Heat Pump Water Heater Daily Load Shifting: Advanced Load Up and Evaluation Challenges

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ABSTRACT

Pacific Gas and Electric Company's WatterSaver program launched in March 2022 and has generated a significant amount of data from participating heat pump water heaters and electric resistance water heaters. These units come from different manufacturers and use various connectivity options (i.e., proprietary application programming interface or CTA-2045). The water heaters are controlled to follow different load shifting schedules based on the presence of a thermostatic mixing valve and the Time-of-Use rate the customer is on.

This publication discusses the effects that different operational settings such as Load Up strategy and user setpoint have on water heater daily load shifting benefits for utilities and ratepayers. Results indicate that load shifting affects energy usage throughout the day, not just within a few hours of events, as such, program impacts need to be examined on a 24-hour duration. Initial results show that Advanced Load Up can reliably shift electricity usage from peak hours to times of significant renewable production, while Basic Load Up proves useful over shorter periods. There is no single solution that optimizes all areas (i.e. energy usage, energy shifted out of peak, carbon emissions and comfort) as different levers may have different effects, which means utilities/program implementers have to decide what to prioritize.

Finally, not all connectivity methods are equal, and the industry and regulatory agencies could benefit from data sharing standardization in order to scale load shifting using thermal storage so it can play its part in climate strategies both in California and nationwide.

Introduction

As a result of California's legislative and regulatory efforts to accelerate the electrification of the built environment and increase the share of renewable energy, particularly solar photovoltaic (PV), in the electricity mix, the state is experiencing a deepening of the duck curve (Figure 1). To mitigate this phenomenon the state has increased its efforts to install energy storage capacity, thus adopting Assembly Bill 2868 (Gatto, 2016) which required the California Public Utilities Commission (CPUC) to direct the state's three electric investor-owned utilities to invest in the deployment of distributed energy storage systems. As a result of AB 2868, Pacific Gas and Electric Company (PG&E) proposed a behind-the-meter thermal energy storage pilot program called WatterSaver (the program). The pilot program was conditionally approved by the CPUC in June 2019. The Association for Energy Affordability (AEA) partnered with Energy Solutions and Virtual Peaker (the implementation team or the team) to bid on PG&E's subsequent request for proposal, and the team was selected to implement the program in December 2019.

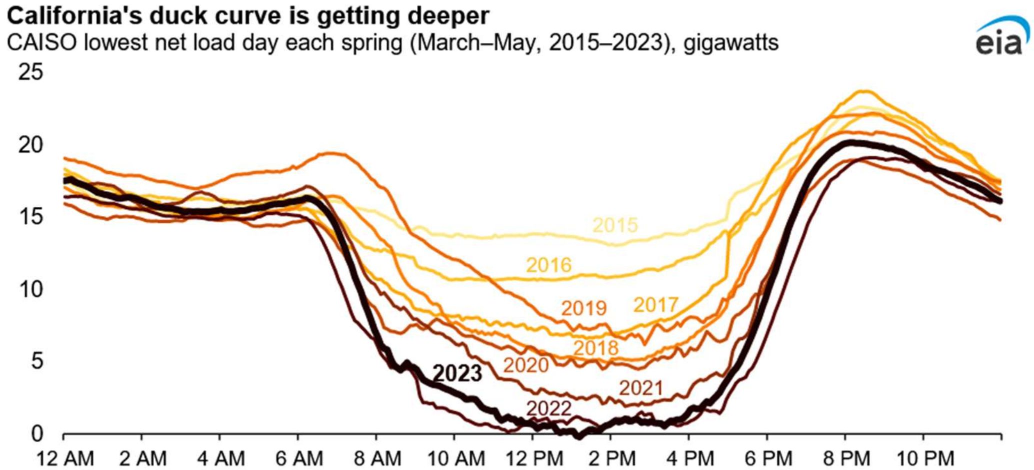

Figure 1. CAISO lowest net load day each spring (gigawatts, March-May, 2015-2023).
Source: EIA 2023 (figure), CAISO (data)

WatterSaver's initial goal was to provide at least 2 MW of peak load reduction by 2025, by controlling existing electric resistance water heaters (ERWHs) and heat pump water heaters (HPWHs). However, due to the nascency of the communication and controls functionality for HPWHs, the slower than expected HPWH adoption, and the difficulties in identifying ERWH customers, the goal has been modified to 0.5 to 1MW. For the program's purpose, peak hours are defined as 4 pm to 9 pm daily. Additional program goals include direct bill savings for customers and greenhouse gas emissions (GHG) reduction. To achieve these goals, the implementation team proposed to use both Basic Load Up (BLU) and Advanced Load Up (ALU), with the expectation that ALU may result in increased daily energy use, but with that energy use happening during peak PV production and at a time when energy rates are lower, it would still result in net bill savings for the customer and net GHG reduction.

Due to the low number of ERWHs enrolled in the program to date, this publication will focus specifically on HPWHs results.

Background

Water Heater Connection and Control Approaches

Since inception, one of WatterSaver's goals has been to work with all Original Equipment Manufacturers (OEMs) who were interested to be able to enroll as many customers as possible. For that reason, the program is using an aggregator that supports both proprietary application programming interface (API) and CTA-2045 approaches to connect and control water heaters. Proprietary APIs rely on Wi-Fi to communicate with water heaters, and the program chose cellular for CTA-2045 communication. These different connection and control approaches result in varied types of data that can be collected and control commands that can be deployed through the program. And even though the use of an aggregator simplifies some aspects of program implementation (i.e. one interface to dispatch commands regardless of connection type, data consolidation), it can also limit the access to certain data and control commands if the aggregator is not set up for them.

While CTA-2045 is available for all OEMs, some OEMs have developed proprietary API specific to their product line. For some legacy water heaters that were not required to comply with the CTA-2045 standard, proprietary API may be the only connectivity option. These proprietary APIs may give access to additional data such as setpoint, temperature and efficiency mode, and some offer the ability to control setpoint and efficiency mode, for a more precise control of water heaters. However, when using an aggregator (as is the case for WatterSaver), access to these more precise control options may not be available to the program implementation team. This API option is available for only a few OEMs, and the exact data (Table 1) and commands (Table 2) available will vary by OEM. Most of WatterSaver's Rheem devices use the API connection pathway. It is being tested for A.O. Smith devices.

Regarding the CTA-2045 standard, multiple versions of the standard are present in the field, which determines what types of water heater data can be collected (Table 1) as well as the commands available (Table 2) for load shifting (ANSI/CTA, OpenADR). The most comprehensive version of the standard is CTA-2045-B Level 2. As of May 2024, only five test devices (from three OEMs) connected to WatterSaver meet CTA-2045-B Level 2. All the other devices enrolled are under the CTA-2045-A or CTA-2045-B Level 1 versions of the standard. As of May 2024, Ariston/American Standard, Bradford White, and GE exclusively use CTA-2045 to carry out load shifting. It is also available for A.O. Smith and Rheem.

To the program team's knowledge, there is no publicly available, comprehensive list of water heater models and their associated CTA-2045 standard version. OpenADR Alliance maintains a list of OpenADR and EcoPort certified products on their website, but in some instances only the manufacturer is listed, not the specific list of models. NEEA includes CTA-2045 certification status on their QPL but without specifying the version of the standard applicable. Having such a list available would simplify program implementation. In the interim, to determine the applicable version of the CTA-2045 standard for the devices connected to the program, OEMs were asked to provide this information for all their CTA-2045 water heater models.

Table 1. Data available per connection type and version of the CTA standard

Data	CTA-2045-A / CTA-2045-B level 1	CTA-2045-B level 2	Proprietary API
Power	Yes	Yes	Yes
Present Take Capacity	Yes	Yes	OEM dependent
Maximum Take Capacity	Yes	Yes	OEM dependent
Advanced Present Take Capacity	No	Yes	OEM dependent
Advanced Maximum Take Capacity	No	Yes	OEM dependent
Setpoint	No	Can be queried	OEM dependent
Temperature	No	Can be queried	OEM dependent
Efficiency Level	No	Can be queried	OEM dependent
Operating Mode	Yes	Yes	OEM dependent
ALU enabled	No	Can be queried	OEM dependent

Table 2. Commands available per connection type and version of the CTA standard

Command	CTA-2045-A (2013)	CTA-2045-A (March 2018) / CTA-2045-B level 1	CTA-2045-B level 2	Proprietary API
Basic Load Up (BLU)	Yes	Yes	Yes	Yes
Advanced Load Up (ALU)	No	No	Yes	OEM/aggregator dependent
Shed	Yes	Yes	Yes	Yes
Critical Peak	No	Yes	Yes	OEM/aggregator dependent
Grid Emergency	No	Yes	Yes	OEM/aggregator dependent
Set Efficiency Level	No	No	Optional	OEM/aggregator dependent

Power Data Reliability

As documented in Metzger and al. (2019), power data reported by water heater control devices is not always reliable. Of the three OEMs represented in the program, only one provides measured power data. The other two report static power values based on whether the HPWH is operating the heat pump, electric resistance, heat pump and electric resistance simultaneously, or idle/off. That number varies by OEM, water heater model and connection type:

- 0W: water heater idle or off
- 356 to 800W: compressor running
- 4500 to 5500W: resistive element running
- 4856 to 5950W: both compressor and resistive element running

The rest of this publication uses data from devices of the OEM providing measured power data (referred to as OEM A).

Water Heater Control Commands

To control water heaters in the WatterSaver program, the program implementer uses the aggregator interface to create a schedule and dispatch commands. The program's dispatched command names are the same as the ones listed in the CTA-2045 standard. The exact water heater response to any given command results from a control algorithm determined by OEMs (Butzbaugh and al. 2022) and/or the aggregator, and thus the HPWH responses to load shifting commands are custom to each OEM and connection type. Table 3 summarizes the observed HPWH behavior in response to specific commands for OEM A, based on data reported by devices via CTA-2045 and/or API.

Initially, the program only used the BLU and Shed commands. The Grid Emergency command, which results in turning off the water heater regardless of the water heater's thermal status, was eliminated due to its impact on customer comfort (it increases the risk of cold-water events). Critical Shed is not in use since not all devices accept it, as shown in Table 2. The ALU command via CTA-2045 was enabled by the program's aggregator in February 2024 and is currently undergoing testing. Up to that point, ALU was conducted solely on devices from OEM A using its proprietary API.

Table 3. Observed response to commands used by WatterSaver per connection type for OEM A

Command	CTA	Proprietary API without TMV	Proprietary API with TMV
Basic Load Up	Temperature set point remains the same, Dead band narrowed No change in efficiency mode	Temperature set point remains the same, Dead band narrowed No change in efficiency mode	Setpoint adjusted to 140 °F, Dead band narrowed No change in efficiency mode
Advanced Load Up (if applicable)	Compressor turns on for a duration based on one of these limiting factors: 1) amount of energy specified in command, 2) duration specified in command, 3) tank reaches its maximum take capacity No change in efficiency mode	Not tested	Setpoint adjusted to 140 °F, Dead band narrowed No change in efficiency mode
Shed	Temperature set point remains the same, Dead band increased Recovery allowed No change in efficiency mode	Setpoint decreased by 10 °F, no lower than 110 °F Recovery allowed No change in efficiency mode	Setpoint decreased by 10 °F, no lower than 110 °F Recovery allowed No change in efficiency mode

Program Participant Cohorts (Platoons)

WatterSaver enrolled its first participants in March 2022. It is opened to participants with and without thermostatic mixing valves (TMV) on their installation. Participants with a TMV may receive ALU commands, while participants without a TMV will only receive BLU commands. Initially, the program only offered 4 pm - 9 pm Shed (4-9 Shed). This aligns with peak hours for customers on the most represented Time-of-Use (TOU) rate among PG&E's customers, TOU-C, as well as customers on TOU-B and the legacy TOU-A. Customers on TOU-D have a 5 pm - 8 pm peak. They are currently placed in the 4-9 Shed groups and may in the future have their own dedicated platoon. In August 2023, a 3 pm - 12 am Shed (3-12 Shed) option was added, to respond to the growing number of applicants on rates with partial peak hours in addition to peak hours, namely EV-A, EV2A and E-ELEC. Ultimately, participants are grouped based on shed duration and load up command applicable, as shown in Table 4.

Table 4. WatterSaver platoons

Platoon	Electricity Rate	Connection Type	Presence of a TMV
4-9 Shed, ALU	Peak only: TOU A, B, C, D	Proprietary API from OEM A	Yes
		CTA-2045-B level 2 (none currently)	Yes
4-9 Shed, BLU	Peak only: TOU A, B, C, D	Proprietary API from OEM A	No
		CTA-2045-B level 2	No
		Proprietary API from other OEM	All
		Other CTA	All
3-12 Shed, ALU	Peak and part-peak: EV-A, EV2A, E-Elec	Proprietary API from OEM A	Yes
		CTA-2045-B level 2 (none currently)	Yes
3-12 Shed, BLU	Peak and part-peak: EV-A, EV2A, E-Elec	Proprietary API from OEM A	No
		CTA-2045-B level 2	No
		Proprietary API from other OEM	All
		Other CTA	All

Methodology

Baseline

To evaluate the pilot impact, a randomized control trial (RCT) protocol is used. Each day at midnight, 10% of devices in active platoons with more than 35 water heaters are set aside and will not receive commands for the day. These numbers (10% and 35 devices) were chosen to balance the need for a baseline to measure the program impact while minimizing the impact on aggregate load shifting results. The baseline protocol has been in place since March 17, 2023, for the 4-9 Shed ALU and 4-9 Shed BLU platoons, and since April 3, 2024, for the 3-12 Shed ALU platoon. It has yet to be started for the 3-12 Shed BLU platoon.

Additionally, load shifting impacts water heaters behavior beyond the Load Up and Shed phases. In particular with ALU and the 3-12 Shed groups, water heaters are impacted during the early hours of the day following an event. For that reason, we look at data from 10 am to 9:59 am the next day. For example, if a water heater was in the active group on April 30, 2024, and is placed in baseline on May 1, 2024, data from April 30, 2024, 10 am to May 1, 2024, 9:59 am will be used for the active group and data from May 1, 2024, 10 am to May 2, 2024, 9:59 am will be used for baseline.

Impact of User Settings

The efficiency mode selected by the user impacts the resistive element (RE) usage. RE trigger is based on internal logic set by the OEMs that revolves around temperature delta to setpoint and varies based on the efficiency mode selected. For water heaters from OEM A, Heat Pump mode is the least likely to trigger the RE, High Demand is the most likely to trigger it and Hybrid mode is intermediate.

User setpoint impacts the amount of energy a device uses. The higher the setpoint, the higher the energy usage. This is the result of a lower coefficient of performance (COP) and increased standby losses. A higher setpoint can also be related to higher hot water usage in general. Since the program does not monitor water flow, quantifying the contribution of each of these factors on energy use is not possible. The user setpoint also affects the HPWH's ability to perform ALU. If the user setpoint is at the maximum allowed by the OEM, then the device will not perform ALU since the temperature is unable to go any higher. For that reason, for all the analyses presented in this paper, the data set has been split as follow:

- ALU: HPWHs from OEM A, connected via proprietary API, with a TMV and user setpoint strictly below 140 °F (maximum allowed by OEM A).
- BLU with setpoint < 140 °F: HPWHs from OEM A, without a TMV and user setpoint strictly below 140°F.
- BLU with setpoint >= 140 °F: HPWHs from OEM A, with or without a TMV and user setpoint equal to or above 140 °F.

In this publication, ALU and BLU results are compared when using a similar schedule and curtailment type, and each active group is compared to its own baseline. For that reason, we are focusing on the 4-9 ALU and BLU Shed groups, under a schedule of 2 hours of Load Up followed by 5 hours of Shed. Data were collected between March 17, 2023, when the baseline protocol was started, and November 30, 2023, after which the Load Up durations were adjusted by the program. Table 5 summarizes the number of unique devices and days of data used in this publication. A HPWH from OEM A with a TMV may have its data used in multiple groups listed in table 5 below. For example, if the customer was initially on a TOU-C rate, with a setpoint of 130 °F, data would be used for the 4-9 Shed ALU analysis. If they then adjusted the water heater setpoint to 140 °F, data would be used for the 4-9 Shed BLU - setpoint >= 140 °F analysis.

Table 5. Unique devices and days of data per load shifting group and user efficiency mode for the period March 17, 2023, to November 30, 2023

Load Shifting Group		Unique devices	Days of Data	Heat Pump Days	Hybrid Days	High Demand Days
4-9 Shed ALU	Active	57	4845	906	3782	157
	Baseline	55	623	115	492	16
4-9 Shed BLU – setpoint < 140 °F subset	Active	62	8692	2572	5750	370
	Baseline	60	925	253	636	36
4-9 Shed, BLU – setpoint >= 140 °F subset	Active	47	3376	601	2715	218
	Baseline	40	281	55	218	8

Greenhouse Gas Emissions (GHG) Emissions Impact

GHG emissions impact is calculated using annualized hourly GHG content of California's electrical grid from the CPUC Avoided Cost Calculator (CPUC) for the period 2023-2025. The values used are summarized in Table 6.

Table 6. GHG content of the California grid per hour

Hour	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Average kg CO2e/kWh (2023-25)	0.35	0.35	0.34	0.35	0.35	0.35	0.33	0.29	0.26	0.25	0.25	0.24
Hour	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Average kg CO2e/kWh (2023-25)	0.24	0.23	0.25	0.29	0.37	0.45	0.45	0.46	0.45	0.43	0.39	0.38

Results

Basic Load Up

WatterSaver results for BLU are consistent with results from past publications (BPA 2018, Illume 2019, Demand Side Analytics 2021, Gabriel 2024) when it comes to energy shifted out of peak and peak power reduction. BLU with setpoint >= 140 °F (Figure 3 and Table 7) yields higher energy savings during peak hours and higher peak power reduction compared to customer on lower setpoints (Figure 2 and Table 7). However, that group uses 30% more energy throughout the day (4 kWh vs 3.08 kWh).

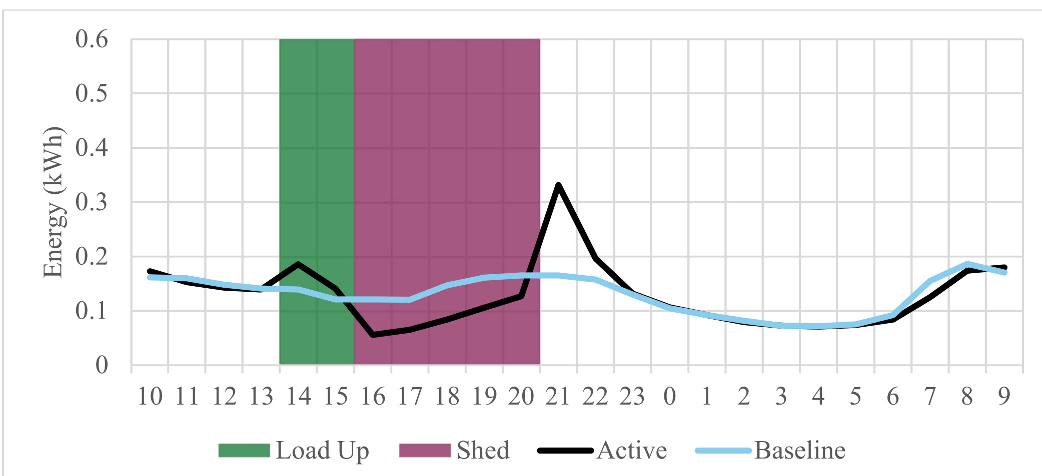

Figure 2. Daily energy usage profile of the BLU with setpoint <140 °F subset, 4-9 Shed and 2hrs Load Up (population-based average)

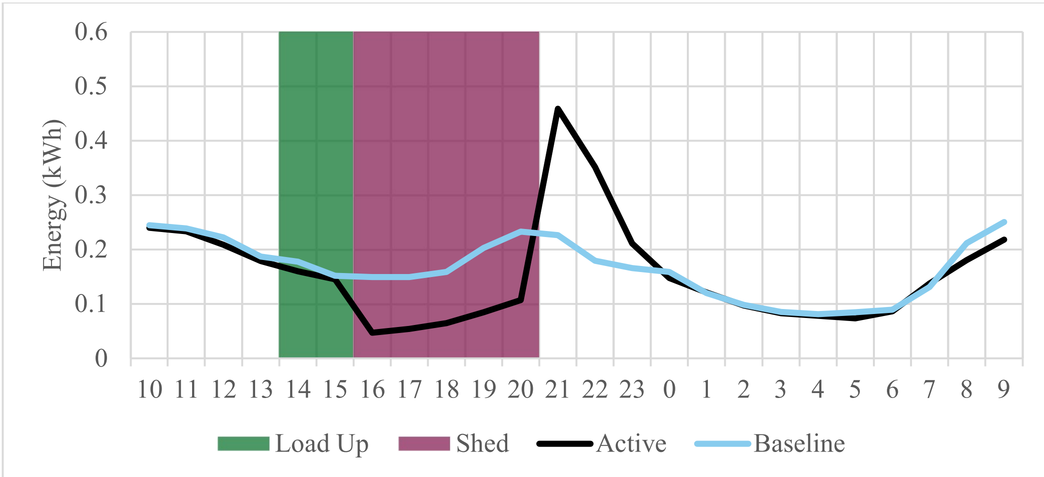

Figure 3. Daily energy usage profile of the BLU with setpoint >=140 °F subset, 4-9 Shed and 2hrs Load Up (population-based average)

Table 7. BLU impact per subset, based on user setpoint

	Setpoint < 140 °F Subset			Setpoint >= 140 °F Subset		
	Baseline	Active	Difference	Baseline	Active	Difference
Total Daily Energy Usage - kWh	3.14	3.09	- 0.05	4.00	3.77	- 0.23
Energy Usage Load Up (2pm-4pm) - kWh	0.26	0.33	+ 0.07	0.33	0.30	- 0.03
Energy Usage Shed (4pm-9pm) - kWh	0.71	0.44	- 0.27	0.89	0.36	- 0.53
Max Power Reduction during Peak (4pm-9pm) - kW			0.12			0.22
Total GHG Impact (annual) - kg CO2e	383	373	- 10	485	453	- 32

Advanced Load Up

On average, ALU reduces energy usage during peak hours by 0.49 kWh per device. The benefits continue for a few hours after the end of the Shed period. ALU results in a peak power reduction of 0.20 kW per device around 7:30 pm and an average annual GHG emissions reduction of 35 kg of carbon dioxide equivalent (CO2e). However, ALU results in increased energy usage on average (Figure 4 and Table 8). This is likely due to a combination of the HPWH operating at a lower COP, greater water heating load (due to higher temperature rise), higher thermal losses, as well as the RE being triggered during the Load Up phase due to a large setpoint delta (see RE Usage section).

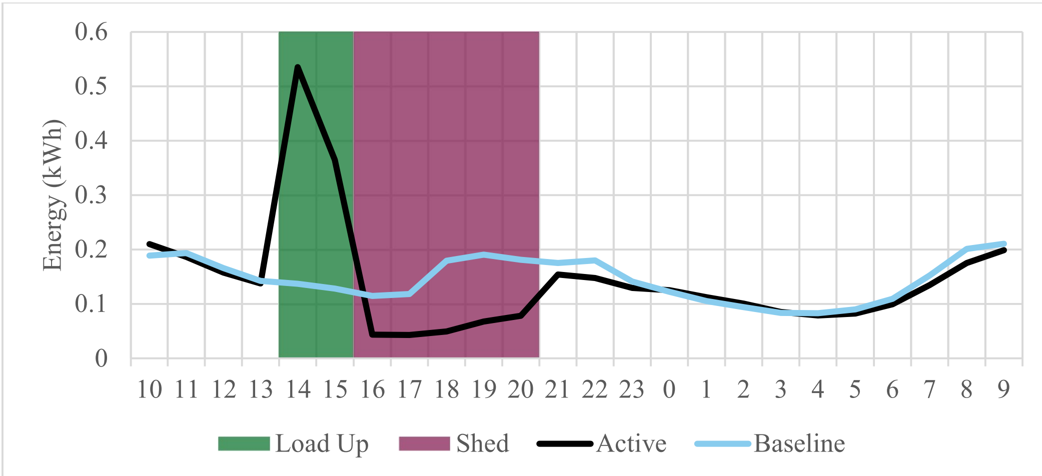

Figure 4. Daily energy usage profile of the ALU group, 4-9 Shed and 2hrs Load Up (population-based average)

Table 8. ALU impact

	Baseline	Active	Difference
Total Daily Energy Usage - kWh	3.48	3.49	+ 0.01
Energy Usage Load Up (2pm-4pm) - kWh	0.26	0.90	+ 0.64
Energy Usage Shed (4pm-9pm) - kWh	0.78	0.28	- 0.50
Max Power Reduction during Peak (4pm-9pm) - kW			0.20
Total GHG Impact (annual) - kg CO2e	426	391	- 35

Resistive Element Usage

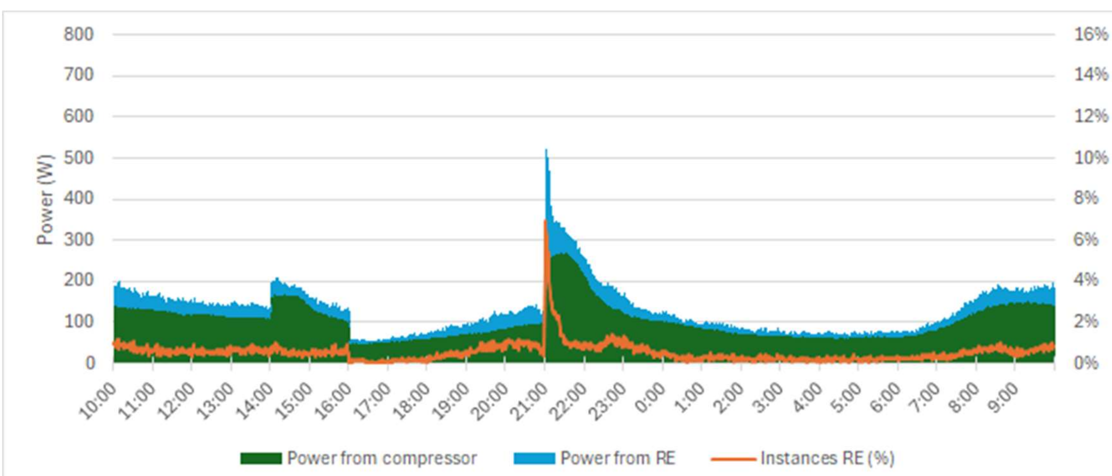

Figure 5. Daily power usage profile of the BLU with setpoint <140 °F subset, 4-9 Shed and 2hrs Load Up (population-based average)

RE usage is triggered by load shifting at the beginning of the Load Up phase for devices in the ALU group (Figure 7), and at the beginning of post-Shed recovery for devices in the BLU groups (Figure 5 and 6). This is due to the higher temperature delta at these specific times.

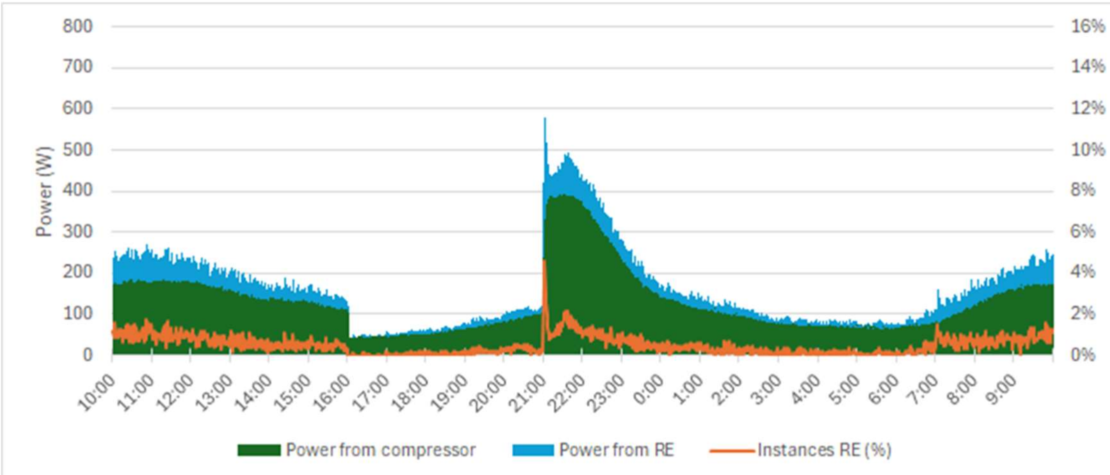

Figure 6. Daily power usage profile of the BLU with setpoint >=140 °F subset, 4-9 Shed and 2hrs Load Up (population-based average)

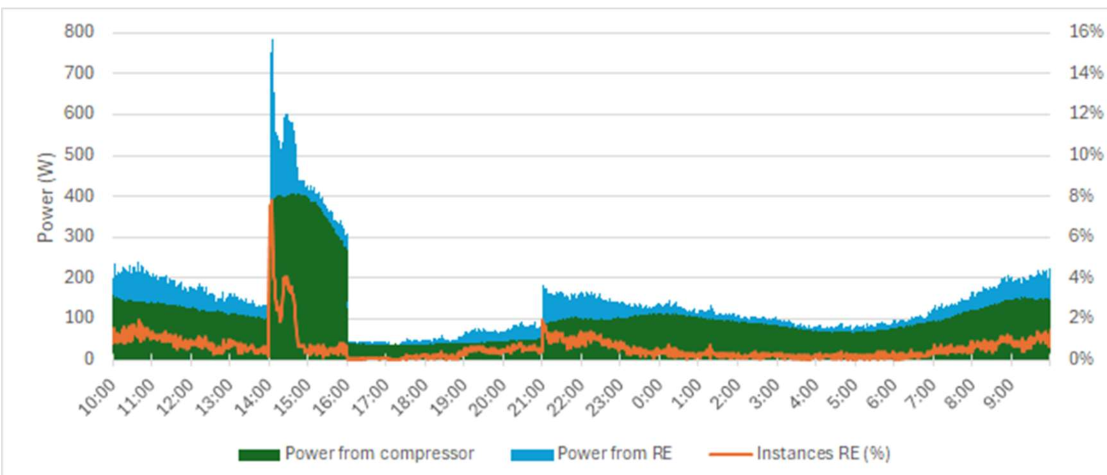

Figure 7. Daily power usage profile of the ALU group, 4-9 Shed and 2hrs Load Up (population-based average)

Outside of the Load Up and immediate post-Shed periods, RE usage is stable throughout the day and similar for all active groups and their baseline, at 0.6% instances. That share of instances rises to 8% at the beginning the Load Up period for the ALU group, when setpoint is raised to 140 F. It raises to 7% for the BLU with setpoint < 140 °F group and 5% for the BLU with setpoint >= 140 °F group at the beginning of the post-Shed recovery when setpoint goes back to the user setpoint, 10 °F above the Shed setpoint.

This increase in RE usage is driven by participants with their water heaters in Hybrid and High Demand mode, as shown in Table 10. While the number of instances remains small, it has a significant impact on the program results due to the power draw being an order of magnitude higher (4500W vs 400W).

Table 10. Share of RE usage by group, efficiency mode and period of the day

	ALU - Active	ALU - Baseline	BLU < 140 °F - Active	BLU < 140 °F - Baseline	BLU >= 140 °F - Active	BLU >= 140 °F - Baseline
Load Up – Heat Pump	0%	0%	1%	0%	1%	0%
Load Up – Hybrid	15%	7%	6%	8%	4%	4%
Load Up – High Demand	11%	2%	2%	2%	3%	5%
Post-Shed (9pm-0am) – Heat Pump	0%	0%	2%	1%	2%	1%
Post-Shed – Hybrid	15%	12%	22%	15%	16%	2%
Post-Shed – High Demand	1%	3%	5%	2%	10%	8%
Other periods – Heat Pump	1%	0%	7%	4%	8%	7%
Other periods – Hybrid	41%	55%	40%	52%	45%	43%
Other periods – High Demand	17%	21%	17%	17%	12%	30%

Impact of Rate Structure

In addition to grid and GHG impacts, the impact of load shifting on participants' bills was analyzed. To do so, the default TOU rates in PG&E and Southern California Edison (SCE) territory were used. PG&E's default rate, TOU-C, has a low peak/off-peak price differential varying between 6% in Winter and 15% in Summer. SCE's default rate, TOU-D-4-9pm, has a large peak/off-peak price differential, around 40% year-round (Table 11).

Table 11. PG&E and SCE default TOU rate in $/kWh, after baseline credit applicable March 1, 2024

	Winter Off Peak	Winter Peak	Winter Super Off Peak	Summer Off Peak	Summer Peak
PG&E TOU-C	0.39	0.42	N/A	0.44	0.52
SCE TOU-D-4-9	0.30	0.44	0.27	0.28	0.51 (weekdays) 0.39 (weekends)

The peak/off-peak price differential plays a significant role in bill impact. A larger differential can result in savings even when energy usage is increased, as illustrated by the reduction in bills for ALU under SCE's default TOU rate (Table 12).

Table 12. Impact of load shifting (4-9 Shed, 2hrs Load Up) on annual customers' bill (population-based average)

	Average Annual Electricity Bill	Program Impact ALU		Program Impact BLU <140F		Program Impact BLU >= 140F	
PG&E TOU-C	$2000	- $7	- 0.4%	- $12	- 0.6%	- $43	-2.1%
SCE TOU-D-4-9	$1600	- $32	- 2%	- $21	- 1.3%	- $55	-3.4%

In the absence of control over rate structure, the program implementation team is focusing its efforts on reducing ALU impact on energy usage. Being energy neutral will ensure that load shifting does not negatively impact customers' bills, regardless of rate structure.

Discussion

Benefits of Different Load Up Strategies

BLU remains a valuable tool for peak demand reduction. It results in net energy savings and net GHG emission reductions. It is also the only available load shifting strategy for a significant portion of HPWHs (75% of HPWHs and all ERWHs enrolled in WatterSaver as of May 2024).

ALU, which requires TMVs to "super heat" water without scalding risks for participants, effectively shifts electricity usage out of utility peak load periods (i.e., reducing peak demand) into periods when renewable energy generation is high. It also allows for more energy savings during Shed, allows for longer Shed durations, and eliminates the post-Shed recovery peak typical of BLU. Given the net demand profile and GHG content of electricity in California, ALU is a desirable tool for GHG reduction strategies.

However, as noted previously, a TMV alone is not sufficient to enable ALU. Devices need to be at a lower setpoint than the maximum temperature allowed, which varies by OEM. To the extent possible, storage should be prioritized when sizing HPWHs so they can be operated at 120 °F or the OEM recommended setpoint, in heat pump only mode, and meet domestic hot water needs of the customer. A higher setpoint results in higher energy usage due to lower COP and higher standby losses. If space is a constraint, the TMV can be used to set the HPWH to a higher setpoint at all times. This may decrease the energy efficiency of the HPWH compared to a setpoint of 120 °F, but the efficiency is still an improvement over an electric resistance water heater.

Command Response and Data Standardization

The CTA-2045 standard accommodates multiple communication protocols, enabling many different approaches to dispatching commands and receiving response confirmation. However, no standardization exists regarding the HPWH's response to a given command, as documented by Peresa (2024). Combined with the absence of standard regarding data reporting (Metzger 2019, Besson 2024, Peresa 2024), it complicates determining the true potential for and impact of load shifting programs as data from one OEM cannot be extrapolated to others. While Butzbaugh and Winiarsky (2020) describe a methodology to forecast load shifting potential at a regional or utility level, a simpler solution would be to evolve the CTA-2045 standard to a conformance standard, explicitly describing what a water heater should do in response to a command (for example: in response the a Shed command, a water heater will drop its setpoint by 10 °F and may recover using its compressor only), as well as the degree of precision expected for data reporting (for example: power reported within 5% of measured power). Moving to a conformance standard would also respond to questions and request for guidance that the program implementation team heard from multiple water heater OEMs.

Access to temperature setpoint and measured tank temperature will help load shifting program administrators determine which load shifting strategy to apply to a given device. If a device has its setpoint at 140 °F and shows a high usage profile, they could decide to place the device in a group that would only do event-based load shifting, during the most critical days of the year. On the other hand, if a device has its setpoint at 120 °F and shows low usage profile during evening peak, they could decide to place the device in a daily load shifting group with a long Shed.

Commands Available to Third Parties

Having access to the full array of DR commands and data reporting covered by CTA-2045B level 2 standard, including optional features such as the Set Efficiency commands is necessary to ensure success of large-scale daily load shifting programs. The Set Efficiency command will help address instances of RE usage triggered by load shifting, both for the ALU group during Load Up and the BLU group during post-Shed recovery. Specifying the efficiency mode during the Load Up phase for the ALU group and having the option to specify efficiency mode for a few hours post-Shed for the BLU group, would help optimize load shifting.

In addition to working with OEMs to transition to the most recent version of the standard, including optional commands, it is important to ensure that aggregator platforms also support all CTA-2045-B level 2 features. Otherwise, program implementers using these types of platforms may not have access to some data necessary to make informed decisions on the best load shifting strategy based on user profile and potentially some DR commands.

Conclusion

While load shifting and especially ALU shows promising results, a significant amount of progress is still needed at the industry level to make daily load shifting a reliable tool in California’s GHG reduction strategy. Beyond ensuring that all HPWH and ERWH installed in the future meet the most comprehensive communication standard, both in new construction and retrofit applications, the utilities and program implementers need to strike a balance between pursuing the highest environmental and grid benefits such as GHG reduction, maximum kWh/kW shifted outside of peak, maximum energy usage during peak renewable production while weighing the potential negative effects on the participants (i.e. bill impact, risk of cold water) that could affect customer willingness to enroll in these types of programs.

The WatterSaver implementation team is dedicated to making large scale load shifting a reality and will continue to share and publish its learnings on various aspects of the program such as the impact of temperature setpoint on HPWH performance and load shifting results, and the impact of Load Up duration on load shifting results.

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