The Food Service Technology Center (FSTC) program is funded by California utility customers and administered by the Pacific Gas and Electric Company under the auspices of the California Public Utilities Commission.

Promoting:

**Energy Efficiency in Commercial Food Service**
Elements of this presentation were developed within the scope of a California Energy Commission PIER Research Project
Restaurants are an Energy and Water Intensive Operation

Energy - Water Interdependence

- Water needed for energy production
  - Power Plants (i.e. Nuclear, Coal)
  - Savings energy conserves water
- Energy needed to use potable water
  - Desalination, purification, distribution, water heating/cooling, treatment
Tracking Utility Costs
(aka Utility Accounting)

- Under utilized tool in the foodservice world, despite spreadsheet literacy of this industry.
- Foundation of an energy/water efficiency initiative - particularly for multi-unit operations.
- 12-month consumption patterns tell important story.

<table>
<thead>
<tr>
<th>DATE</th>
<th>DAYS</th>
<th>THERMS</th>
<th>therms/degF</th>
<th>USE/DAY</th>
<th>CHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep</td>
<td>30-30</td>
<td>565</td>
<td>18.8</td>
<td>307.58</td>
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<tr>
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<td>31-31</td>
<td>605</td>
<td>19.5</td>
<td>328.4</td>
<td></td>
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<tr>
<td>Nov</td>
<td>1-31</td>
<td>402</td>
<td>25.9</td>
<td>577.13</td>
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<tr>
<td>Dec</td>
<td>30-Dec</td>
<td>695</td>
<td>24</td>
<td>501.15</td>
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<tr>
<td>Jan</td>
<td>31-Jan</td>
<td>768</td>
<td>24.6</td>
<td>583.64</td>
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<tr>
<td>Feb</td>
<td>2-Mar</td>
<td>650</td>
<td>21.7</td>
<td>485.48</td>
<td></td>
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<tr>
<td>Mar</td>
<td>1-Apr</td>
<td>666</td>
<td>22.2</td>
<td>492.86</td>
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<tr>
<td>Apr</td>
<td>29-Apr</td>
<td>666</td>
<td>22.2</td>
<td>492.86</td>
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<tr>
<td>May</td>
<td>31-May</td>
<td>666</td>
<td>20.9</td>
<td>371.18</td>
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<tr>
<td>Jun</td>
<td>27-Jun</td>
<td>538</td>
<td>19.9</td>
<td>302.83</td>
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<tr>
<td>Jul</td>
<td>28-Jul</td>
<td>571</td>
<td>18.4</td>
<td>326.28</td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>28-Aug</td>
<td>553</td>
<td>17.8</td>
<td>310.5</td>
<td></td>
</tr>
<tr>
<td>Sep</td>
<td>28-Sep</td>
<td>594</td>
<td>19.2</td>
<td>332.95</td>
<td></td>
</tr>
</tbody>
</table>
Full Service Restaurant Water Use History

Monthly Water Use

Summer Time Landscaping
Lanscaping Water Use Increase of 3500 gpd

Hot Water Usage
(Casual Dining Restaurant)
All restaurants use hot water!

Restaurant Hot Water Use*

<table>
<thead>
<tr>
<th>water heating load [gal/d]</th>
<th>Steakhouse</th>
<th>Quick Service</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3500</td>
<td>240</td>
</tr>
</tbody>
</table>

Full-Service ≠ Quick Service & Restaurant ≠ Residential

* EPRI Commercial Water Heating Applications Handbook, 1992
How much hot water do you use?

Without this…

…you don’t know!

### FSTC Monitored Facilities to date...

<table>
<thead>
<tr>
<th>Facility</th>
<th>Hot Water Use (gal/day)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corp. Cafeteria</td>
<td>1800</td>
<td>48</td>
</tr>
<tr>
<td>Full Service 1</td>
<td>3700</td>
<td>67</td>
</tr>
<tr>
<td>Full Service 2</td>
<td>2500</td>
<td>71</td>
</tr>
<tr>
<td>Full Service 3</td>
<td>2300</td>
<td>74</td>
</tr>
<tr>
<td>Full Service 4</td>
<td>2100</td>
<td>68</td>
</tr>
<tr>
<td>Quick Service 1</td>
<td>550</td>
<td>71</td>
</tr>
<tr>
<td>Quick Service 2</td>
<td>500</td>
<td>90</td>
</tr>
<tr>
<td>Quick Service 3</td>
<td>1200</td>
<td>69</td>
</tr>
<tr>
<td>Quick Service 4</td>
<td>700</td>
<td>NA</td>
</tr>
</tbody>
</table>
Actual Daily Hot Water Consumption for a Full-Service Restaurant

Average = 2100 gal/day

24 hour Hot Water Flow Rate Profile

3741 gallons

After Hours Cleaning – 550 gal/hr
The Water Implications...

California Foodservice Hot Water Use

Annual Sector Hot Water Load
Facility Water Heater Gas Use

The Energy Implications...

Annual Sector Gas Load
Estimate 115,000 A.F. + 350 million Therms in CA Food Service for Hot Water

Restaurant Hot Water Costs

$1.30\text{ Therm}$  $6.00\text{ Gal}$  $0.15\text{ kWh}$

<table>
<thead>
<tr>
<th>San Francisco</th>
<th>Hot Water Use (gal/d)</th>
<th>Gas Use (therms/y)</th>
<th>Gas Cost</th>
<th>Water and Sewer Cost</th>
<th>Electricity Cost</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick Service</td>
<td>500</td>
<td>1400</td>
<td>$1,800</td>
<td>$2,400</td>
<td>--</td>
<td>$4,200</td>
</tr>
<tr>
<td>Full Service</td>
<td>2,500</td>
<td>7860</td>
<td>$10,200</td>
<td>$12,200</td>
<td>$4,300</td>
<td>$26,700</td>
</tr>
</tbody>
</table>
Design Path for Savings

- Specify ultra-low flow pre-rinse spray valves
- Specify Energy Star or better (gal/rack) dishwashers
- Specify ultra-low flow aerators on hand sinks

The Dish Room
Pre-Rinse Spray Valves

High Temp. Dishmachines

<table>
<thead>
<tr>
<th>High Temperature Dishmachines (gal/rack)</th>
<th>Inefficient</th>
<th>Conventional</th>
<th>Energy Star</th>
<th>Best in Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Washer</td>
<td>&gt; 2.5</td>
<td>1.2</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Under Counter</td>
<td>&gt; 2.0</td>
<td>1.5</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Door Type</td>
<td>&gt; 2.0</td>
<td>1.4</td>
<td>0.95</td>
<td>0.7</td>
</tr>
<tr>
<td>Single-Tank Conveyor</td>
<td>&gt; 1.4</td>
<td>1.1</td>
<td>0.7</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Conveyor Dishmachines

Wait time estimate based on 12 feet of ¾" diameter piping.

Hand Sink Aerators
Mirror the men’s and women’s bathroom lavatories on both faces of the same wall.

Minimize the length and diameter of pipe to reduce the volume of water in the pipes.

Specify one-inch-thick insulation on all hot water pipes.

Design with short pipe drops or eliminate pipe drops to fixtures from main distribution line.

Design without continuous recirculation, use demand circulation as an alternative.

Position heater centrally close to dishmachine and other sanitation equipment.

Simple Distribution

- Uses a trunk, branch and twig configuration to deliver water from the heater to the point of use
- Benefit: compatible with all heater types
- Drawbacks: long wait times at hand sinks
- Typically designed for QSR where each line is kept to 60 feet or less
- Two common systems: single line and two-line distribution providing 140°F water to sanitary equipment and 120°F to hand sinks
Continuous Recirculation

- Goal to keep the distribution line hot at all times – like moving the heater much closer to the points of use
- Drawbacks: this method does not always ensure hot water delivery to the tap, especially with low flow aerators installed, high operating costs
- In typical FSR, 140°F water circulates around the clock constantly loosing heat to the surroundings

Demand Circulation

Goal: to get the distribution line hot just before the need for hot water
Benefits: saves energy and increases delivery performance
Distributed Generation

• A hybrid system that is a combination of electric tankless heaters at remote hand sinks and a simple distribution system delivering water to sanitary equipment

• Benefits: works well with low flow aerators, saves energy and increases delivery performance

Reducing Heat Loss from Piping

Several ways to reduce pipe heat loss

• Pipe insulation on all hot water lines
  – Extends the cool down time
  – Saves energy, less noise
  – Improves the effectiveness of the distribution system
  – Reduction of unwanted heat gain to air-conditioned spaces
  – 1”-thick insulation is the law for 2” dia pipes or smaller
• Installation of a recirc. time clock
Hot Water Delivery Problems

- Two areas in food service where quick delivery of hot water to the point of use is critical
- Inlet water to dishwasher/booster requires temps in the 140°F range
- Timely delivery of hot water to the hand sink is a commonly occurring problem,
- Even with a recirc. line installed
- With a 0.5 gpm aerator, it takes 30 sec to purge a 10 foot section of 3/4” piping

Hot Water Delivery Solutions

- Vertical recirculation will reduce the wait time by reducing the length of branch pipe in between the recirc line and twig
- A 3 foot branch from a recirc loop will deliver hot water to the sink in 10 seconds
- A variation of vertical circulation uses balancing valves
- Using electrical heat trace is a way to counteract the heat loss from the pipe
Distribution System Cost Comparison

FSR with 80%TE tank is modeled with 220 feet of recirculation piping to investigate the operating costs of the recirc system.

Specify high-efficiency condensing water heaters.
Standard Efficiency Tank-Type

Pros
- simple
- robust
- low cost
- industry standard
- easy to spec
- easy to fix
- easy to replace

Cons
- 80% thermal efficiency
- stand by loss (100 gal): 1000 – 1300 Btu/h

http://www.gamanet.org
High Efficiency (Condensing) Tank-Type

**Pros**
- condensing
- 95%+ efficiency
- Standby loss: 600 – 1000 Btu/h
- potential lower cost installation

**Cons**
- condensing
- more complex
- not the standard
- potential for repair delay
- higher first cost
Tankless (On Demand)

The Process:
1. A hot water tap is turned on.
2. Water enters the heater.
3. The water flow sensor detects the water flow.
4. The computer automatically ignites the burner.
5. Water circulates through the heat exchanger.
6. The heat exchanger heats the water to the designated temperature.
7. When the tap is turned off, the unit shuts down.

Tankless

Pros
• smaller footprint
• outside installation possible (some climates)
• no standby loss

Cons
• 80 - 84% thermal efficiency
• low-flow limits
• may need multiple units
• special installation required (stainless venting)
• maintenance may be higher

High efficiency condensing models (>92%) are now available in California!
System Efficiency

Full-service @ 2500 gallons/day -- Foremost supporters of high-efficiency heaters

System Efficiency

Quick-service @ 500 gallons/day
Optimizing a hot water system

Design Examples in FSR and QSR

Typical FSR w/ Recirculation System
### Design Scenarios in FSR

<table>
<thead>
<tr>
<th>System Components</th>
<th>Business as Usual</th>
<th>Low Cost</th>
<th>Dabbling in the Efficiency Pool</th>
<th>Knee Deep in Efficient Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerators</td>
<td>2.2 gpm*</td>
<td>0.5 gpm</td>
<td>0.5 gpm</td>
<td>0.375 gpm</td>
</tr>
<tr>
<td>Pre-rinse spray valve</td>
<td>2.6 gpm*</td>
<td>1.6 gpm</td>
<td>1.15 gpm</td>
<td>0.64 gpm</td>
</tr>
<tr>
<td>Conveyor dishmachine</td>
<td>1.45 gal/rack</td>
<td>0.95 gal/rack</td>
<td>0.7 gal/rack</td>
<td>0.35 gal/rack</td>
</tr>
<tr>
<td>Circulation system</td>
<td>Water pump 24 hr/d</td>
<td>Pump w/ timer 14 hr/d</td>
<td>Pump w/ timer 14 hr/d</td>
<td>Demand circulation</td>
</tr>
<tr>
<td>Pipe insulation</td>
<td>No insulation*</td>
<td>½”-thick insulation partial installation*</td>
<td>1”-thick insulation on circulation line</td>
<td>1”-thick insulation throughout</td>
</tr>
<tr>
<td>Water heater</td>
<td>Min. recovery 510 gph 80% TE**</td>
<td>Min. recovery 445 gph 80% TE</td>
<td>Min. recovery 340 gph 95% TE</td>
<td>Recovery 285 gph 95% TE</td>
</tr>
</tbody>
</table>

* Measure doesn’t meet energy efficiency regulations. **TE stands for thermal efficiency.

### Design Scenarios: Daily Hot Water Use

<table>
<thead>
<tr>
<th>System Components</th>
<th>Estimate of Use</th>
<th>Business as Usual</th>
<th>Low Cost Scen.</th>
<th>Dabbling Scenario</th>
<th>Knee Deep Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyor</td>
<td>500 racks</td>
<td>1.45 gpm</td>
<td>0.95 gpm</td>
<td>0.70 gpm</td>
<td>0.35 gpm</td>
</tr>
<tr>
<td>PRSV</td>
<td>125 minutes*</td>
<td>2.6 gpm</td>
<td>1.6 gpm</td>
<td>1.15 gpm</td>
<td>0.64 gpm</td>
</tr>
<tr>
<td>3-comp. sink</td>
<td>300 gallons</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Utility sinks</td>
<td>80 gallons</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Mop sink</td>
<td>20 minutes</td>
<td>15 gpm</td>
<td>15 gpm</td>
<td>15 gpm</td>
<td>15 gpm</td>
</tr>
<tr>
<td>Dipper well</td>
<td>600 minutes</td>
<td>0.5 gpm</td>
<td>0.5 gpm</td>
<td>0.5 gpm</td>
<td>0.5 gpm</td>
</tr>
<tr>
<td>Hand sinks</td>
<td>250 washes**</td>
<td>2.2 gpm</td>
<td>0.5 gpm</td>
<td>0.5 gpm</td>
<td>0.375 gpm</td>
</tr>
<tr>
<td>Lavatory sinks</td>
<td>400 washes**</td>
<td>2.2 gpm</td>
<td>0.5 gpm</td>
<td>0.5 gpm</td>
<td>0.375 gpm</td>
</tr>
<tr>
<td>Water Use</td>
<td></td>
<td>2510</td>
<td>1760</td>
<td>1580</td>
<td>1320</td>
</tr>
</tbody>
</table>

*15 seconds per rack pre-rinse **20 seconds per hand wash
### Demand Circulation Scenario

![Diagram of water circulation system]

#### Annual Operating Cost of Scenarios

<table>
<thead>
<tr>
<th>System Components</th>
<th>Business as Usual</th>
<th>Low Cost Scenario</th>
<th>Dabbling in the Pool Scenario</th>
<th>Knee Deep Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Use (gal/day)</td>
<td>2510</td>
<td>1760</td>
<td>1580</td>
<td>1320</td>
</tr>
<tr>
<td>Temperature Rise (°F)</td>
<td>70°F</td>
<td>70°F</td>
<td>70°F</td>
<td>70°F</td>
</tr>
<tr>
<td>System Efficiency</td>
<td>68%</td>
<td>70%</td>
<td>85%</td>
<td>90%</td>
</tr>
<tr>
<td>Gas Use (therms/year)</td>
<td>7860</td>
<td>5350</td>
<td>3960</td>
<td>3120</td>
</tr>
<tr>
<td>Electricity Use* (kWh/y)</td>
<td>28910</td>
<td>19000</td>
<td>14400</td>
<td>7010</td>
</tr>
<tr>
<td>Gas Cost</td>
<td>$10,200</td>
<td>$7,000</td>
<td>$5,100</td>
<td>$4,100</td>
</tr>
<tr>
<td>Water + Sewer Cost</td>
<td>$7,300</td>
<td>$5,200</td>
<td>$4,600</td>
<td>$3,900</td>
</tr>
<tr>
<td>Electricity Cost</td>
<td>$4,300</td>
<td>$2,900</td>
<td>$2,200</td>
<td>$1,100</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$21,800</td>
<td>$15,100</td>
<td>$11,900</td>
<td>$9,100</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>$6,700</td>
<td>$9,900</td>
<td>$12,700</td>
<td></td>
</tr>
</tbody>
</table>

*Including energy used for the pump and electric booster heater with 40°F temperature rise, 0.1kWh standby loss (14h/d), 97% efficiency
Typical Low-Cost System in QSR

Configuration A

Tankless Installed Over Mop Sink

Configuration B
Demand Circulation w/ Cond. Tankless

Configuration C

Hybrid System w/ Electric Tankless

Configuration D
Est. Wait Time For Hot Water

Priorities in the design of QSR:
• Minimize water heater footprint and installed cost

Recap...
• Reduce [Hot] Water Use
  – Spec Energy Star dishwashers
  – Low flow pre-rinse valves
  – 0.5 gpm (or less) aerators

• Increase Water Heating System Efficiency
  – Higher efficiency [condensing] water heaters (tank type or tankless)
  – Distribution efficiencies (re-circulation pump control, insulation, optimized plumbing)
Thanks for Listening

Food Service Technology Center

www.fishnick.com