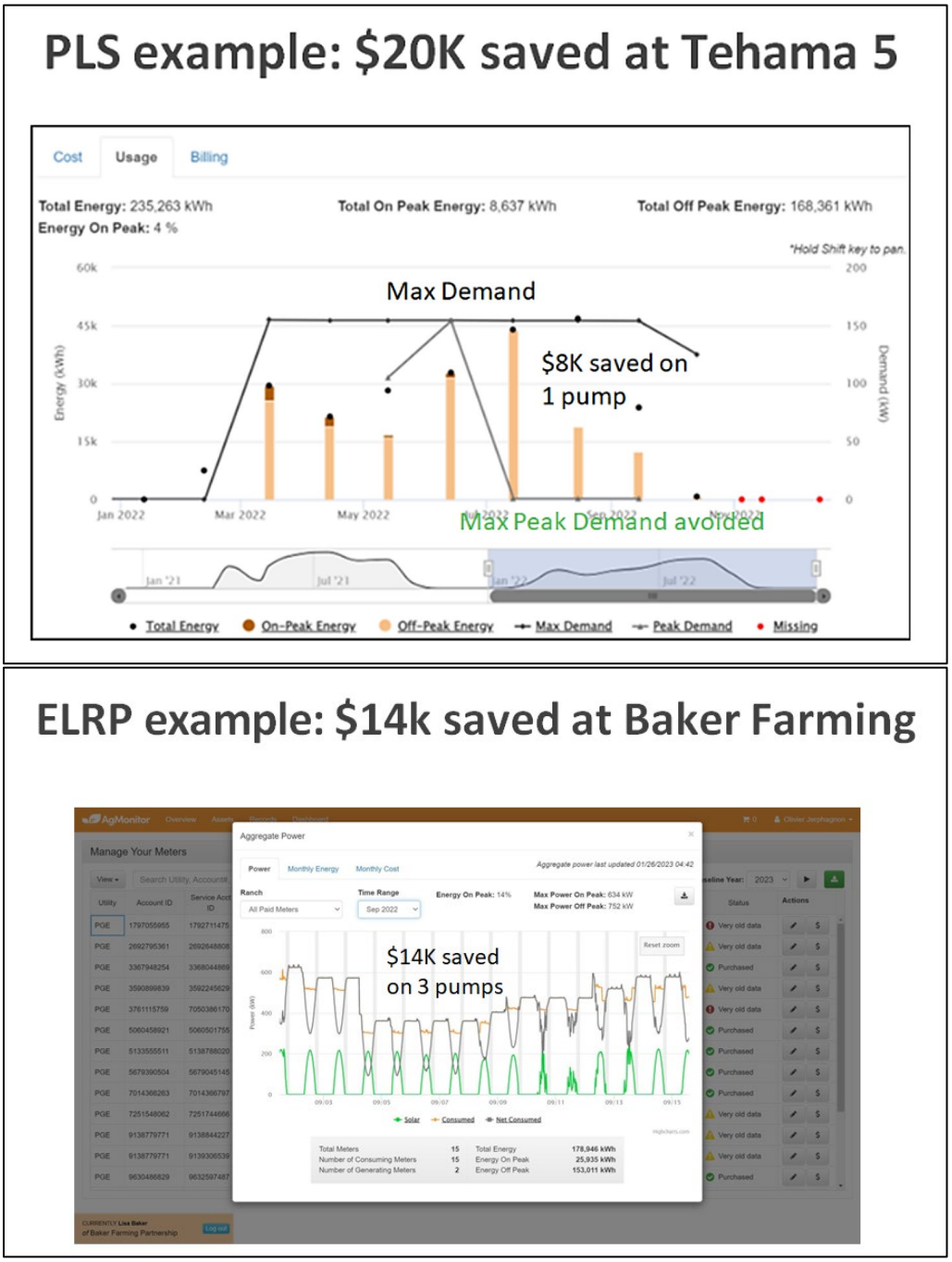
The project team's work with Justin Witte at PG&E, who was on the project's technical advisory committee, led the team members to compare PLS and ELRP.

1. **Cost savings:** Representatives from PG&E and SCE wanted to understand the cost benefits the PLS program could provide and compare then to DR programs like ELRP. The team found that it could provide monthly savings (Figure 19, left) of $50 per kW consistently, and, in some cases, savings of $75 per kW for high loads under AGC

rates. In contrast, benefits from DR programs like ELRP occur only if there are emergency events, which do not happen every summer.

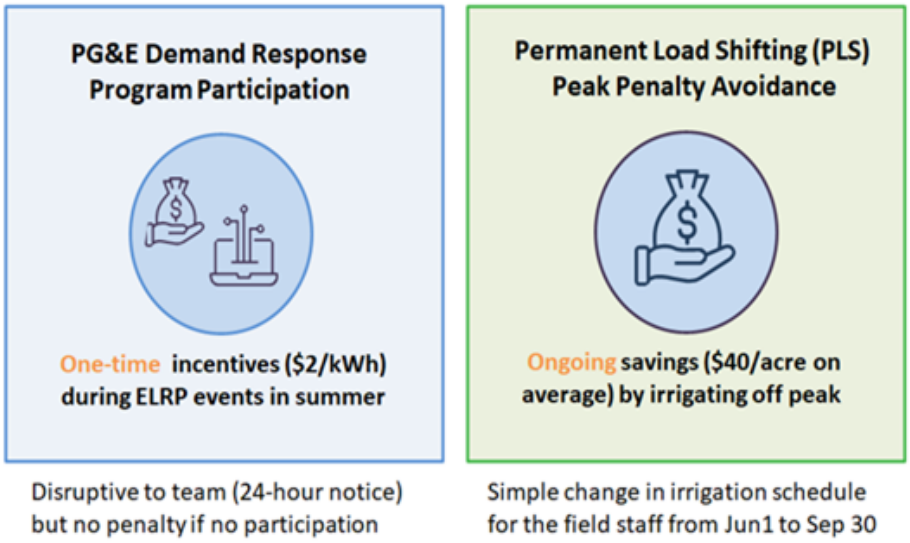
2. **Complementarity:** Not all pump loads can be shifted and eligible for PLS. AgMonitor wanted to provide a cost-saving option for the pumps not signed up under PLS; it offered ELRP as a DR option because it does not have a penalty for non-participation. The team decided to track one farm in Merced County in 2022, as shown in Figure 19, right.

Figure 19: Examples of Savings at Two Farms Using PLS (left) or ELRP (right)



Source: AgMonitor, 2023

Figure 20: Summary of Savings From Two Options: ELRP and PLS



Over the summer of 2022, farms enrolled in an ELRP program received savings of $2 per kWh during emergency events associated with the heat wave in early September (left); a farm in a PLS program achieved savings of $40/acre by turning off two pumps between 5 pm and 8 pm of five days per week (right). Both programs provided savings of about $50/kW, but PLS is recurring every summer.

Source: AgMonitor, 2023

Case Study with Olam Food Ingredients

The project team first worked with Olam Food Ingredients (Olam), which had 22 power meters registered with the project in Bakersfield near the site of Ag-Wise Enterprises. The company had installed automation for irrigation scheduling, and the deployment of PLS went well in 2022. A significant factor contributing to the successful implementation was that the ranch manager was bilingual (English and Spanish) and tech savvy. As part of its technology transfer efforts, the team worked with the Senior Director of Agronomy, Zac Ellis, on how to scale up the technology to other ranches with different farming properties.

Mr. Ellis organized regular meetings among ranch managers to share their experiences. Olam's VP of Operations for California and the ranch manager at one property in Firebaugh were also interested in irrigating off-peak to reduce risk of grid power outages and save money. After evaluating the three different options supported by the project's software platform, they decided to go with semi-automation (timers on pumps) and invested $15,000 in devices and labor to implement PLS. As the ranch manager needed flexibility to irrigate over the weekends to avoid significant labor cost increases, they switched their power rate to the AGFB-SatSun flexible rate. The expansion project went well. Olam saved $100,000 during the summer of 2023, with an ROI of 650 percent. The team shared a LinkedIn post about the expansion project (Jerphagnon 2024b) that received many reviews online (Figure 21).

Figure 21: The Director of Agronomy and Ranch Manager at KG Ranch (Olam)

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"We like working with AgMonitor because they understand agriculture. They provided options to irrigate off-peak at a ranch as part of the Permanent Load Shifting (PLS) program. The results speak for themselves: we saved $100,000 in one summer." – Zac Ellis, Sr Director of Agronomy at Olam.

Farmers are navigating an increasingly difficult landscape of rising energy costs and complex solar integrations, and finding effective solutions can be overwhelming. Olam faced these challenges head-on with the help of our RanchMonitor™ platform. By consolidating all energy assets and data into one streamlined system, Zac Ellis and the GM of Operations were able to not only maximize solar investments, but also explore various "what if?" scenarios to optimize their energy usage.

Despite the initial focus on solar optimization, it became clear that it alone wasn't enough to counteract the post-COVID inflation and utility rate hikes of 20% per year in 2022 and in 2023. They deployed the Permanent Load Shifting (PLS) program, developed by AgMonitor under a California Energy Commission grant, as a solution. Unlike traditional Demand Response programs, PLS allows growers to select five days a week for off-peak irrigation, providing ample time to coordinate with field irrigators and ensure agronomic needs are met. This easy-to-use solution offers options from simple pump timers to fully automated systems, significantly reducing labor costs and energy expenses. After talking to Diego Landin, the manager at KG ranch, the Olam team opted to deploy cheap timers (pump off only) and to work with him to adjust the irrigation schedule.

Olam received a weekly pump report thanks to PumpMonitor™, which gave them real-time pump alerts and weekly updates how the PLS program was going. They made some corrections during the first month of June and achieved full savings during the rest of the summer.

The measures helped Olam save a remarkable amount of money. The results speak for themselves:
- $136,307 total savings in 2023 despite a 20% energy rate increase
- $39,864 savings from solar credits
- $96,443 from reduced peak charges
- Over 600% ROI on $14,400 AgMonitor project costs

Due to these results, Olam intends to scale up at other ranches in the future. They also like the flexibility to make adjustments year to year. No season is is the same in farming. In 2023, they will utilize PLS for three out of four months in the summer to save $75,000 and optimize crop revenues. Olam's team appreciates the tailored approach of AgMonitor platform, and our commitment to continue to align with their needs. We enjoy partnering with the Olam team to show how innovative technology can drive both sustainability and profitability in agriculture.

#sustainability #agritech #transformingagriculture #agmonitor

106 5 reposts

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Source: AgMonitor, 2024

Field Day with Henry Miller Reclamation District

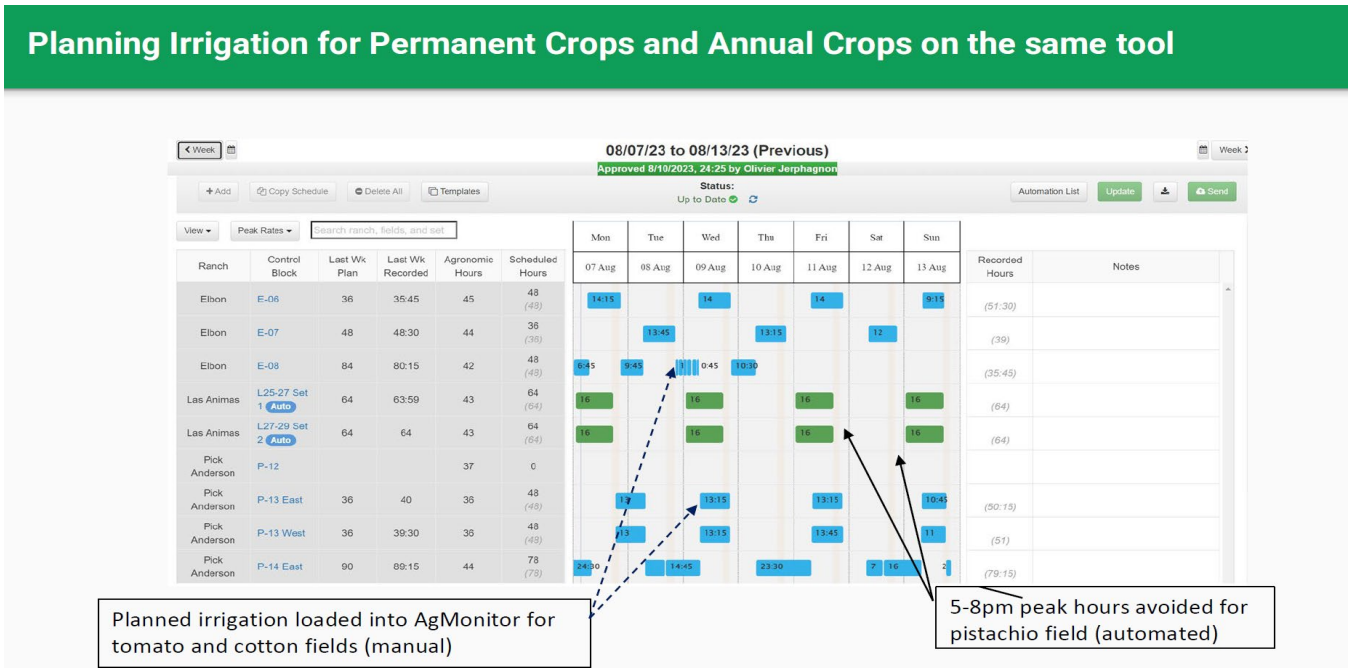
By interacting with row crop growers at Site #1 and Site #6, the project team realized that irrigating off-peak with surface water (from canals) is a bit more complicated because the water levels of irrigation canals are maintained by water/irrigation districts. Aside from one pilot project at Bowles Farming that did not affect canal levels, it was critical to engage with district water engineers. As a result, Bowles Farming introduced the team members to staff from the Henry Miller Reclamation District (HMRD) near Los Banos. The team organized a field day in September 2023 with HMRD and the Mobile Energy Lab of CIT at CSU Fresno, which is sponsored by PG&E. Figure 22 shows Bill Green of CIT and CSU Fresno, Olivier Jerphagnon of AgMonitor and the principal investigator of the PLS project, and John Wiersman of HMRD participating in the field day. Takeaways from the event included:

1. The need to educate farm ownership and accounting staff about utility bills (Figure 22)
2. The need to work with field crews when they adopt PLS into their irrigation process. Bowles Farming showcased both manual and automated irrigation, with a precision of 91 percent for row crops (manual) and 97 percent for tree crops (auto) (Figure 23).

Figure 22: Bill Green, Olivier Jerphagnon, and John Wiersma (left to right) Speaking in Front of the Mobile Energy Lab at the September 2023 Field Day

Source: Center for Irrigation Technology at CSU Fresno, 2023

Figure 23: Screenshot of Calendar Schedule Page for Row Crops and Tree Crops



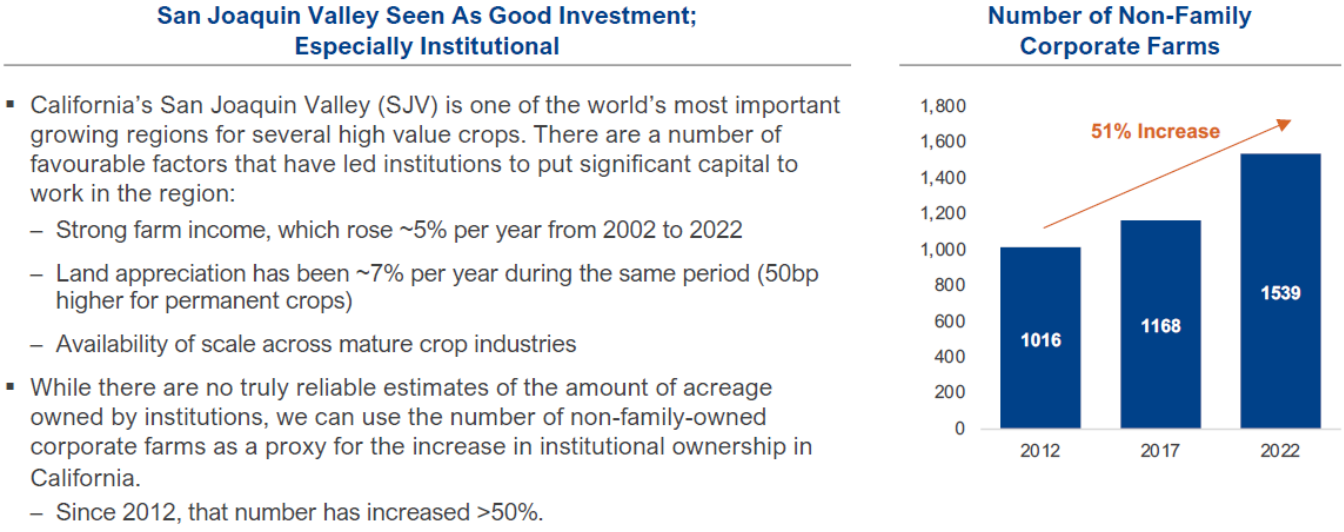
Source: Bowles Farming, 2023

Sustainability Reports for Responsible Investment

The project team has observed an increase in the number of farming properties owned by institutional funds (insurance groups or pension funds). Over 95 percent of California farms are still family businesses. However, there is a clear trend; and it is expected that funds will

own more farmed land as water restrictions, labor regulations, and energy transition require more capital investment.

Figure 24: Evolution of Farmland Owned by Nonfamily Farms From 2012 to 2022



Source: USDA and California ASFMRA, 2022

One of the investment groups that the project team worked with, AgIS Capital, included the results of the PLS implementation at Site #3 in its *Sustainability and Responsible Investing Report 2023* (Evers 2024). The Director of Sustainability states: 'With the improvements in precision of irrigation and other inputs, our clients' farms can continue to improve their yield performance while reducing input costs. This junction of environmental, efficiency and performance improvement is exactly what sustainable farming is about. Higher food production per unit of inputs, while being responsible for our impacts to the environment (water precision) and to communities (demand on the energy grid)." That is an excellent summary of the impact of the PLS project.

Figure 25: Screenshot of AgIS Capital Website That Released Its Annual Report

Source: AgIS Capital, 2023

CHAPTER 4: Conclusion

The project team completed the main goals of the project successfully, with over 3 MW of power shifted in the summer of 2021 and 11 MW in the summer of 2022 across more than 100 meters and covering more than 10,000 acres. It developed a new measurement and verification (M&V) method that tracked the reduced peak load every week and provided simple cost metrics to farms. The recurring savings for PLS of $75/kW, or $50/acre, are superior to DR emergency events, which do not occur every year.

The make-up of farming is changing, with a growing number of ranches owned by institutional funds and nonfamily corporate farms due to the growing cost of meeting regulatory compliance and implementing water restrictions. Energy transition and access to capital are also factors. One example is the installation of solar power generation, which made this project more complicated. The team developed additional software modules under AgMonitor's platform to keep cost metrics simple for farms. It saw first-hand how NEMA and PLS can be deployed together to make the cost of water extracted by electric pumps cheaper than the cost of water extracted by diesel pumps. That is a significant milestone in energy policy implementation in rural areas.

This project was responsible for 1 percent of the power drop during the emergency event that was declared by Governor Newson in September 2022, when the grid was under extreme strain at the onset of the fire season that coincided with a heat wave and high winds. The project team estimates conservatively that applying PLS to farms covered by IOU territories, which include PG&E and SCE, has the potential to shift 1,500 MW out of the total 3,000 MW load from agricultural users. DR is still useful to dispatch load when farms or water districts cannot consistently turn the pumps off from 5 pm to 8 pm. A significant portion of the California water system uses canals with water levels that are controlled on a 24-hour basis.

The project team also found that groundwater recharge can shift the energy load for well pumps from dry years to wet years by banking diverted flood waters to restore the water table. Over 1,000 MWh of energy reduction and $200,000 in annual savings were observed at one ranch that banked 18,000 Ac-Ft of flood water in the spring and summer of 2023 and restored the level of the water table to pre-drought conditions.

Farming communities are feeling pressured by labor regulations, water use restrictions, and electricity rate increases. They are overwhelmed and need help. By and large, this PLS project was seen with relief by farmers because it clearly and predictably provided cost-saving opportunities that were not antagonistic to farming practices. Quite to the contrary, the increase in farming precision and improved management of irrigation, from afternoon tasks to 15-minute increments, led to improvements in crops (almond, alfalfa, garlic, grapes olive, pistachio, tomato, and walnut) and a reduction in load at peak times during the summer.

The project team recommends that PLS be widely deployed in tandem with other energy efficiency measures (installation of variable frequency drives, pump efficiency tests, conversion to micro-irrigation, etc.) and that agricultural rate payers have access to on-bill financing. The

project team shared its results with the farming community through online classes sponsored by IOUs and field days hosted by important stakeholders, such as a water district. This technology is part of the ongoing evolution of agriculture in response to more frequent and more intense droughts and floods associated with a systemic shift in climate and the dynamic power supply environment resulting from greater penetration of renewable energy resources into the grid.

Two of the case studies, family-owned Terranova Ranch and KG Ranch owned by Olam, have been widely shared on social media, including a mention by Karen Ross, Secretary of the California Department of Food Agriculture. The energy and water data collected during the project will be useful for growers and food processors to comply with the new Senate Bill 253 (Climate Corporate Data Accountability Act) and Senate Bill 261 (Climate-Related Financial Risk Act).

List of Terms/Glossary

Term	Definition
Ac-Ft	acre-foot; volume of water covering an area of one acre to a height of one foot
AGB	Agricultural B rates
AGC	Agricultural C rates
CEC	California Energy Commission
CFS	flow of water in cubic feet per second
CIT	Center for Irrigation Technology
CSU	California State University
DR	demand response
ELRP	Emergency Load Reduction Program
Green Button	Standard to provide end-users with a digital receipt of their utility consumption of energy, and access to third-party applications
HMRD	Henry Miller Reclamation District
HP	horsepower
IOU	investor-owned utility
ISO	Independent System Operator
kW	kilowatt
kWh	kilowatt-hour
M&V	measurement and verification
MW	megawatt
MWh	megawatt-hour
NEMA	Net Energy Metering Aggregation
PG&E	Pacific Gas & Electric Company
PLS	permanent load shifting
ROI	return on investment
SaaS	Software-as-a-Service
SCE	Southern California Edison Company
TAC	Technical Advisory Committee

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Project Deliverables

The project deliverables were:

- Task 1:
  - TAC Meeting Schedules, Agendas and Summaries
  - TAC Performance Metric Summary
  - Project Performance Metrics Results
- Technical Tasks 2 to 4:
  - Seasonal Planning Report
  - Daily Operation Report
  - Yearly Summary Report
- Task 5:
  - List of Farm Sites with Commitment Letters for Summer 2021
  - Updated List of Farm Sites with Commitment Letters for Summer 2022
  - Demonstration and Deployment Report
- Tasks 6 and 7:
  - M&V Findings Report
  - Project Benefits Questionnaire
  - Project Profile on EnergizeInnovation.fund
  - Organization Profile on EnergizeInnovation.fund
- Task 8:
  - Technology Transfer Plan
  - Summary of TAC Comments
  - Technology Transfer Results
  - High Quality Digital Photographs