California Energy Commission

High Efficiency Hot Water Systems

The Counter Restaurant
San Mateo, CA

Delivering Hot Water Efficiently

The Counter is a full-service restaurant chain with 22 locations in California. Their menu consists of customizable gourmet burgers, fries and shakes, and it offers a full bar. After experiencing high energy bills, the Counter's Northern California management team invited Frontier Energy to conduct an energy assessment of its San Mateo restaurant to identify energy saving opportunities.

Following the comprehensive survey of the hot water system (HWS) as part of the larger audit, Frontier Energy formulated a multi-year research study, the *Demonstration of High-Efficiency Hot Water Systems in Commercial Foodservice.* Conducted for the California Energy Commission's Natural Gas Research and Development Program with co-funding from PG&E, the study measured the performance of the existing system and then replaced it with a cutting-edge system that incorporated the best-available-technologies and design practices to achieve significant energy and water savings as well improvements in hot water delivery performance.

Annual Operating Costs

Original System	$24,100
Replacement System	$17,900

Based on utility rates of $34/HCF, $0.17/kWh, $1.10/therm
Based on 365 days/year operation

Original System

The original HWS consisted of:

- Two 199,000 Btu/h gas tankless water heaters rated at 84% thermal efficiency
- Continuous recirculation loop with 235 feet of pipe

All the hot water piping throughout the building was uninsulated as shown in the picture of the garage where the tankless water heaters were located.

The picture of the dishroom shows the pre-rinse sprayer, dishmachine, and a 3-compartment sink. The dishroom accounted for 73% of the system's hot water use.

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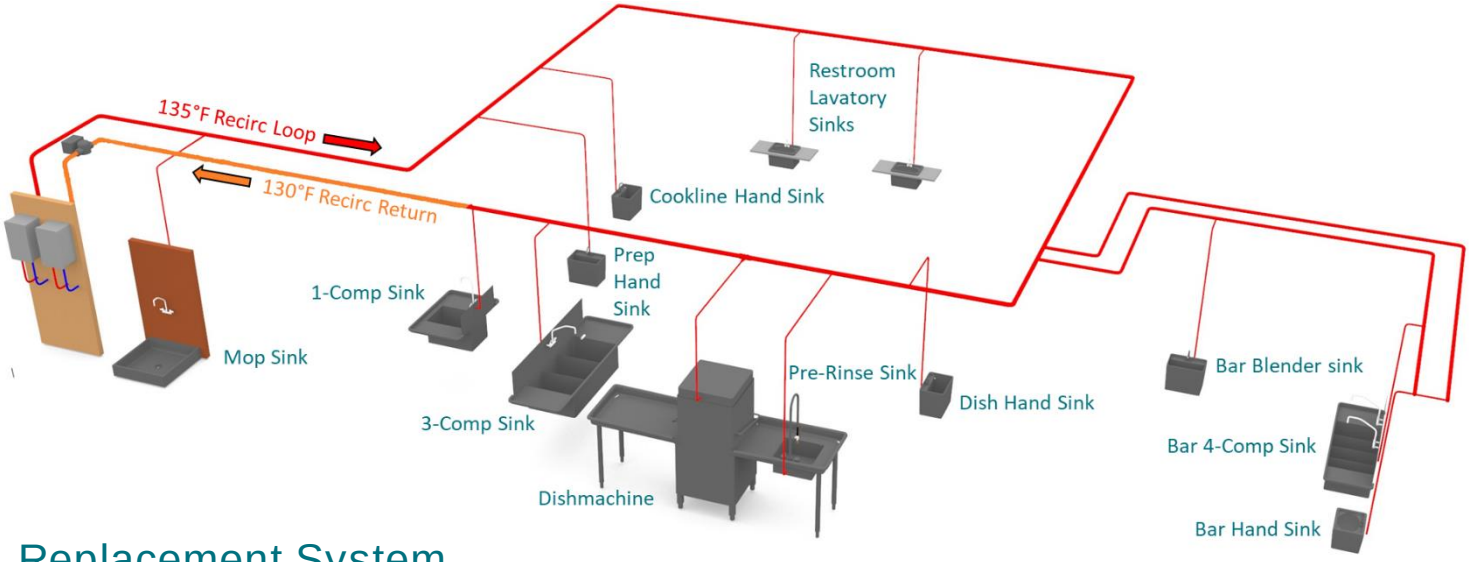
The restaurant experienced a host of problems with the original system. Sometimes the water heaters would malfunction and shut down multiple times per day, requiring a manual restart. The uninsulated distribution system caused long hot water wait times at hand sinks and at the bar, and low average water temperatures at the dishmachine and bar. Additionally, the tankless heaters could not keep up with the hot water demand caused by the simultaneous use of multiple high-flow fixtures. This caused low water pressure issues on occasion at various points of use, most importantly at the dishmachine and hand sinks.

On an average day, the original HWS consumed 820 gallons of water, 724,000 Btu of natural gas and 121 kWh of electricity to heat and distribute 135°F water and to operate the dishmachine.

The layout of the original HWS is shown below. The flow direction of the recirculation loop from the heater towards the low flow rate and low water use areas like the restroom and bar sinks required an increased length of large diameter piping to reach the dishroom where the high flow rate fixtures are located. This large and uninsulated pipe surface area combined with 24-hour recirculation, caused severe pipe heat loss in the loop to the tune of over 200,000 btu/day.

The original system had a point-of-use (POU) system efficiency of 40%, meaning that for every 10 units of energy put into the system to heat and circulate water, along with operate the dishmachine, on average 4 units of energy were delivered at a fixture.



Replacement System

The design goal of the new system was to minimize energy and water use, while improving hot water delivery performance and system reliability. To achieve this, a centralized high-efficiency gas-fired heater and optimized distribution system was used to serve the kitchen along with a decentralized system equipped with five electric heaters installed in the bar and restrooms. This hybrid approach collectively allowed for major reductions in system heat loss.

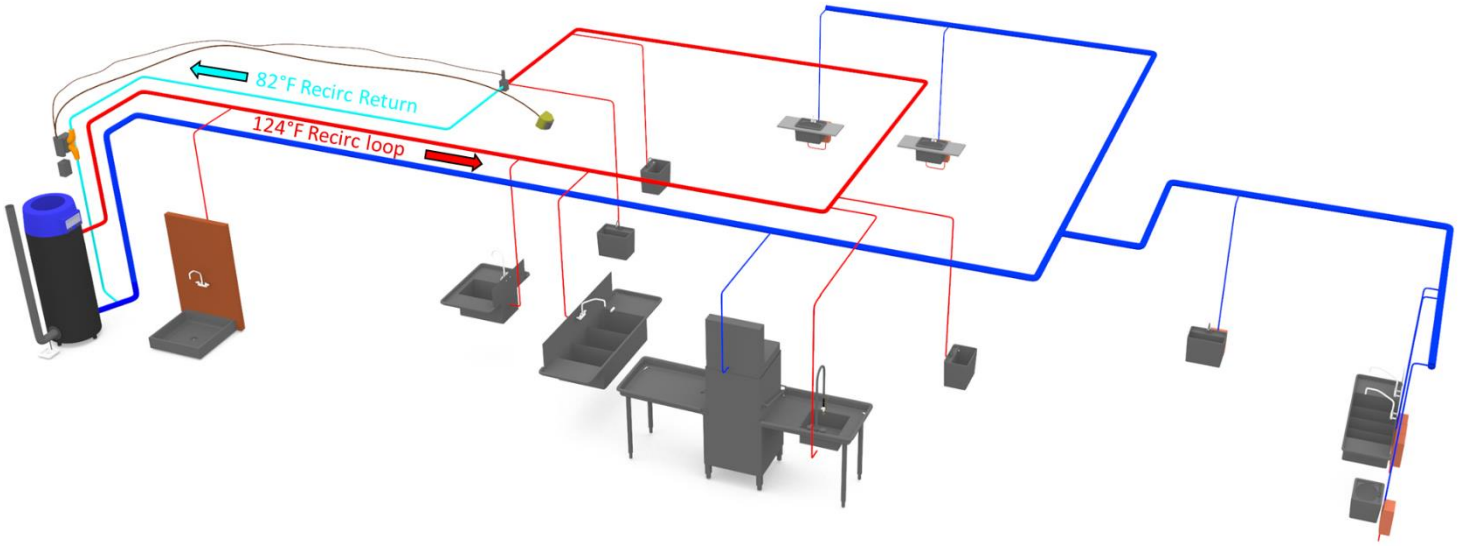
The centralized HWS consisted of:

- Rheem-199,000 Btu/h, 100-gal. heater rated at 96% thermal efficiency
- Compact circulation loop with 180 feet of pipe and 1-inch thick pipe insulation designed to prioritize hot water delivery to the dishroom
- ACT D'MAND circulation system with motion and temperature sensors

Demand Control Circulator Pump with Motion Detector

Condensing Storage Heater as Installed Onsite

The continuous recirculation system was replaced with an ACT D'MAND circulation system which relies on a motion sensor in the kitchen and inline temperature sensor at the last fixture before the return line in order to circulate hot water only when the facility required it.



The replacement system had an overall POU system efficiency of 63% when accounting for the centralized and decentralized systems. This increase in efficiency from the original system is impressive when factoring in that hot water use was also reduced by 33% in the replacement system with the addition of the new dishmachine and spray valve.

The decentralized HWS components consisted of:

- Two 4.1kW tankless electric heaters installed under restroom hand sinks
- 24kW, 8.2 kW, and 4.1 kW tankless electric heaters installed under bar 4-compartment, utility and hand sink
- A high-temperature door-type dishmachine with exhaust heat recovery system and electric heaters

The replacement dishmachine only required a cold-water supply, which allowed it to operate independent of the central HWS. The dishmachine was responsible for most of hot water savings associated with the new system—resulting in an average of 200 gallons saved daily with almost a 60% reduction in dishmachine water use. The dishmachine replacement saved the facility $4,200 per year in utility costs!

Dishmachine Comparison

Original:

Water Use Per Rack
Rated: 0.96 gal
Measured: 1.54 gal

Energy Use Per Rack
Gas: 1,360 Btu
Electricity: 0.48 kWh
Total: 2,990 Btu

Racks per Day: 233
Annual Cost: $14,100

New:

Water Use Per Rack
Rated: 0.74 gal
Measured: 0.71 gal

Energy Use Per Rack
Gas: 0 Btu
Electricity: 0.51 kWh
Total: 1,750 Btu

Racks per Day: 224
Annual Cost: $9,900
Savings: $4,200

The replacement system allowed the high-efficiency gas heater to operate at close to maximum efficiency since the hot water return temperature averaged only 82°F, which allowed for increased condensing operation. Because the new dishmachine did not require 140°F supply water like the original dishmachine, the setpoint of the new heater was reduced by 15°F to 125°F. This was sufficient to supply 120°F water to all fixtures in the kitchen. In addition, the new distribution system with the ACT D'MAND KONTROLS® pump stopped circulation during non-operating hours to minimize heat losses. Water pump runtime decreased from 24 hours to 35 minutes per day which further reduced distribution system heat loss. Average daily heat loss was reduced from 200,000 Btu for the original HWS to just 8,500 Btu for the replacement HWS.

Hot Water Delivery

Hot water delivery performance with the original system was poor, especially at the bar sinks where a long branch line from the recirculation loop had to be purged of tepid water. Consequent wait times to deliver 120°F water at utility sinks were as long as 80 seconds. Besides being an energy waste, up to three gallons of purge water was wasted per occurrence —and an inconvenience to staff. The restroom sinks were another area where hot water was typically not available in a timely manner at 100°F or above during non-meal periods, but was available most of time during the busy periods due to clustering of hand sink uses. Accounting for all uses throughout the day, the average user operated the sink for only 6 seconds, and hot water (greater than 100°F) was delivered only 50% of the time.

Delivery performance was improved at these key locations where POU electric heaters were installed. Hot water wait time at the 4-compartment sink was reduced to 9 seconds and the average delivery temperature increased from 108°F to 116°F. At the restroom sinks, 74% of users with an average use duration of 7 seconds, received hot water.

Choose Wisely

The research showed that almost all users of the single handle faucet in the restrooms choose the center flow position, which provides roughly equal flow of 0.25 gpm water from both the cold and hot water line at full flow. This ultra-low flow rate is problematic for most centralized systems, since it is difficult to deliver hot water present in the recirculation loop through the branch line in time. It is also problematic of most POU electric water heaters that have activation rates from 0.3 to 0.5 gpm. In fact, only two tankless POU heater model lines out of over 20 on the market meet the 0.2 gpm activation flow rate recommended for acceptable hot water delivery performance at hand sinks with 0.5 gpm faucet aerators installed. More information is available on qualifying models in the Commercial Kitchen HWS Design Guide which is located on the project webpage using the webpage link shown in the lower right column.

The Eemax unit pictured below is able to respond rapidly and provide 100°F water in 5 seconds from a cold start to ensure users have hot water to wash and rinse hands.

Lavatory Point of Use Heater with instrumentation

Resource Use and Cost Summary

On an average day, the high-performance system consumed 560 gallons of water, 164,000 Btu of natural gas and 127 kWh of electricity to heat and distribute hot water and to operate the dishmachine. That was a savings of 32% water and 77% gas with only a 5% increase in electricity use. The new system is estimated to save approximately 94,000 gallons of water and 2,050 therms of natural gas annually while only using an additional 2,020 kWh of electricity for an annual utility cost savings of $6,200.

	Before	After	Savings
Water (HCF/y)	400	275	125
Gas (therms/y)	2,650	600	2,050
Electricity (kWh/y)	44,290	46,310	-2,020
Annual Cost	$24,100	$17,900	$6,200

The Verdict

Clearly the decentralized system was a success in that it saved energy and water, greatly improved hot water system efficiencies and hot water delivery performance.

For More Info

The project report, industry presentations, design guide, design examples, a school case study, and the design tool and cost calculator spreadsheet are available at: www.fishnick.com/cecwater/.