AABC Commissioning Group

AIA Provider Number 50111116

Understanding Hot Water Consumption, Energy Use & System Efficiencies in High Use Facilities

Course Number: CXENERGY1616

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Course Description

How to:

1. Estimate hot water demands; and
2. Determine the requirements for calculating the capacity for the water heating system in high use facilities.

Topics include:

1. The effects of efficiency on the consumption of energy in water heating systems,
2. How those efficiencies calculate into actual costs,
3. How specifying higher efficiency equipment can reduce energy consumption; and
4. Operating cost (with realistic ROIs) and emerging technologies.

Learning Objectives

At the end of the this course, participants will be able to:

1. Understand the methods of calculating estimates for hot water demand and capacity in a high use facility.

2. Understand the methods of calculating energy consumption of water heating equipment based on hot water demand.

3. Understand how energy efficiency affects energy consumption and calculating operating costs.

4. Understand and calculate how emerging technologies can impact operating costs.

Hot Water Demand

Defining a high use facility:

A High Use facility is one that uses a large consistent volume of hot water in a day.

Examples:

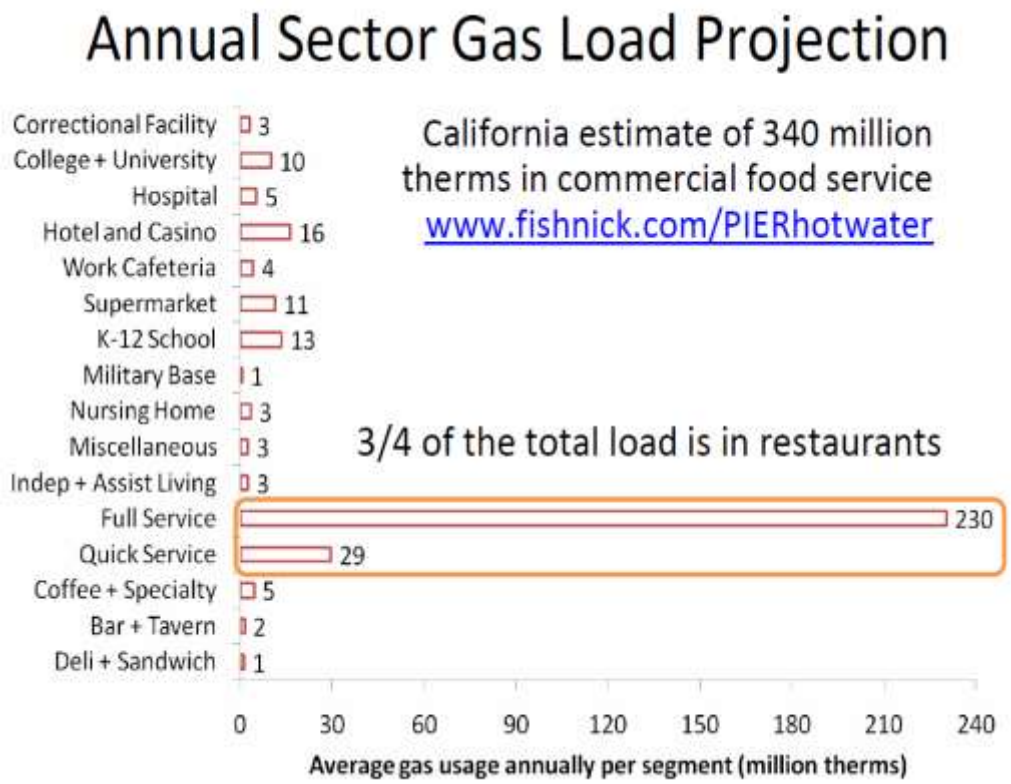
- Restaurants, Food Service, and Cafeterias
- Athletic Facilities, Clubs, and Gyms
- Hospitality, Hotels, Motels, and Conference Centers
- Extended Health Care, Retirement Homes, and Rehabilitation Centers

Hot Water Demand

Defining a high use facility:

Fisher Nickel Study

- Defined Gas Loads by Industry
- Identified High Energy Costs Facilities



*source: http://aceee.org/files/pdf/conferences/hwf/2011/5B%20-%20Don%20Fisher.pdf

Hot Water Demand

Defining a high use facility:

Fisher Nickel Study

- Defined Restaurants by type
  - Café
  - Quick Service
  - Full Service

- Estimated Usage Range by square footage

	Average Area (ft^2)	Avg Daily Hot Water Use (gal)	Max Daily Hot Water Use	Max Hourly Hot Water Use	Max Hot Water Flow Rate (gpm)	Outlet Temp (°F)	Storage (gallons)	Standard Input Rate
Small Café	200-1000	30-100	50-140	20-40	3--8	125-135	40-50	40-60
Medium Café	1000-2000	100-350	150-500	40-80	3--8	125-145	50-70	50-75
Large Café	2000-3000	200-500	300-800	60-120	5--10	125-145	60-100	60-100
Small QSR	1000-2000	50-400	100-700	40-100	5--10	125-145	60-100	60-100
Medium QSR	2000-3000	400-700	700-1000	100-200	5--15	125-145	60-100	100-160
Large QSR	3000-5000	700-2200	1000-3500	150-400	10--15	125-145	80-150	130-200
Small FSR	1500-4000	700-2000	1000-3000	150-400	5--15	125-150	80-150	100-200
Medium FSR	4000-7000	2000-3500	2500-4000	300-600	10--40	135-160	80-200	200-400
Large FSR	7000-12000	3500-7000	4500-12000	450-800	10--40	135-195	80-250	400-2000

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Hot Water Demand

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Medium Café	1000-2000	100-350	150-500	40-80	3--8	125-145	50-70	50-75
Large Café	2000-3000	200-500	300-800	60-120	5--10	125-145	60-100	60-100
Small QSR	1000-2000	50-400	100-700	40-100	5--10	125-145	60-100	60-100
Medium QSR	2000-3000	400-700	700-1000	100-200	5--15	125-145	60-100	100-160
Large QSR	3000-5000	700-2200	1000-3500	150-400	10--15	125-145	80-150	130-200
Small FSR	1500-4000	700-2000	1000-3000	150-400	5--15	125-150	80-150	100-200
Medium FSR	4000-7000	2000-3500	2500-4000	300-600	10--40	135-160	80-200	200-400
Large FSR	7000-12000	3500-7000	4500-12000	450-800	10--40	135-195	80-250	400-2000

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Hot Water Demand

Methods of Calculating estimates:

Three factors you need to know:

- Time
- Temperature
- Quantity

Hot Water Demand

Methods of Calculating estimates:

Time

- How long is the demand
- How long is the recovery
- Used to determine the delivery rating
  - First Hour Recovery
  - Gallons Per Minute Recovery

Hot Water Demand

Methods of Calculating estimates:

Temperature

Hot Water Temperature °F

- 140°F

Supply (Cold) Water Temperature °F

- 60°F

Recovery Δt °F

- 140°F - 60°F = 80°F

Hot Water Demand

Methods of Calculating estimates:

Quantity

Total Gallons per Hour (GPH)

- Stored Capacity, Tank

Peak Gallons per Minute (GPM)

- Continuous Flow or Tankless

Hot Water Demand

Methods of Calculating estimates:

Common Calculations

- Measure and Quantify Fixture GPM Flow Rates
- Sum all Fixture Quantities
- Calculating GPH
  - GPM ^{x} Minutes per Hour of Use for each
  - Some Equipment, like dishwashers, list this in specification sheets

Fixture Type	Flow Rate	
	Tankless (gpm)	Tank (gph)
Restroom sinks	0.5	5
Hand sinks	0.5	5
3-comp. sink (18” X 18”)	2	42
3-comp. sink (bar)	2	18
Pre-rinse spray valve	1.6	48
Mop sink	2	15
Utility sink	2	5
Utensil pre-soak sink	2	5
Dipper well	0.5	30
Door-type dishwasher (variable)	4.4	30
Conveyor dishwasher (variable)	2.1	126
Total	19.6	329

Hot Water Demand

Water Usage Calculation Example:

Quick Usage Calculations:

- Average QSR
- GPH for Tank WH
- GPM for Tankless WH
  - Dish @100%
  - Others at % Simultaneous Use

Usage				Tankless		Tank
QTY	Min/Hr	%/Hr	Fixture Type	(gpm)	Total	(gph)
4	6	10%	Restroom Sink	0.5	2	5
2	6	10%	Hand Sinks	0.5	1	5
1	10	17%	Utility/Mop Sink	5	5	15
1	30	50%	3-Comp Sink	5	5	42
% Sim Use		40%	Total Consumption		5.2	
1	60	100%	Conveyor Dish	2.1	2.1	126
1	30	50%	Pre-Rinse Spayer	1.6	1.6	48
					GPM	GPH
			Total Hot Water Demand		8.9	241

Calculating Energy Consumption

Energy required to heat potable water:

BTU Calculation Formula

Based on GPH

BTU	=	GPH X (8.33 X Delta-T)

- 8.33 is BTU to raise 1 gallon of water, 1 degree, in 1 hour

Based on GPM

BTU	=	GPM X (500 X Delta-T)

- 500 is (8.33x60) BTU to raise 1 gallon of water, 1 degree, in 1 hour

Calculating Energy Consumption

Energy required to heat potable water:

BTU Calculation Formula

Based on 241GPH @80°F

160,602	**=**	**241 X (8.33 X 80)**

- 8.33 is BTU to raise 1 gallon of water, 1 degree, in 1 hour

Based on 8.9 GPM @80°F

356,000	**=**	**8.9 X (500 X 80)**

- 500 is (8.33x60) BTU to raise 1 gallon of water, 1 degree, in 1 hour

Energy Efficiency Consumption

Water Heater Efficiency and Consumption:

Water Heater Input BTU Calculation Formula

Based on GPH

$$\text{WH BTU} = \frac{\text{GPH X (8.33 X Delta-T)}}{\text{WH Efficiency}}$$

- WH Efficiency is the Thermal Efficiency of the Water Heater
- For GPM use 500 in place of 8.33

Energy Efficiency Consumption

Water Heater Efficiency and Consumption:

Water Heater Efficiencies

- Thermal Efficiency
  - Amount of Energy Transferred to Water
- Thermal Loss
  - Amount of Energy Lost during Standby
- First Hour Rating - Gallons
  - 70% of Tank Capacity plus One Hour Recovery

Thermal Efficiency	
Standard Tank	80%
Condensing Tank	94%
Condensing Tankless	96%
Boiler	82%
Condensing Boiler	96%
Electric Water Heater	100%

Energy Efficiency Consumption

Water Heater Efficiency and Consumption:

Water Heater Input BTU Calculation Formula

Based on GPH

$$\text{WH BTU} = \frac{\text{GPH X (8.33 X Delta-T)}}{\text{WH Efficiency}}$$

- WH Efficiency is the Thermal Efficiency of the Water Heater
- For GPM use 500 in place of 8.33

Energy Efficiency Consumption

Water Heater Efficiency and Consumption:

Water Heater Input BTU Calculations

Based on 241GPH @80°F or 160,602BTU Required

Standard Tank	200,753 BTUH
Condensing Tank	170,854 BTUH
Condensing Tankless	167,361 BTUH
Electric Tank	160,602 BTUH (47kw)

- Tankless Calculated at 4GPM

Energy Efficiency Consumption

Water Heater Consumption and Energy Costs:

Water Heating Costs

Based on 241GPH @80°F for 8 hours or 1,928 Gallons per day

Heater Type	Daily		Annual
	Fuel Consumption	Energy Costs	Energy Costs
Standard Tank	1,562 CF	$ 19.60	$ 7,153.30
Condensing Tank	1,330 CF	$ 16.68	$ 6,087.92
Condensing Tankless	1,302 CF	$ 16.34	$ 5,963.47
Electric Tank	377 kwh	$ 45.19	$ 16,493.28

- $12.54 Average Natural Gas per 1,000cf
- $0.12 Average Electrical Price per kwh

Calculating Energy Consumption

Energy required to heat potable water:

BTU Calculation Formula

Based on 241GPH @80°F

160,602	**=**	**241 X (8.33 X 80)**

- 8.33 is BTU to raise 1 gallon of water, 1 degree, in 1 hour

Based on 8.9 GPM @80°F

356,000	**=**	**8.9 X (500 X 80)**

- 500 is (8.33x60) BTU to raise 1 gallon of water, 1 degree, in 1 hour

Emerging Technologies

Combined system energy recovery technologies:

Air Conditioning Heat Recovery

- Many Technologies available

Direct Water Cooled Refrigerant Condenser Advantages

- Higher Temperatures >125°F
- Higher Operating Efficiency
  - Reduced compressor loading
  - Greater Heat Rejection
- Larger Potable Water Heating Capacity

Emerging Technologies

Combined system energy recovery technologies:

Energy Recovery Calculations

Based on 241GPH Hot Water Demand

	Temp °F	BTU
Cold Water Temp	60	
Hot Water Temp	140	Required
Delta-T	80	160,602
Energy Recovery Temp	120	Recovered
Recovery Delta-T	60	120,452
Water Heater Delta-T	20	40,151

- Tankless Calculated at 4GPM
- 75% of Required Energy Recovered in this Scenario

Emerging Technologies

Combined system energy recovery technologies:

Savings Equation

$$\text{Energy Recovered} = \sum(\Delta BTU_{H2O} + \Delta BTU_{Gas} + \Delta BTU_{H2O\ HEATER} + \Delta BTU_{RTU})$$

- Calculate Delta from Baseline
- Calculate Energy Output of Recovery System

Emerging Technologies

Combined system energy recovery technologies:

Reduced Water Heating Costs:

- With 120°F Pre-heated Water provided by Energy Recovery System
- Based on 241GPH @20°F for 8 hours or 1,928 Gallons per day

Heater Type	Daily		Annual
	Fuel Consumption	Energy Costs	Energy Costs
Standard Tank	391 CF	$ 4.90	$ 1,788.33
Condensing Tank	332 CF	$ 4.17	$ 1,521.98
Condensing Tankless	326 CF	$ 4.08	$ 1,490.87
Electric Tank	94 kwh	$ 11.30	$ 4,123.32

- $12.54 Average Natural Gas per 1,000cf
- $0.12 Average Electrical Price per kwh

Emerging Technologies

Combined system energy recovery technologies:

Savings Potential:

- With 120°F Pre-heated Water provided by Energy Recovery System
- Based on 241GPH @20°F for 8 hours or 1,928 Gallons per day

Heater Type	Annual Energy Costs		
	Standard	w/Recovery	Savings Potential
Standard Tank	$ 7,153.30	$ 1,788.33	$ 5,364.98
Condensing Tank	$ 6,087.92	$ 1,521.98	$ 4,565.94
Condensing Tankless	$ 5,963.47	$ 1,490.87	$ 4,472.60
Electric Tank	$ 16,493.28	$ 4,123.32	$ 12,369.96

- Savings example does not count for seasonality
- Assumes 8 hours of mechanical cooling per day

Learning Objectives

In this course we have covered

1. The methods of calculating estimates for hot water demand and capacity in a high use facility.

2. The methods of calculating energy consumption of water heating equipment based on hot water demand.

3. How energy efficiency affects energy consumption and calculating operating costs.

4. How emerging technologies can impact operating costs.

Question
And Answer

What questions do you have regarding these methods:

This concludes The American Institute of Architects
Continuing Education Systems Course

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