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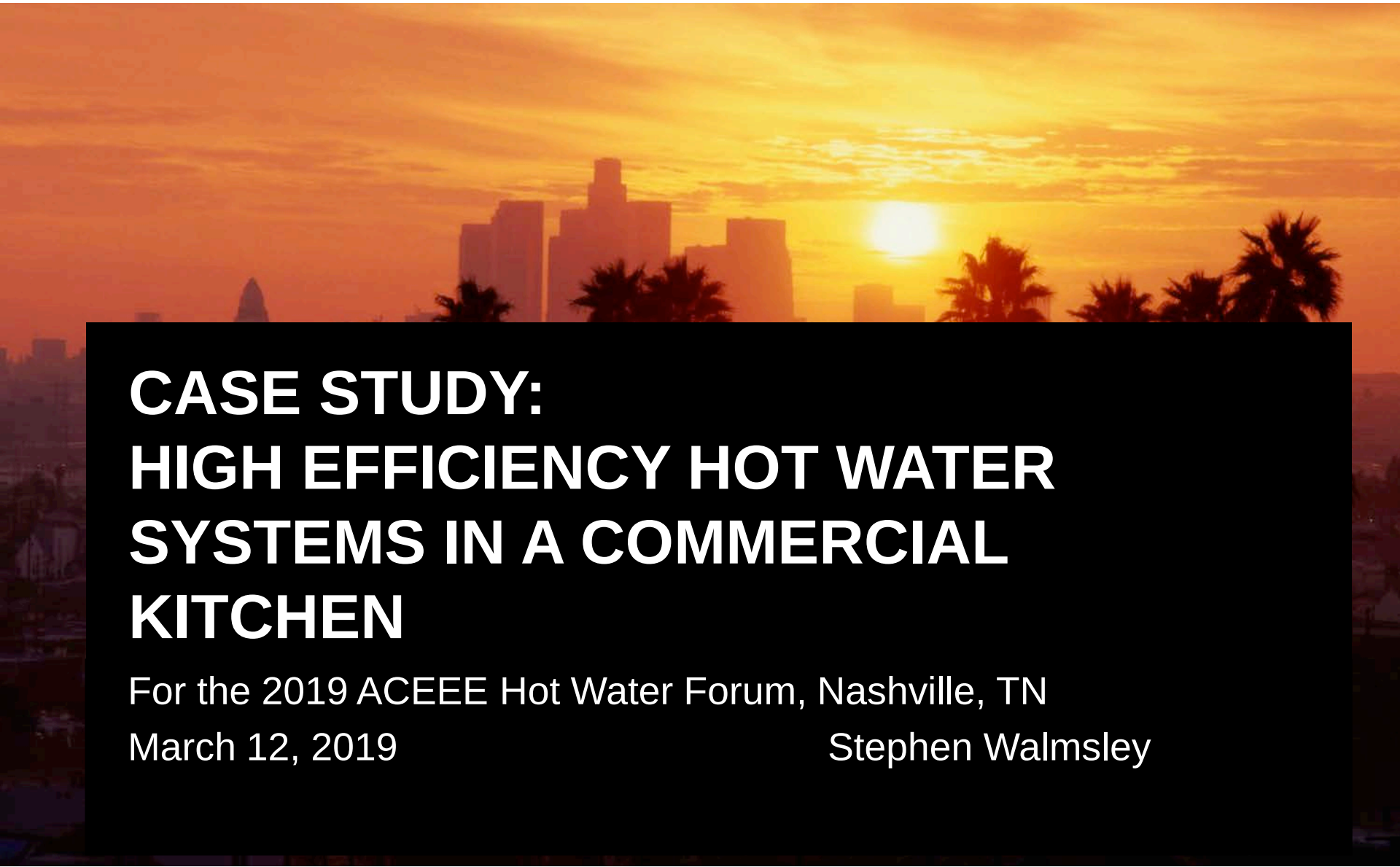

CASE STUDY: HIGH EFFICIENCY HOT WATER SYSTEMS IN A COMMERCIAL KITCHEN

For the 2019 ACEEE Hot Water Forum, Nashville, TN

March 12, 2019

Stephen Walmsley


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Purpose and Goals

- Understand the importance of hot water delivery performance in commercial foodservice applications
  - Identify features of conventional and high efficiency hot water systems
  - Design innovative hot water systems based on existing high-efficiency products
  - Condensing Boiler, New dishwasher, On-demand recirculation pump, Pre rinse spray valve (PSRV)

Acknowledgement & Credits

- Franklin Elementary, Santa Barbara California
- Frontier Energy
- SoCalGas
  - Research and Development
  - Emerging Technologies Program
  - Engineering Analysis Center

Disclaimer

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Franklin Elementary School

Operating Parameters

- Serves students and families enrolled in Kindergarten - 6th grade
- Centralized kitchen, serves two remote schools
- Open breakfast, lunch and dinner (5 days/week)
  - Also open 5 days/week during summer
  - 241 working days per year
- Number of working days per year taken from school calendar
- 241 working days per year (180 school, 61 summer meals)
- 124 weekend/holiday days per year
- Utility rates based on available billing data for Santa Barbara

$1.10 / Therm

$0.15 / kWh

$8.00 / HCF

Challenges and Obstacles

- Overcoming the existing hot water system infrastructure deficiencies
- Health department guidelines
- Operational issues
- Retrofitting / M&V in a kitchen in full operation
- Dishwasher normalization differs for different machines; booster heater adds heat, at out-of-wall temperature

Approaches

- Use baseline results to optimize retrofit
  - Select equipment and complete installation

- M&V: Compare baseline to replacement system
  - Water heater efficiency increase and energy savings
  - Distribution system energy loss reduction
  - Spray valve and dishwasher water/energy savings

Baseline Hot Water System

Domestic WH
275,000 Btu/h

Baseline Rack Conveyor Dishwasher

Baseline Hot Water System

» Site operates breakfast, lunch and dinner for 241 working days per year.

Retrofit

Condensing WH, 100 Gal. 250,000 Btu/h

ECM Circulator and Controller

Pre Rinse Spray Valve (PRSV)

Rack Conveyor Dishwasher

Retrofit

Baseline

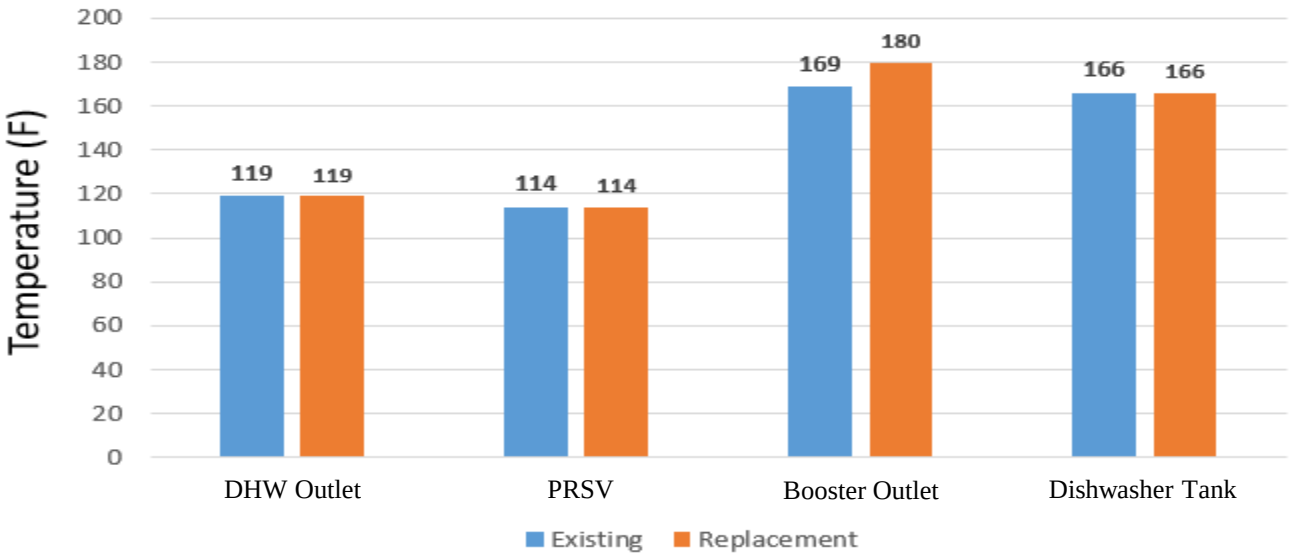
- **Water Heater**
  - Standard 80% DHW
  - Burner rated at 275,000 Btu/h
- **Continuous Recirculation Pump**
  - Constant Volume
  - 2.5 GPM PSRV

Replacement

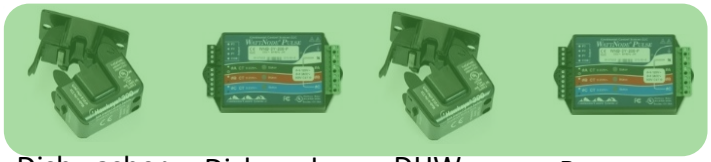
- **New Water Heater**
  - Modulating Condensing water heater rated at 96% efficiency
  - New burner rated at 250,000 Btu/h
- **New Recirculation Control and pump**
  - ECM pump reduced input rate from 88 W to 14 W
  - Timer plug-style recirculation controller brought pump runtime down to ~8h/d
- **New Dish Washing Machine**
  - Updated version of the baseline machine
  - Auto scale and clean functions
  - Energy-saver mode
- **New PRSV**
  - Reduced PRSV flow rate from 1.6 to 1.05 gpm

Retrofit

- DHW outlet temp didn't change
- Booster outlet temp increased from 165 to 180°F
  - Took load off tank heater
  - Elevated dishwasher sanitizing temperature



M&V

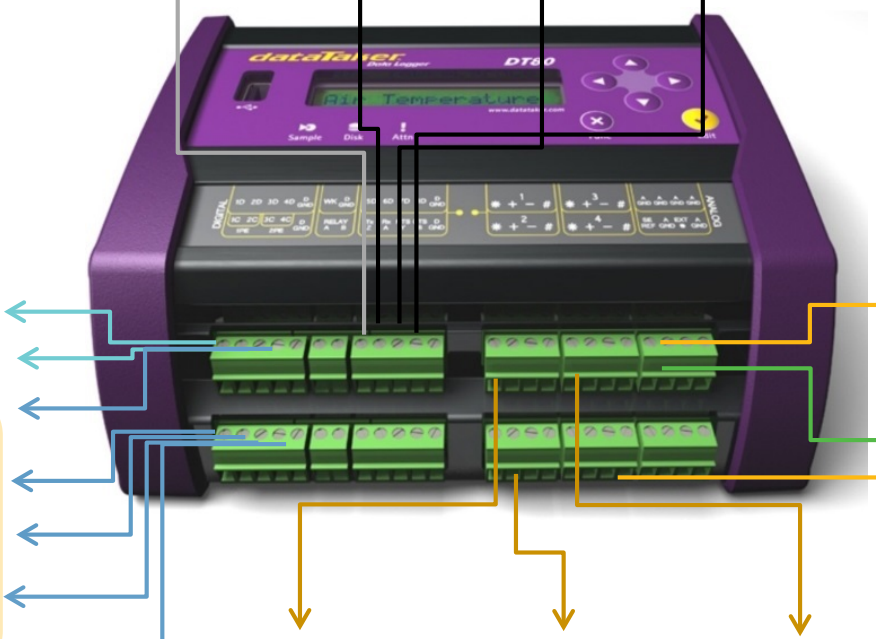


Dishwasher Gas On/Off Sensor **D5**

Dishwasher (Wh) **D6**

DHW Recirc Pump **D7**

Booster Recirc **D8**



Left Booster Heater (ft³) **D1**

Right DHW Heater (ft³) **D2**

¾" DHW Recirc Return Hot (gal) **D3**

1" DHW Cold Supply (gal) **C1**

¾" Booster Hot Supply (gal) **C2**

½" Disposer Cold (gal) **C3**

½" Pre-Rinse Spray Hot (gal) **C4**

Dish Drain (°F) **5** Rinse (PSI) **5B**

Dish Tank Heat **4** Pre Rinse Hot (°F) **4B**

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Energy Savings

	Electricity use	Gas Use
	kWh/y	**therms/y**
Baseline	2431	4446
Replacement	1463	2112
Savings	**968**	**2334**

Water Savings

	Dish machine	PRSV	Total
	hcf/y	hcf/y	hcf/y
Baseline	174	55	229
Replacement	83	40	123
Savings	91	15	**106**

- Dishwasher accounted for 86% of the total savings
- Significant total savings

Money Savings

Equipment Update	Water Savings (Gal/yr)	Gas Savings (Therms/yr)	Electric Savings (kWh/yr)	Benefits
Replaced standard efficiency water heater with a best-in-class water heater	N/A	300	0	New unit had a dedicated return port and modulating burner to achieve higher efficiency operation over similar condensing heaters
Replaced 88-watt pump with 14-watt high-efficiency pump and added smart controller	0	225	683	Saved gas at heater by lowering recirculation flow rate from 2.2 gpm to 1.0 gpm and run time from 24 hrs/day to 8 hrs/day
Replaced conveyor dishwasher with an ENERGY STAR conveyor dishwasher	68,070	1,697	285	Improved performance, reduced water and energy use
Replaced 2.5 gpm pre-rinse spray valve with 1.05 gpm unit	11,220	112	0	Reduced water consumption
Total Utility Savings	**79,290**	**2334**	**968**	
Total Annual Energy Cost Savings	**$1,708**	**$1,983.90**	**$165.56**	

$3,226 in annual energy savings!

Simple Payback

Even a "Light Retrofit" pays for itself in 6 years

	Rebate Value	Equipment Cost	First Year Operating Cost	Simple Payback Time
Dishwasher	$2,100	$20,000	$2,400	6 years
Pump, Controls, and Spray Valve	$450	$530	$550	< 1 year
Water Heater	$300	$6,900	$250	No payback for voluntary replacement at low hot water use site
Overall	$2,900	$27,430	$3,300	6 years

Market Potential

SoCalGas Commercial Restaurants	
NAICS 722000-722410	
250K - 1MM Therms/Yr	1 Restaurant
50K - 250K Therms/Yr	159 Restaurants
< 50K Therms/Yr	39,817 Restaurants
Total	39,977 Restaurants
Segment Usage (Therms)	234,852,334
Avg Therms/Yr Each	5,875

Data Source: SoCalGas CIS 2014

Demonstration Results

1. Average daily results showed significant water and energy savings
2. Overall increase in the hot water delivery performance
3. Increase in the overall production efficiency

Next Steps

- Communicate Findings To System Stakeholders
- Commercial Kitchen Designers
- Plumbing Professionals
- Regulatory bodies
- Good opportunity to pivot the industry away from the inefficient 20th century hot water system designs that are still commonplace and found in over 99% of existing facilities and incentivize them to embrace new equipment and design practices

Q&A

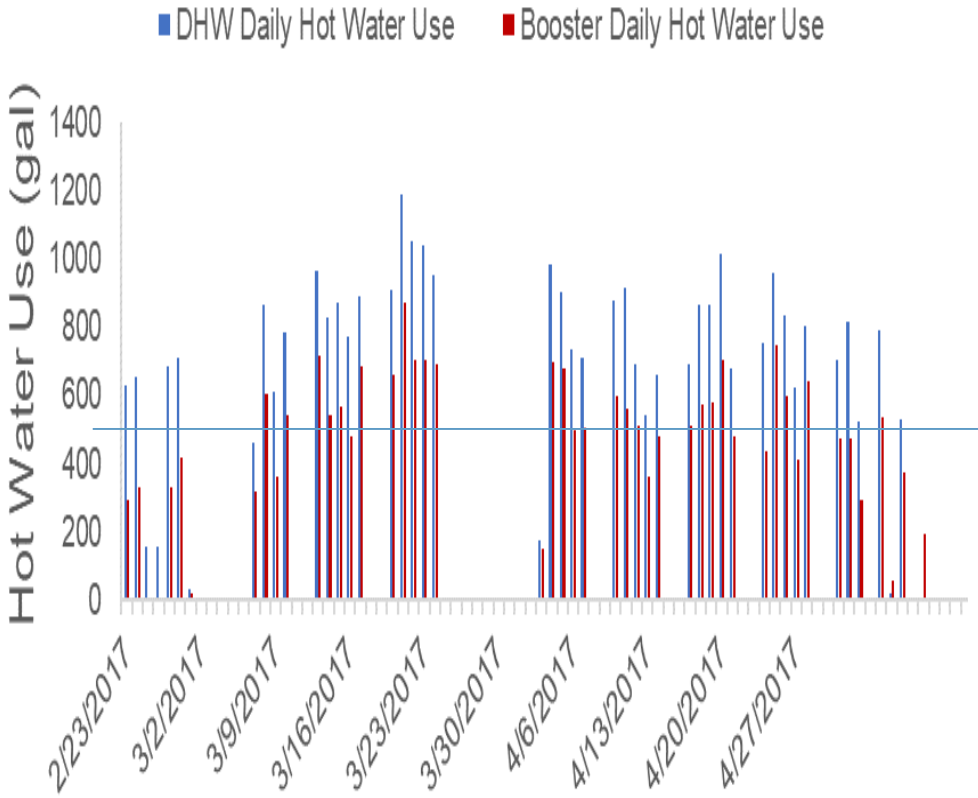
Contact Information

- **Stephen Walmsley**
  - SoCalGas
  - swalmsley@semprautilities.com
- **Michael Slater**
  - Frontier Energy
  - mslater@frontierenergy.com

Appendix – Contrast Before & After

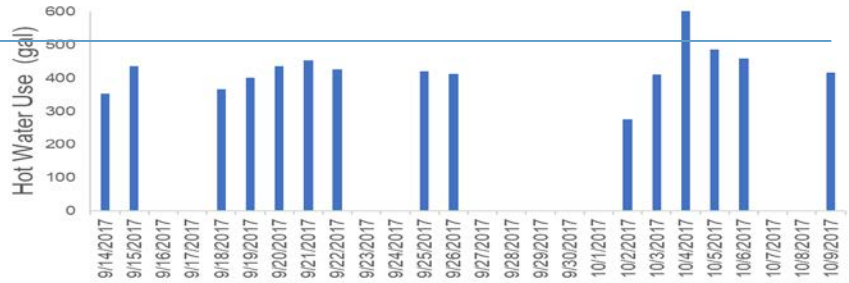
Hot Water Use Comparison

Before



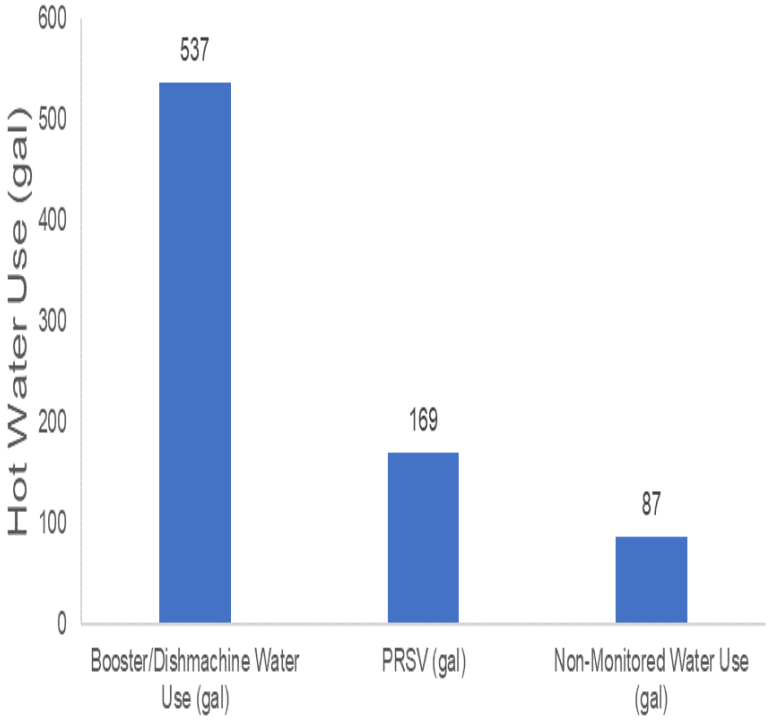
After

	Water Use (gal/d)	Electricity Use (kWh/d)	Gas Use (therm/d)	Total Energy Use (equiv. therm/d)
Weekday	464	5.2	7.5	7.7
Weekend	0	1.1	2.0	2.1
Average	306	3.8	5.6	5.8

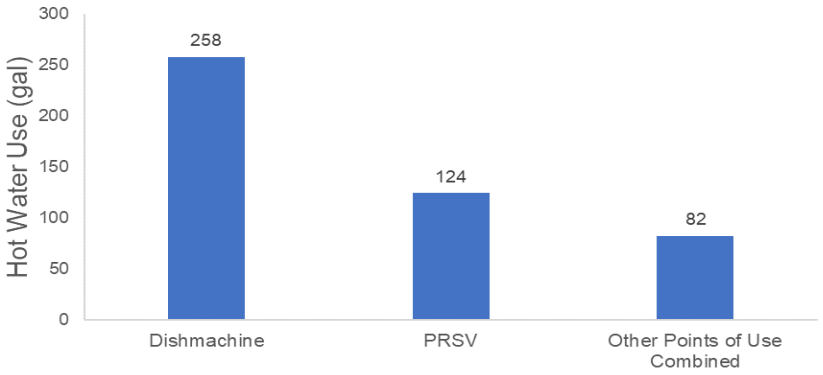


Daily Hot Water Use at Each Fixture

Before

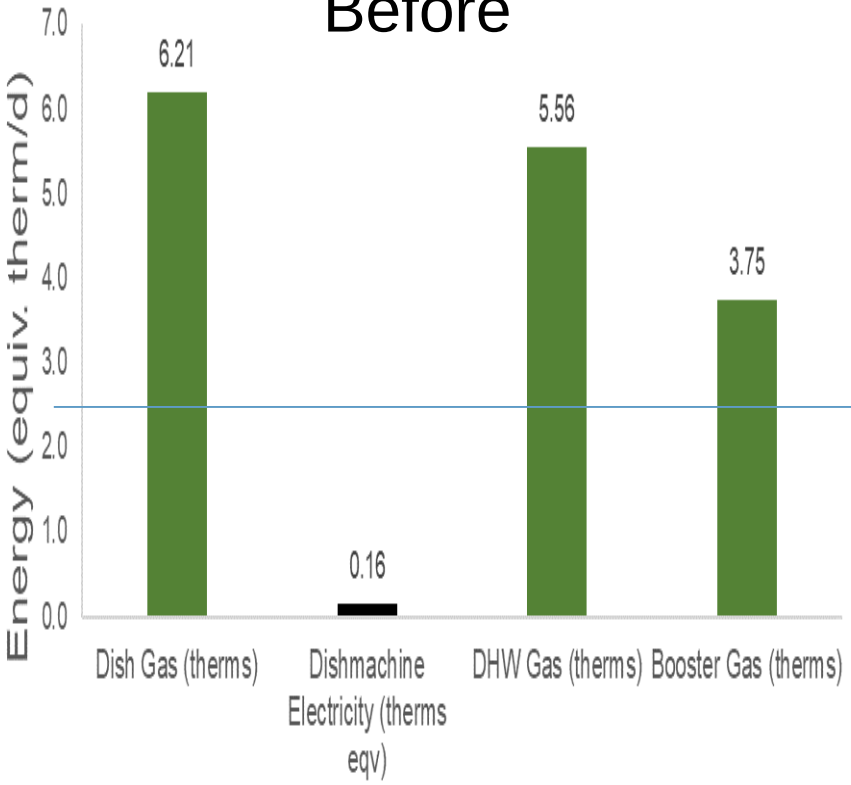


After

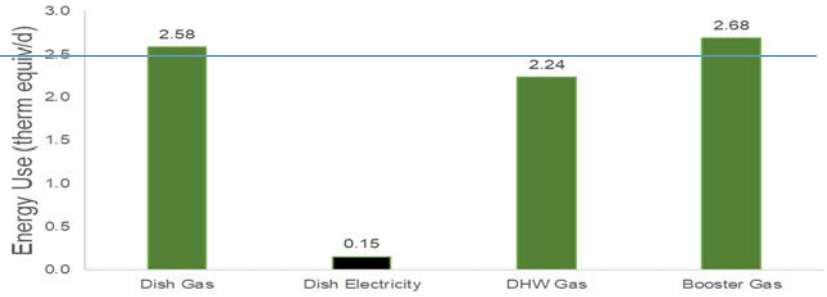


Avg Daily Energy Consumption at Each Heat Source

Before

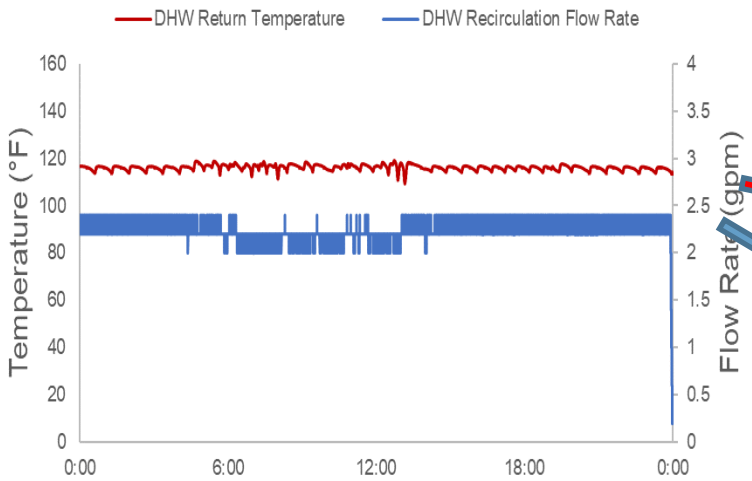


After



DHW Recirculation Profile

Before



After

	Recirculation Water (gal/d)	Delivered Energy Use (therm/d)
DHW Recirc	475	0.5
Booster Recirc	132	0.1