Condensing Hybrid Water Heater Performance Field Evaluation Report
FSTC Report # 5100131004-R0

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Test Site:
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San Ramon, CA 94583

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Retention of this consulting firm by PG&E to develop this report does not constitute endorsement by PG&E for any work performed other than that specified in the scope of this project.

Acknowledgments
FSTC acknowledges the support provided by Jeff Jordan and Jason Hanleybrown of the Fast Water Heater Company in designing and installing the hybrid water heating system and their technical support through this entire project. We also would like to thank Enrique and Carlos Gomez and their restaurant staff in accommodating us on our on-site visits.

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Executive Summary

The hot water load represents a significant portion of the energy and water consumed in a commercial foodservice operation. The objective of this field study was to characterize the hot water demand and associated energy use of an existing standard-efficiency gas-fired storage water heater monitored sequentially with a high-efficiency (condensing) gas-fired hybrid water heater replacement in a quick-service restaurant. All work was done under the auspices of the Pacific Gas and Electric Company (PG&E) within the scope of the Food Service Technology Center (FSTC) program.

The study was conducted at a Mexican-themed quick-service restaurant located in San Ramon, California. From the perspective of the restaurant owner, key motives to participate in this study were space savings, energy savings, and end-of-life heater replacement. Key motives for the manufacturer and plumbing contractor were to demonstrate the hybrid heater technology in a commercial foodservice facility, show energy savings of hybrid heaters versus standard-efficiency units and highlight other benefits versus conventional storage and tankless units. The existing water heater in this restaurant was a 76,000 Btu/h, 75 gallon standard-efficiency water heater. The FSTC collaborated with the Fast Water Heater Company on this project. FSTC’s role was to monitor the original system and the new system after the Fast Water Heater Company had installed the hybrid heater. The replacement heater was a high-efficiency hybrid heater with qualities similar to a storage water heater with two gallons of internal storage and a tankless heater with a high input burner in a wall-hung unit. This unit had an input rate of 195,000 Btu/h (with a thermal efficiency of 98% as listed in the manufacturer’s specification sheet) and was installed in tandem with a 7.2-gallon wall-hung supplemental storage tank to handle the peak water flow requirements of a door-type dishwasher. With tankless and hybrid water heaters installed without an external storage tank, the hot water flow at full capacity can be restricted to maintain a constant [setpoint] outlet temperature, thus affecting flow-sensitive equipment in the restaurant such as the dishwasher.

All pertinent data was logged at five-second intervals. The parameters of interest were temperature of the incoming cold water, temperature of the outgoing hot water, water flow through the heater, and gas consumption of the heater. The daily hot water consumption averaged 300 gallons per day (gal/d), nominally ranging from 200 to 400 gal/d over the monitoring period. With both heaters, peak flow rates were comparable at 12 gallons per minute (gpm) calculated over a five-second interval, and approximately eight gpm based on the average over a one-minute period. This confirmed that the hybrid heater, combined with an external storage tank, functioned like a storage water heater by providing adequate hot water flow to sinks and other equipment. Figure ES-1 illustrates a water use profile for a heavy hot-water-use day with the hybrid heater in operation. On this day, the average outlet temperature during flow periods was 149°F. Averaged over the monitoring period, with a 67°F cold water supply temperature, the hybrid heater delivered a 146°F outlet temperature. This showed that the hybrid water heater installed with the external storage tank maintained outlet temperatures well above the minimum food safety guidelines of 120°F.
Figure ES-1: Daily Hot Water Use and Temperature Profile of Hybrid Heater

Figure ES-2 shows a plot of daily energy efficiency versus daily hot water use for the standard-efficiency storage and high-efficiency hybrid water heaters. The overlaid trendline for each heater shows the operating efficiency increase, hence energy savings of the hybrid condensing heater.

Figure ES-2: Daily Operating Efficiency Versus Hot Water Use
Calculated water heating energy efficiencies, projected annual gas consumption, and operating costs for the two heaters for a typical small quick-service restaurant are shown in Table ES-1. The energy use of both heaters was normalized for a water consumption of 310 gal/d and an 80°F temperature rise. Daily operating energy efficiencies averaged 66.1% for the standard-efficiency storage heater and 88.1% for the high-efficiency hybrid heater.

**Table ES-1: Summary of Results and Energy Cost Projections**

<table>
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<th>Standard-efficiency Storage Heater</th>
<th>High-efficiency Hybrid Heater</th>
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<td>Average Water Consumption (gal/d)</td>
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<tr>
<td>Mass-Weighted Average Temperature Rise</td>
<td>80°F</td>
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<tr>
<td>Average Daily Operating Efficiency (%)</td>
<td>66.1%</td>
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<td>Projected Gas Consumption (therms/y)*</td>
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<td>Projected Annual Cost ($/y)**</td>
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* Results normalized to 363 days/year operation
** Based on $1.00/therm. Does not include electricity costs attributed to water heater blower motors and water pump.

The annual energy cost of the standard-efficiency storage water heater was projected to be $1,141, while the cost for the high-efficiency hybrid heater was projected to be $856. The high-efficiency hybrid heater energy cost saving would be $284 per year over the standard-efficiency storage unit.
Introduction

Background
The hot water load represents a significant portion of the energy and water consumed in a commercial foodservice operation. The opportunity to reduce the energy use of water heaters by replacing standard-efficiency, gas-fired heaters with high-efficiency condensing storage and tankless heaters has been demonstrated in previous studies conducted by the Food Service Technology Center (FSTC) in quick- and full-service restaurants. These studies are available for download at www.fishnick.com/publications/waterheating/. Although these high-efficiency heaters are economically viable for replacement in restaurants and deliver paybacks in the one- to four-year range, restaurateurs have not embraced condensing heater technology in California, where penetration rates are estimated to be in the 10% range.

With the advent of the gas-fired hybrid water heater, which incorporates condensing technology and integrates the benefits of both tankless and storage heaters, there is an opportunity to introduce and market an emerging product to sweeten the value proposition for operators. The goal of the hybrid heater is to reduce the operating costs for water heating, while saving space in the kitchen and maintaining solid hot water delivery performance. The types of foodservice facilities that would benefit the most include cafés and quick-service restaurants, which are light hot-water users and have compact kitchens where saving space is highly valued.

Objectives and Scope
The objective of this field study was to (1) characterize the hot water demand and hot water load in a fast-casual Mexican-themed restaurant, (2) document the associated energy use of the existing standard-efficiency gas-fired storage water heater and monitor it sequentially with the replacement high-efficiency gas-fired hybrid heater in the restaurant, (3) characterize the hot water delivery performance of both the storage and hybrid heater. All work was done under the auspices of the Pacific Gas and Electric (PG&E) Company within the scope of the FSTC Program.

Water Heater Technologies
A high-efficiency water heater differs from a standard-efficiency unit in its ability to transfer energy from the combustion gasses to the water. Generally, a high-efficiency unit will utilize a multi-pass heat exchanger design as opposed to the single-pass system of most standard-efficiency units. The former allows substantially more heat to be extracted from the hot combustion gasses and transferred to the water. In this case, these gasses are cooled below the dew point temperature, causing water vapor in the combustion product to condense. High-efficiency (condensing) water heaters exhibit thermal efficiencies around 95%, as opposed to 80% for standard-efficiency, non-condensing units.
There are four types of water heaters installed in restaurants: Storage heaters, boilers with external storage tanks and recirculation pumps, tankless heaters, and hybrid heaters. The most common type is a storage heater, which accounts for approximately 85% of installations in restaurants. Boilers with external storage tanks are found typically in the largest full-service restaurants. Tankless heaters are typically found in much smaller facilities like cafés and quick-service restaurants, but are occasionally found in full-service restaurants as well. The hybrid heater has only been on the market for a few years, so there are a limited number of installations in commercial kitchens. The operation of each heater type is unique and will be characterized briefly to help distinguish the operating characteristics of the hybrid heater installed in this facility.

Storage heaters integrate the burner and storage tank into one unit. The input rates of the burners are lower since the large volume of water in the tank buffers high volume draws. The benefit is that these units can handle peak flow rates easily, as there is little pressure loss. However these units are heavy and take up a larger amount of space in the kitchen, as they are typically installed on the floor. They may also run out of hot water if sized incorrectly, in terms of input rate and tank volume relative to the minimum hourly recovery capacity requirements of the facility.

A tankless water heater, as its name implies, has no internal hot water storage capacity and is light enough to be wall-hung (though it may be integrated with an external storage tank and a temperature-controlled recirculation pump). The main advantages of tankless water heaters are their compact size and their ability to provide a continuous supply of hot water at a certain maximum flow rate (which is dependent on the associated temperature rise between the incoming cold water to the outgoing hot water). Not having a storage tank limits their capacity to deliver hot water during transient periods of high water consumption. An individual unit with the burner rated at 199,000 Btu/h will have a maximum water flow rate for a given temperature rise (e.g., five gpm at a 70°F rise). Depending on the particular application, this “flow limiting” characteristic may or may not be acceptable. In some instances, limiting hot water flow may interfere with the performance of other equipment, such as a dishwasher. In other cases, it might only slow cleaning time since the time to fill a pot sink with hot water, for example, may increase. It is important to determine the minimum acceptable peak flow rate for a given application. With tankless heaters, the water is only heated when flow is initiated, and if the heater has cooled down, it takes 15 to 30 seconds before the water reaches the setpoint temperature. Most tankless heaters installed in restaurants do not work well with door-type dishwashers that require 140°F hot water in short time spans of 5 to 20 seconds.

A boiler with an external storage tank and recirculation pump takes up a larger amount of space and is the most expensive to install, but makes up for it by having a longer operating life. They are typically used in very large commercial or institutional kitchens where the combination of long operating life and very high hot water load plays to the strength of these units. The hybrid water heater combines the water storage and recirculation capability of a storage heater and endless hot water characteristics, compact size and the wall-mounting feature of a tankless heater. The hybrid heater has a small internal storage tank to handle peak short-term draws and is able to operate with continuous recirculation systems.
Site Description

The study was conducted at Mexxi’s Taqueria, an independent quick-service restaurant with a Mexican-theme menu located in San Ramon, California. The hours of operation are Monday through Saturday, from 11 a.m. to 9 p.m. The size of the establishment including dining room and kitchen is 1,300 square feet with 400 square feet of patio space. The dining area inside the restaurant has 40 chairs and the patio has 20 chairs. This site was chosen because the owner was very motivated to replace the existing storage heater since it was approaching its “end of life”, and he also expressed interest in a smaller wall-hung unit to free up floor space in the back of the store.

Existing Equipment

The original storage water heater was a vintage A.O. Smith model BT-80 standard-efficiency unit with a 75-gallon tank and 76,000 Btu/h input rate (Figure 1). It handled all water-heating needs, including one preparation sink, one door-type low temperature dishwasher, one three-compartment sink with pre-rinse sprayer, one mop sink, one hand sink, and two lavatory sinks. The heater was located in the back of the kitchen next to the mop sink by the back door. The compact floor plan ensured reasonable hot water delivery performance in the bathrooms and at the dishwasher without the need to use a continuous recirculation loop and pump.

Technical Approach

Replacement Equipment

The FSTC worked with Fast Water Heater Company to install a Grant Hall Eternal GU195S with a 195,000 Btu/h input rate and an internal two-gallon storage tank (Figure 2). This wall-hung hybrid water heater is a high-efficiency condensing heater rated with a thermal efficiency of 98%. The heater was installed approximately six feet off of the ground, providing space beneath it for the addition of a storage table when the project was completed.

It was determined that the hybrid heater on its own may not have the capacity to meet the peak flow requirements of the dishwasher, so a seven-gallon external storage tank was installed next to the heater to act as a...
buffer and ensure the heater would sustain the short-duration, high-flow draws characteristic of most door-type dishwashers during their rinse operation (Figure 3). The plumbing was arranged so that hot water would be recirculated from the heater (at 155°F temperature setpoint) to maintain a 140°F external storage tank temperature. As installed, the hybrid heater operates similarly to a boiler with a storage tank.

Test Instrumentation
The instrumentation package included a diaphragm gas meter with a one-pulse-per-cubic-foot output, an ultrasonic water meter with a 40-pulse-per-gallon output installed on the cold water supply, and temperature probes (Type T thermocouples) installed at the water inlet and outlet piping of each heater. A data acquisition system, operating with a one-second scan interval and a five-second recording interval, logged the average inlet and outlet water temperatures, and the cumulative water and gas consumption from the meters’ pulse outputs.

Onsite Test Plan
Water heater daily operating efficiency was defined as the amount of energy required to heat the daily water volume (from the measured inlet temperature to the measured outlet temperature) divided by the daily gas consumption of the water heater. After collecting and analyzing the data, daily operating efficiencies were calculated using the following formula:

$$\text{Operating Efficiency} = \frac{\text{Energy into Water}}{\text{Energy Consumed by Heater}}$$

$$\text{Operating Efficiency} = \frac{\text{Mass Flow Rate}_{\text{water}}[\text{lbs/day}] \times \Delta T_{\text{water}}[^{\circ}\text{F}] \times C_{\text{p}}_{\text{water}}[\text{Btu/(lb \times ^{\circ}\text{F})}]}{\text{Volumetric Flow Rate}_{\text{gas}}[\text{ft}^3/\text{day}] \times \text{Higher Heating Value}_{\text{gas}}[\text{Btu/ft}^3]}$$

In calculating these daily efficiencies, Mass$_{\text{water}}$ * $\Delta T_{\text{water}}$ was computed for each five-second test interval, summed over the day, and then divided by gas energy. This technique eliminated the inclusion of any no-flow periods to correctly calculate the operating efficiency. Reported average mass-weighted inlet and outlet temperatures were calculated by dividing the daily summed five-second interval Mass$_{\text{water}}$ * $\Delta T_{\text{water}}$ values by the daily Mass$_{\text{water}}$ total. A higher heating value of 1,022 Btu/ft$^3$, representative of gas supply in the area, was used in all efficiency calculations.
Results and Discussion

Hot Water Load

The restaurant’s average daily hot water consumption was 306 gal/d (dashed line in Figure 4) and ranged between 157 and 521 gal/d (highlighted in red) when the restaurant was open over the 145-day monitoring period. The restaurant was closed on Sundays, and therefore the hot water use for that day was not factored into the average daily water use calculation. The storage water heater was monitored for 21 days and the hybrid water heater was monitored for 124 days. Average daily hot water use was equal for both heaters.

![Figure 4: Daily Hot Water Use over Monitoring Period](image)

Figure 5 shows a histogram of daily hot water use throughout the monitoring period, represented in 20 gal/d intervals. The histogram reflects a bell curve for the days when the restaurant was open to the public. The average (or mean) and median daily water use rates of 306 and 305 gal/d, respectively also help demonstrate the uniformity of the daily hot water use data.
During the Monday through Saturday operating week, with the exception of Friday (where extra traffic to the restaurant drove up hot water use by 40 gallons), average hot water use was very consistent at approximately 300 gal/d, as shown in Figure 6. Figures 4-8 show that this facility had a consistent daily operating schedule, with minimal variation in day-to-day hot water use.

**Flow Profile**

The typical daily hot water flow profile, measured with the storage heater in operation, is shown in Figure 7. In the morning, there was hot water used for store cleaning and sanitation of wares after food preparation. In the afternoon, there was significant use for dish sanitation after lunch, food preparation prior to dinner, and dish sanitation after evening meals. The majority of the flow rate spikes corresponded to the dishwasher in the rinse operation. On this typical day shown, the dishwasher used approximately half the hot water total.
Figure 7: Typical Daily Hot Water Use Profile and Load (300 gal/d)

The maximum hot water use day (Figure 8) occurred when the hybrid heater was in operation. On this day, there appeared to be additional cleanup before lunch preparation from 8 a.m. to 10 a.m. and a much busier day overall, as dish sanitation remained steady from 2 p.m. to 10 p.m.

Figure 8: Maximum Daily Hot Water Use Profile and Load (500 gal/d)

Peak hot water flow rates are provided in Table 1. The AVG Peak Flow involved sorting the data into bi-monthly periods and identifying the maximum peak flow rate during that period and then averaging the values. The MAX Peak Flow is the maximum peak flow rate overall throughout the monitoring period. Peak flow rates from a five-second interval to the peak two-hour demand are listed, mainly for reference to aid in sizing water heaters for similarly-sized facilities. The data reported in gallons per minute (gpm) from five
seconds to three minutes can be used to size for tankless and hybrid heaters, while the data presented in gallons can best be used in sizing storage heaters. The hybrid heater was able to handle MAX Peak Flows in gpm at similar flow rates compared to the storage heater.

<table>
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<th>Table 1: Maximum Hot Water Flow Rates</th>
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<tr>
<td>AVG Peak Flow</td>
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<td>MAX Peak Flow</td>
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**Water Heater Characteristics and Performance**

Performance differences between the two water heating technologies were observed with respect to the thermostat setpoint in relation to the delivered outlet temperature. Typically, tank-type heaters cycle the burner to maintain the average tank temperature at or above the thermostat setpoint to deliver water at or above its setpoint. The thermostat on this heater was missing the faceplate, so we could not verify that the setpoint was below the average outlet temperature. The monitoring data showed that the burner fired when the outlet temperature was approximately 145°F and turned off at 152°F. During the monitoring period in fall 2012, the standard-efficiency storage water heater delivered water at a mass-weighted average outlet temperature of 148.8°F with a mass-weighted average inlet temperature of 72.2°F. The storage heater water flow rate and temperature profile for a 24-hour period on October 27 are shown in Figure 9. The water heater maintained outlet temperatures above 140°F during the majority of the operating day, with an average outlet temperature of 149°F. The water flow profile (in black) is representative of a high water use day.

![Figure 9: Storage Heater Water Flow Rate and Temperature Profile](image)
The hybrid heater was installed in combination with a 7.2-gallon external storage tank. Hot water was maintained in the storage tank at a setpoint temperature of 140°F. Upon a hot water draw, the heated water from the external tank flowed back through the hybrid heater and through the two-gallon internal tank that was being maintained at a 155°F thermostat setpoint before flowing to its destination. A piping schematic and operating sequence for the hybrid system is displayed in Figure 10 for when the dishwasher is in operation.

![Figure 10: Storage Tank (Left) and Hybrid Heater (Right) Piping Schematic and Operating Sequence](Photo Credit: Fast Water Heater Company)

The monitoring data showed that the hybrid heater typically delivered hot water at below the heater setpoint, but above the storage tank setpoint. During the monitoring period in winter, the high-efficiency hybrid water heater delivered a mass-weighted average outlet temperature of 145.7°F with a mass-weighted average inlet temperature of 66.1°F. The hybrid water flow rate and temperature profile for a 24-hour period on April 19 are shown in Figure 11. The temperature measured on the outlet pipe of the heater (in red) maintained an average outlet temperature of 149°F when there was hot water flowing. When the hot water pipe had cooled during zero flow periods, the outlet water temperature dipped to as low as 122°F. The water use profile (in black) shown on this graph is representative of a high water use day.
Both units maintained hot water at elevated temperatures to ensure the hot water delivery temperature at various sinks. The dishwasher was above the minimum food safety requirements of 120°F, and hot water was able to reach the low-temperature dishwasher at the manufacturer’s recommended inlet temperature of 140°F (instead of the manufacturer’s minimum inlet temperature specification of 120°F). To emphasize the ability of the hybrid heater to maintain outlet temperatures at 120°F or above, the highest hot water consumption day over the 145-day monitoring period at 521 gallons was on February 15, displayed in Figure 12. It shows that the hybrid heater was able to produce a mass-weighted average outlet temperature of 145°F.
Figure 12: Hybrid Heater Flow Rate and Temperature Profile on Highest Water Use Day

Zooming in to look at a six-hour period between noon and 6 p.m. in Figure 13, it clearly shows that the only times the temperature in the outlet pipe dipped below 120°F was during no-flow periods. During flow periods, the minimum temperature measured on the hot water pipe was 130°F.

Figure 13: Hybrid Flow Rate and Temperature Profile on Highest Water Use Day from Noon to 6 p.m.
In Figure 14, the six-hour time period between 6 p.m. and midnight shows that the hybrid heater had no trouble keeping above 130°F during the operating day. During cleaning operations after closing hours, there was a large draw at 10 p.m. for 11 minutes, consuming 52 gallons of hot water at an average flow rate of 4.7 gpm. The minimum temperature measured on the hot water pipe during this draw was 122°F. This was the single largest draw over the 145-day monitoring period for both the storage and hybrid water heater. In fact, hot water use on this day was so intense that it held the maximum peak hot water flow rates for the 15-minute (53 gal), 30-minute (89 gal), 1-hour (145 gal) and 2-hour (172 gal) draw periods in Table 1.

Figure 14: Hybrid Flow Rate and Temperature Profile on Highest Water Use Day from 6 p.m. to Midnight

Water Heater Operating Efficiency and Energy Use

Figure 15 shows a plot of daily energy efficiency versus daily hot water use for the standard-efficiency storage and high-efficiency hybrid heaters. The overlaid trendline for each heater shows the operating efficiency increase, hence energy savings, of the hybrid condensing heater over the standard-efficiency storage heater.
Figure 15: Daily Operating Efficiency Versus Hot Water Use

The summary of results for this monitoring project is displayed in Table 2. The existing storage heater was monitored in fall 2012, when the average inlet temperature was 72.4°F. The replacement hybrid heater was monitored in winter 2013, when the average inlet temperature was 67.3°F. There was significant daily gas savings by replacing the standard-efficiency unit with the high-efficiency hybrid water heating system. Daily operating energy efficiencies averaged 66.1% for the standard-efficiency storage heater and 88.1% for the high-efficiency hybrid heater.

Table 2: Summary of Results

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<th>Standard-efficiency Storage Heater</th>
<th>High-efficiency Hybrid Heater</th>
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<tr>
<td>Heater Temperature Setpoint</td>
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<tr>
<td>Average Water Consumption (gal/d)</td>
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<td>311</td>
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<tr>
<td>Average Gas Consumption (ft³/d)</td>
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<tr>
<td>Mass-Weighted Average Inlet Temperature</td>
<td>72.4°F</td>
<td>67.3°F</td>
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<tr>
<td>Mass-Weighted Average Outlet Temperature</td>
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<tr>
<td>Average Daily Operating Efficiency (%)</td>
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<td>88.1%</td>
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Projected annual gas consumption and operating costs for the two heaters for a typical small quick-service restaurant are shown in Table 3. The results use the calculated water heating energy efficiencies and are normalized for a water consumption of 310 gal/d and an 80°F temperature rise. Based on $1.00 per therm, the annual energy cost of the standard-efficiency storage water heater was projected to be $1,135, while the cost for the high-efficiency hybrid heater was projected to be $851, for an operating cost saving of $284 per year.
Table 3: Energy and Cost Projections for a Small Quick-Service Restaurant

<table>
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<td>Average Daily Efficiency (%)</td>
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<tr>
<td>Projected Gas Consumption (therms/y)*</td>
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<tr>
<td>Projected Annual Cost ($/y)**</td>
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<td>$851</td>
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</table>

* Results normalized to 363 days/year operation. Heating Value = 1,022 Btu/ft²
** Based on $1.00/therm. Does not include electricity costs attributed to water heater blower motors and water pump.

Water Heater Heat Loss Comparison

In restaurants that do not use a large volume of hot water, heat losses from the tank and piping are a proportionately large component of the energy load. Most Sundays provided a good opportunity to determine a real-world heat loss rate (which accounts for the standby firing of the heater) by measuring the energy input to the heater during this 24- to 36-hour period when the restaurant didn’t use any hot water but consumed natural gas to maintain hot water temperatures in the tank. Firing losses (heat loss up the flue) occurred when the heater cycled on to maintain the stored water at the setpoint temperature. Standby losses involved the heater losing heat from all surfaces of the tank, through the exhaust flue pipe and by the standing pilot light when the unit was idling. The original storage heater installed was a light commercial unit that did not use a flue damper to save energy when the burner was off. The storage heater’s average heat loss over a 24-hour period was measured at 41,700 Btu/d or at a rate of 1,738 Btu/h (Table 4). It is important to note that this unit was old, which may have slightly elevated the heat loss rate. The tank heat losses accounted for 14% of the energy consumed on a daily basis at the storage heater. With the hybrid heater with external storage tank, the average daily heat loss was measured at a rate of 9,965 Btu/d, or 415 Btu/h. This accounted for 4% of the energy used by the heater on an average operating day. There was significant heat loss savings by removing the old storage heater and replacing it with a hybrid heater with external storage tank.

Table 4: Heat Loss Comparison

<table>
<thead>
<tr>
<th></th>
<th>Standard-efficiency Storage Heater</th>
<th>High-efficiency Hybrid Heater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Heat Loss During No Flow Periods (Btu/d)</td>
<td>41,700</td>
<td>9,965</td>
</tr>
<tr>
<td>Average Heat Loss Rate (Btu/h)</td>
<td>1,738</td>
<td>415</td>
</tr>
<tr>
<td>Heat Loss as a Percentage of Daily Energy Use</td>
<td>14.0%</td>
<td>4.3%</td>
</tr>
</tbody>
</table>
Conclusions and Recommendations

In other restaurants monitored by FSTC, the daily hot water use has shown higher variability over the monitoring period and based on the day of the week. This fast-casual Mexican-themed restaurant used hot water consistently on a day-to-day basis based on the owner/operator running an operation where water and energy waste is minimized. One way that hot water use was reduced to a nominal 300 gal/d was by mopping the floors instead of hosing them down. Since the storage water heater did not get much use, and after hours cleanup practices were light, this original heater was able to last over a decade, reflecting a longer lifespan than most storage heaters installed in restaurants.

The existing standard-efficiency, gas-fired storage water heater exhibited a 66% operating efficiency, which is reasonable since the heater standby losses make up a larger portion of the daily gas use. The average heat loss rate of the storage heater was 1,738 Btu/h. On average, 14% of the daily gas use was utilized to counter the heat losses from the storage heater. The replacement high-efficiency gas-fired hybrid heater with external storage tank was able to increase the operating efficiency to 88%, which is a 25% gain. This was accomplished by reducing the standby losses and moving from an atmospherically vented heater to a forced draft condensing heater. The annual energy cost of the original storage water heater was projected to be $1,135, while the cost for the high-efficiency hybrid heater was projected to be $851, for an operating cost savings of $284.

The space gained eliminating the large storage tank allowed for an additional storage area in the kitchen. The hybrid heater installed with an external storage tank performed well in supplying hot water to the door-type dishwasher in the winter when the water supply was coldest. The new heater was able to handle peak flow rates of 12 gpm in the facility. Overall, the hot water flow rate and temperature data showed good delivery performance for both the storage and hybrid water heaters, with average outlet temperatures during flow periods above 145°F—well above the minimum food safety guidelines of 120°F. Both heaters met the hot water needs of the facility. The high-efficiency hybrid heater with the optional external storage tank demonstrated that it is well suited for operation in cafés and small quick-service restaurants.

It is recommended that hybrid water heaters with and without external storage tank be tested for efficiency and hot water delivery performance in other foodservice facilities and in the laboratory to expand the research on this emerging technology. By improving the familiarity of building and health department staff with this technology, it will make it easier for designers to specify and size, and for contractors to install condensing hybrid heaters to save energy for water heating while adding value for the operator. In the existing setup, the hybrid heater external storage tank held the setpoint temperature 24/7.

A strategy to minimize standby heat losses of the hybrid water heater with external storage tank during off hours would be to install a timer to keep the pump from operating overnight and on Sundays when the restaurant is closed. Another consideration for future testing by the manufacturer would be to document the water pressure loss of the hybrid heater, with and without the external storage tank, to help guide designers in specifying these products.
References


Food Service Technology Center

Addendum: Report Certification

EPA Organization ID: 1113443

This certifies that the undersigned has performed equipment testing according to the methodology outlined in the report described below, and verifies that the results recorded in that report were the actual results observed.

Report #: 5100131004-R0 Date published: 10/2013
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