Welcome

Continuing Education Unit presented by Eemax®

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Rethink Water Heating

HOT WATER DISTRIBUTION | SAVE ENERGY, WATER, AND SPACE

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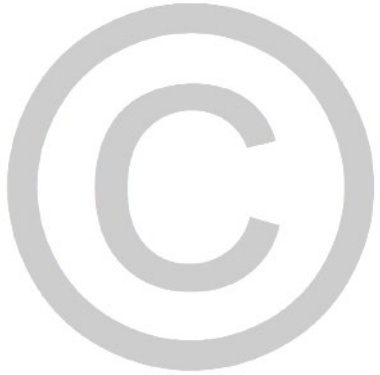

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Course Description

The challenge for plumbing design professionals is finding the right balance between performance and efficiency in water heating systems.

A review of plumbing code requirements and insights into specification considerations will be shared.

This course will identify types of water heating technologies with a focus on **Tankless Electric Water Heater (TEWH)** function and design.

Learning Objectives

- Code considerations
  - UL, UPC, IPC, IECC, ANSI, NEC
- Water heating technologies
  - Tank type
  - Indirect
  - Renewables
  - Tankless
- Tankless Electric Water Heating
  - Technology overview
  - Advantages & Attributes
  - Savings
  - Applications & Sizing
  - Addressing misconceptions
- Design considerations

Where to Apply the Knowledge

- Commercial

- Residential

- Industrial

Design & Selection Considerations

- Available resource
- Product availability
- Water consumption and waste
- Energy consumption and waste
- Reliability
- Performance
- Code & Regulatory Compliance

- Costs associated with:
  - Product
  - Installation
  - Operation
  - Maintenance
  - Ownership

Codes & Regulations

- UPC
- IPC
- NEC
- IECC
- ANSI/ISEA

Code Bodies

Uniform Plumbing Code

Designated as an American National Standard, the Uniform Plumbing Code (**UPC**) is a model code developed by the International Association of Plumbing and Mechanical Officials (IAPMO) to govern the installation and inspection of plumbing systems as a means of promoting the public's health, safety and welfare.

International Plumbing Code

The International Plumbing Code (**IPC**) is a plumbing code and standard which sets minimum requirements for plumbing systems in their design and function, and which sets out rules for the acceptances of new plumbing-related technologies.

National Electrical Code

The National Electrical Code (**NEC**), or NFPA 70, is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States. It is part of the National Fire Codes series published by the National Fire Protection Association (NFPA), a private trade association

Source: Wikipedia, November 2018

Code Bodies

International Energy Conservation Code

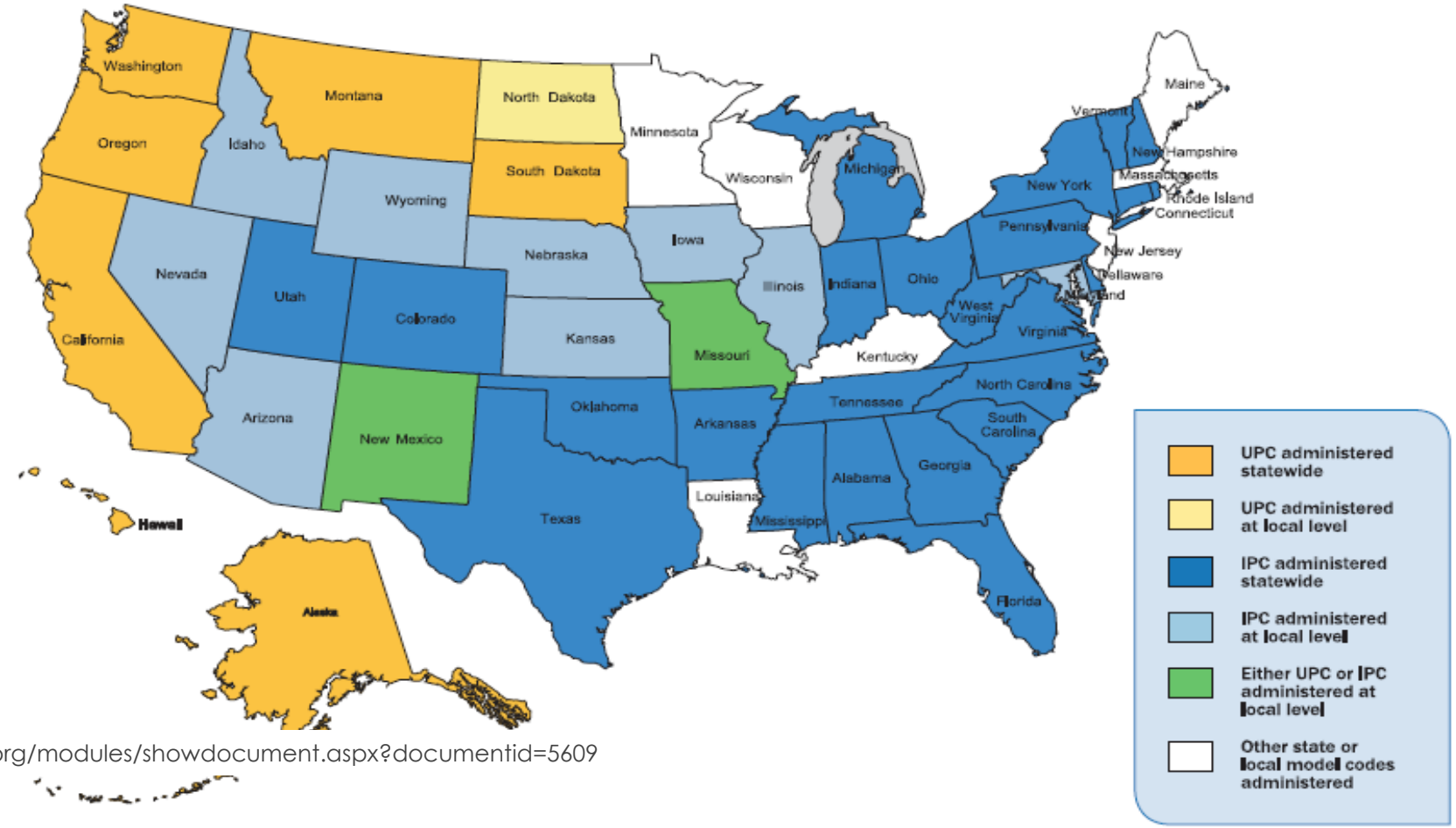
The International Energy Conservation Code (**IECC**) is a building code created by the International Code Council in 2000. It is a model code adopted by many states and municipal governments in the United States to establish minimum design and construction requirements for energy efficiency.

American National Standards Institute

American National Standards Institute (**ANSI**) Codes. ANSI codes are standardized numeric or alphabetic codes issued by the ANSI to ensure uniform identification of geographic entities through all federal government agencies

Source: Wikipedia, November 2018

Model Plumbing Code Adoption Map



Source: https://sfwater.org/modules/showdocument.aspx?documentid=5609

What do these codes govern?

- Water delivery → Efficiency
- Energy consumption → Efficiency
- Reliable performance → Safety
- User hygiene → Safety
- Design liability → Safety

Temperature Control

Impacts on Handwashing

Code updates have greatly impacted this application over the last few years.

Private vs. Public

Private: In the classification of plumbing fixtures "private" applies to fixtures in residences and apartments, and to fixtures in nonpublic toilet rooms of hotels and motels and similar installations in buildings where the plumbing fixtures are intended for utilization by a family or an individual.

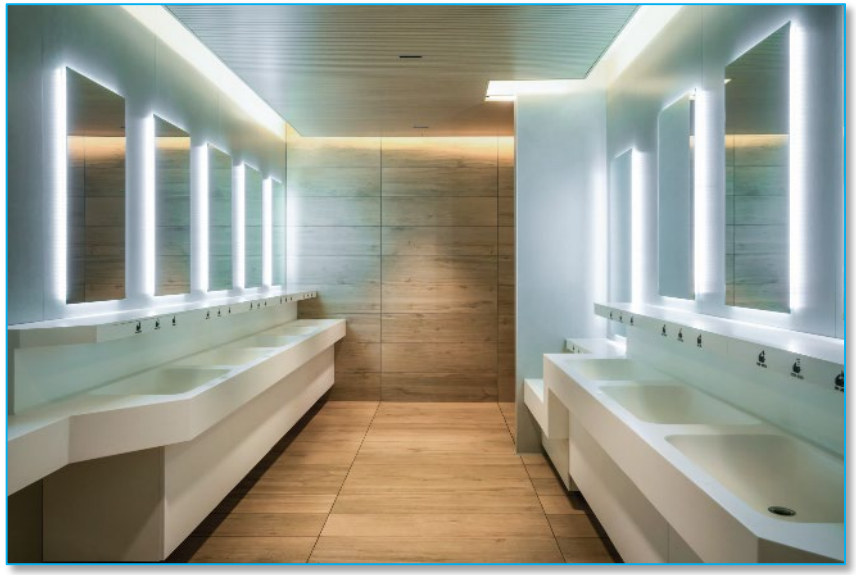
Public: In the classification of plumbing fixtures, "public" applies to fixtures in general toilet rooms of schools, gymnasiums, hotels, airports, bus and railroad stations, public buildings, bars, public comfort stations, office buildings, stadium, stores, restaurants and other installations where a number of fixtures are installed so that their utilization is similarly unrestricted.

Source: International Plumbing Code (IPC), November 2018

Public Handwashing Temperature Control

The 2018 Uniform Plumbing Code (UPC)

- 407.3 Limitation of Hot Water Temperature for Public lavatories. Hot water delivered from public-use lavatories shall be limited to a maximum temperature of 120 °F by a device that is in accordance with ASSE 1070 or CSA B 125.70. The water heater thermostat shall not be considered a control for meeting this provision.



Public Handwashing Temperature Control

- **Appendix L 603.4.5.3** – Sustainable Practices Outlet Temperature Controls. Temperature controlling means shall be provided to limit the maximum temperature of water delivered from lavatory faucets in public facility restrooms to **110 °F**. [ASHRAE_90.1:7.4.4.3].

Source: Universal Plumbing Code (UPC), November 2018

Public Handwashing Temperature Control

The 2015 International Plumbing Code (IPC)

- 416.5 Tempered water for public hand-washing facilities. Tempered water shall be delivered from lavatories and group wash fixtures located in public toilet facilities provided for customers, patrons and visitors. Tempered water shall be delivered through an approved water-temperature limiting device that conforms to ASSE 1070 or CSA B125.7.
- Tempered water is defined as water having a temperature range between 85 °F and 110 °F.

Image source: watts.com

Hot Water Delivery

International Energy Conservation Code (IECC)

SERVICE WATER HEATING

- C404.5
- C404.5.1
- C404.5.2

Source: https://up.codes/s/service-water-heating-mandatory

IECC Considerations

Energy Efficiencies

International Energy Conservation Code (IECC)

- Internationally, code officials recognize the need for a modern, up-to-date energy conservation code addressing the design of energy-efficient building envelopes and installation of energy-efficient mechanical, lighting and power systems through requirements emphasizing performance.

Source: International Code Council (ICC), November 2018

Source: International Energy Conservation Code (IECC) November 2018

Today's IECC is known for

Conservation

It has a proven track record addressing the design of energy-efficient building envelopes and installation of energy-efficient systems.

Embrace of New Technology

The IECC and its predecessors have a tradition of innovation while protecting the health and safety of the public.

Correlation

The IECC is specifically correlated to work with International Code Council's (ICC) family of codes.

Open and Honest Code Development Process

Revised on a 3-year cycle through ICC's highly respected consensus code development process that draws upon the expertise of hundreds of plumbing, building, and safety experts from across North America.

Section C404

Service Water Heating (mandatory)

International Energy Conservation Code (IECC)

C404.5 Efficient heated water supply piping

Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2.

The flow rate through 1/4 inch piping shall not be greater than 0.5 GPM. The flow rate through 5/16 inch piping shall not be greater than 1 GPM. The flow rate through 3/8 inch piping shall be not greater than 1.5 GPM.

Source: https://up.codes/s/service-water-heating-mandatory

Pipe & Water Volume

International Energy Conservation Code (IECC)

C404.5.2 Maximum allowable pipe **volume** method

The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply shall be as follows:

1. For a public lavatory faucet: **not more than 2 ounces**.
2. For other plumbing fixtures or plumbing appliances; **not more than 0.5 gallon**.

C404.5.2.1 Water volume determination

The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

Source: https://up.codes/s/service-water-heating-mandatory

Pipe Length

Source to termination

Source: https://up.codes/s/service-water-heating-mandatory

International Energy Conservation Code (IECC)

C404.5.1 Maximum allowable pipe **length** method

The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1.

1. For a public lavatory faucet, use the "Public lavatory faucets" column in Table C404.5.1.
2. For all other plumbing fixtures and plumbing appliances, use the "Other fixtures and appliances" column in Table C404.5.1.

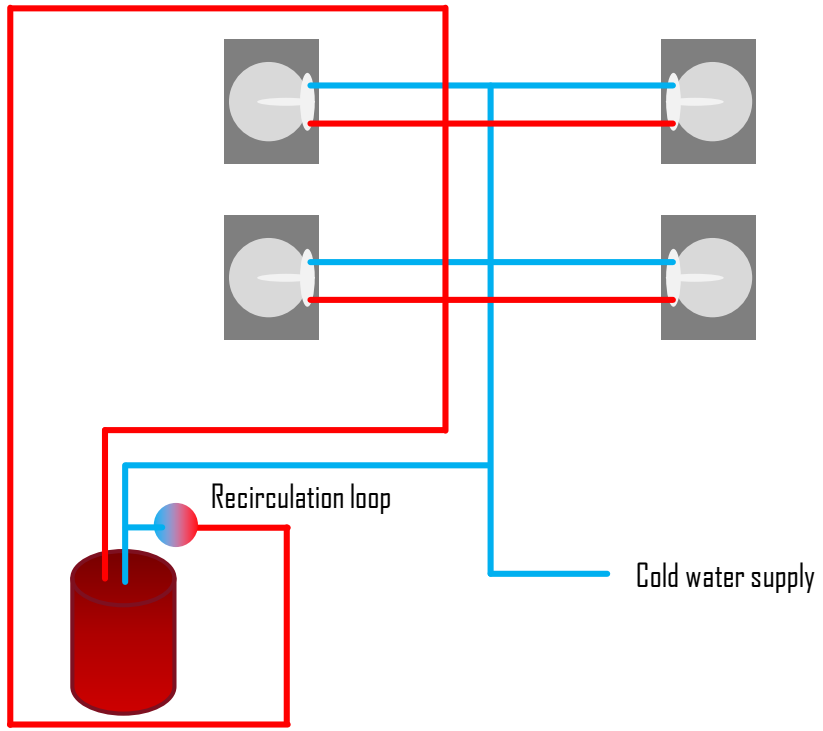
Table C404.5.1
Piping Volume and Maximum Piping Lengths

Nominal Pipe Size (inches)	Volume (liquid ounces per foot length)	Maximum Piping Length (feet)	
		Public lavatory faucets	Other fixtures and appliances
3/8	0.75	3	50
1/2	1.5	2	43
3/4	3	0.5	21
1 1/4	8	0.5	8

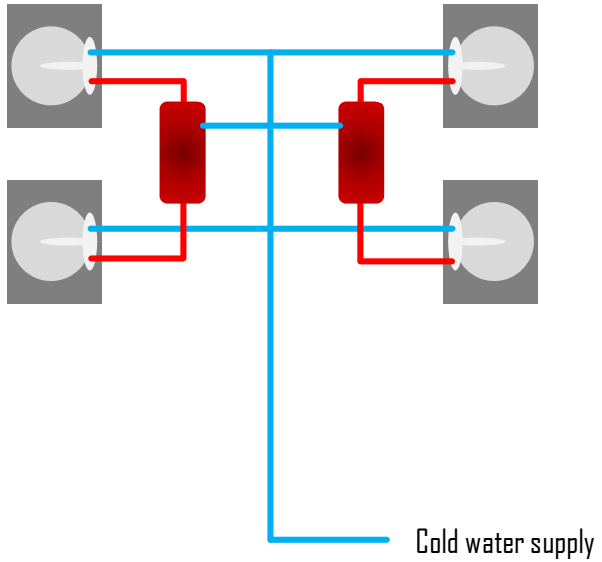
Hot Water Distribution

Any application 0.2 to 40.0 GPM

Traditional Design with Recirculation



Distributed Point-of-Use



ANSI/ISEA Z358.1

One of the most important standards in the industry today

- The American National Standards Institute ANSI Z358.1 requirement for tepid water is 60 °F – 100 °F for Emergency Eye/Face and Drench Showers. This requirement is a direct response to reduce employers' liability and increase employee safety. The problem with untempered water is that the minimum recommendation of 15 minutes to flush hazardous chemicals from contaminated parts of the body is often not met because incoming water temperature can be as low as 35 °F. This condition can cause hypothermia and discourage proper flushing of contaminates.

Tepid Water | ANSI Z358.1

Safety Applications

- Eyewash
- Eye, face, and drench
- Drench shower system
- Flow rate of 3 – 30 GPM

Temperature and flow consistency

23 GPM for 15 min at 60 ° to 100 °F = 345 gal

Tepid Water | Safety Priorities

Locations/applications

- Manufacturing plants
- Industrial or commercial sites
- Schools and universities
- Laboratories
- Warehouses

Where reliability matters

IPC Section 411.3

Tepid Water

International Plumbing Code (IPC)

- 2018 IPC section 411.3 indicates that where both cold and hot water (≥110 °F) are supplied to an emergency shower, the water temperature (discharged by the shower/eyewash) is to be controlled by an ASSE 1071 mixing valve.
- The **set** temperature for the shower/eyewash is determined by the person (building designer, industrial safety expert) who specified the installation of the shower/eyewash.

Source: 2018 IPC Update, based on 2018 International Plumbing Code

Tepid Water • ANSI Z358.1

Emergency Eyewash and Drench Shower

Traditional System

- 300+ gal storage capacity needed (storage, water heater, steam)
- Mixing valves, recirculation system, extensive piping
- Requires continuous heating 24/7 at prescribed temp
  - Moderate temperature water creates conditions for bacteria growth (Legionella)

With complex systems, it can be difficult to ensure code compliance and reduce scald risk.

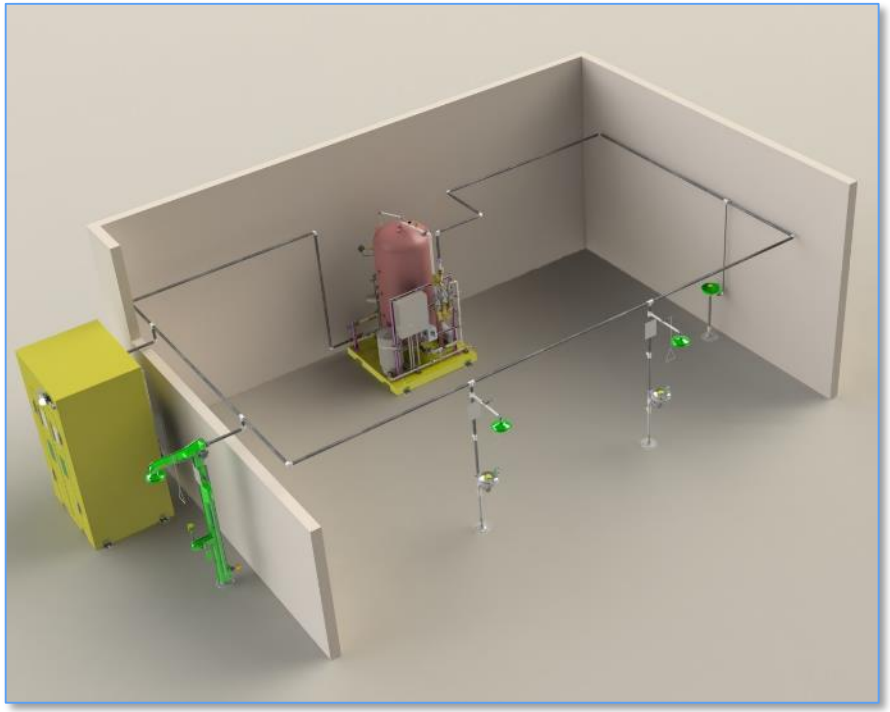


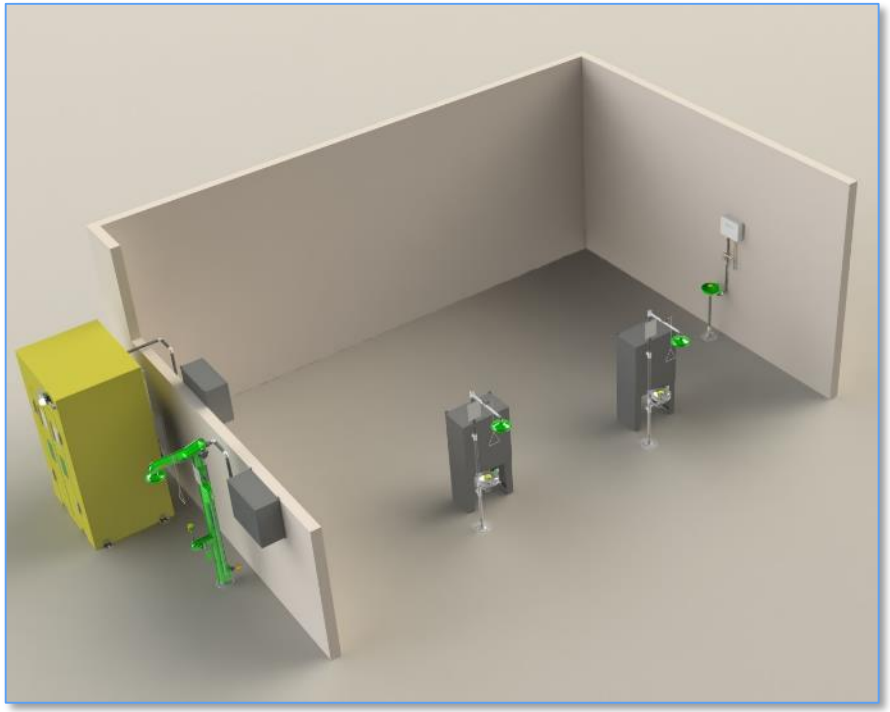
Image: Copyright © 2019 Haws, a Traynor Family Enterprise(TM)

Tepid Water • ANSI Z358.1

Emergency Eyewash and Drench Shower

On-Demand System

- Compact footprint
- Energy efficient
- 1-pipe system
- Precise temperature control
- Quick time to temperature
- No mixing valve required (unless dictated by local code)



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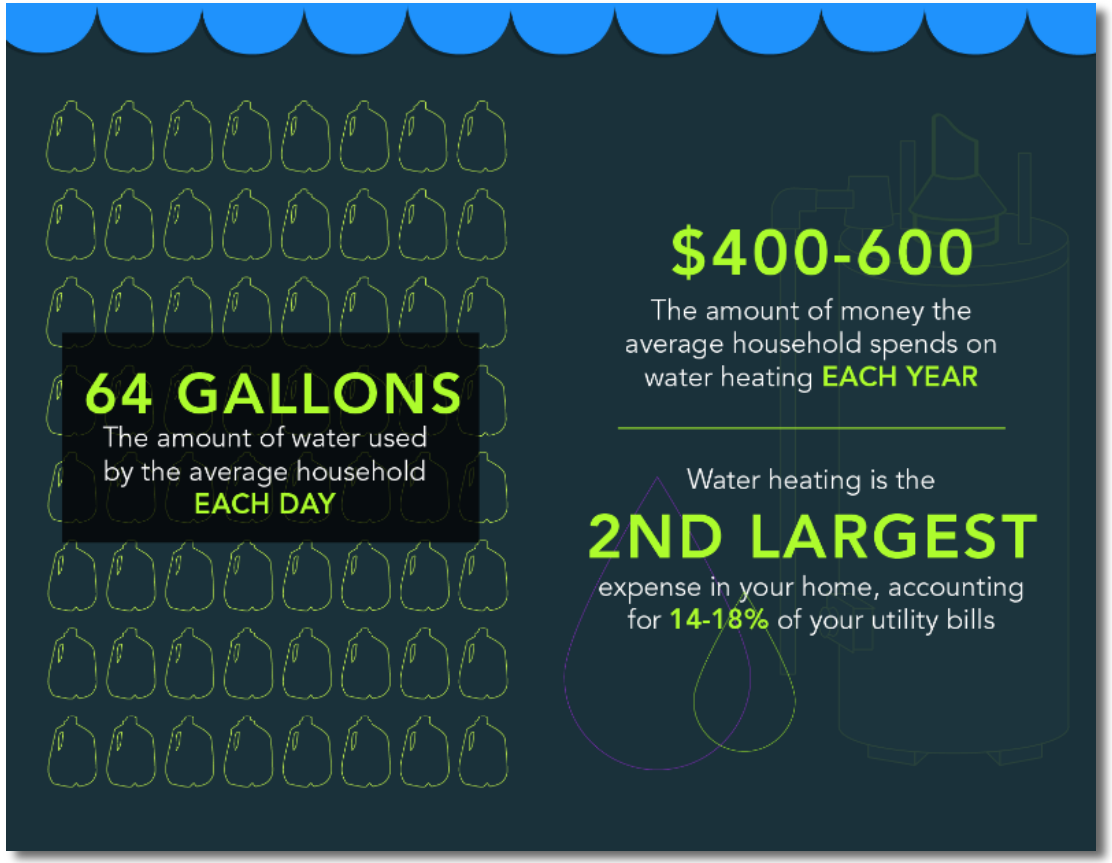
Why it Matters

Department of Energy

Consider options that support sustainability



Source: Department of Energy, April 19, 2013, *New Infographic and Projects to Keep Your Energy Bills Out of Hot Water*

Consumer Experience

Waiting for hot water

125 feet of ¾" pipe = 3.14 gal

10 x per day = 31 gal

1 year = 11,461 gal

25 M homes = 300 B gal/yr

- Waiting for hot water **wastes** water; adding to both supply and sewer costs

Water Heating Technologies

Water Heating Technologies

- Gas, oil, electric tank-type
- Indirect or tankless coil
- Renewables
  - Geothermal system
  - Solar water heating
- Tankless
- Tankless Electric Water Heater

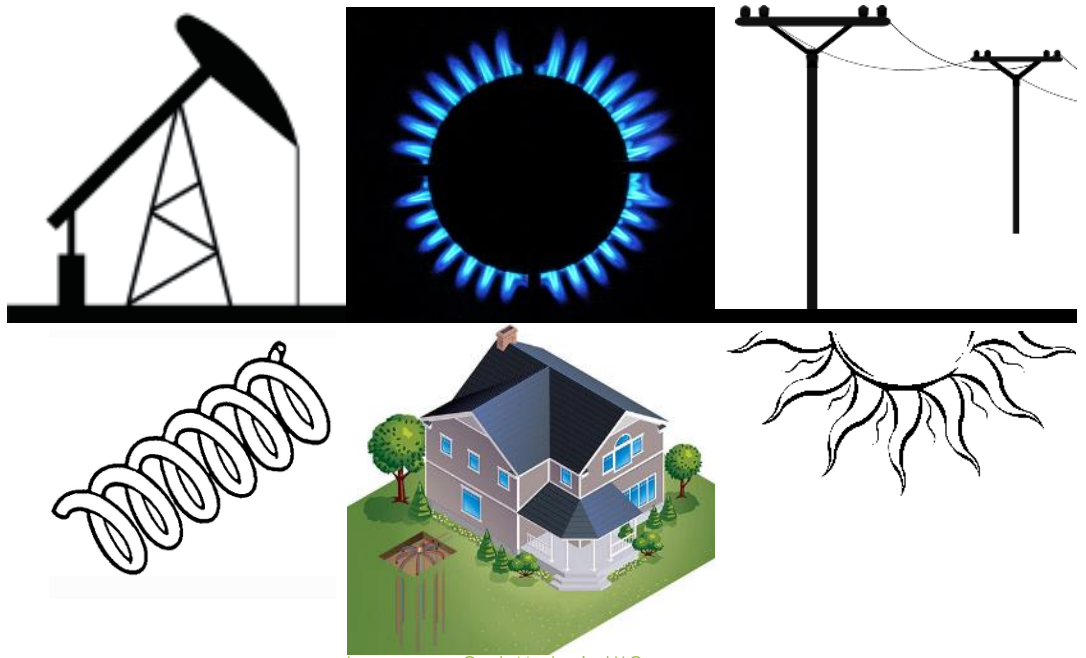
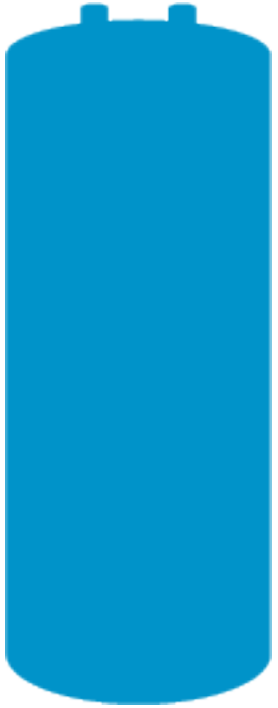


Image source: Grady Mechanical LLC

Tank-Type Water Heaters

- Fuel: Gas, oil, or electric
- Construction
  - Enamel lined steel or stainless steel cylinder
  - Control boards, thermostats, electrical components
  - Exterior finishes vary by type and manufacturer
- Heat transfer method
  - Immersed electric element or burner with a flue
- Heats and maintains stored water to set temperature



By The Way

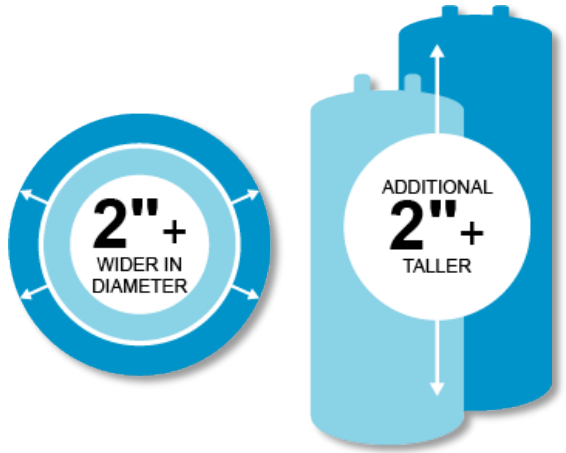
NAECA 3

NAECA 3

Department of Energy (DoE)

- Requires manufacturers to produce more efficient water heater tanks
- Tankless water heaters are unaffected by this regulation

The National Appliance Energy Conservation Act (NAECA) of 1987 is a United States Act of Congress that regulates energy consumption of specific household appliances



Residential Changes

- The Department of Energy changed efficiency minimums for residential gas and electric water heaters.

	Size	Old (EF)	New (EF)
Gas-Fired Storage	≤ 55 gal	0.59	0.62
	> 55 gal	0.55	0.75
Electric Storage	≤ 55 gal	0.9	0.95
	> 55 gal	0.86	1.97
Oil-Fired Storage	> 30 gal	0.53	0.62

Residential Impact

Changes on electric models

- 55 gal heaters and above will increase to ~2.0 EF
- 80 gal heaters will cease production
- 20 - 55 gal will increase to ~.95 EF
- No change in tankless electric
- No requirements for electric tank heaters below 20 gal

Source: April 2015, National Appliance Energy Conservation Act (NAECA)

Commercial Impact

- DoE defines commercial electric water heaters as a product with kilowatt input > 12 kW or volume >120 gal.
- Any electric water heater with input of ≤12 kW or <120 gal, is defined as residential and must comply with minimum efficiency standards established by NAECA.
- Many traditional commercial tank-type water heaters (such as a 6 kW, 80 gal) can no longer be sold in the U.S.
- Compliance to the new requirement is based on date of manufacture.

Source: National Appliance Energy Conservation Act (NAECA)

Water Heating Technologies

CONTINUED

Indirect Water Heating

- **Boilers**

Systems that are used for central heating, or process heat, also serve domestic hot water needs.

Residential Boiler

- Effective option when used with an indirect water heater
- High-cost system that makes sense when hydronic heating is installed

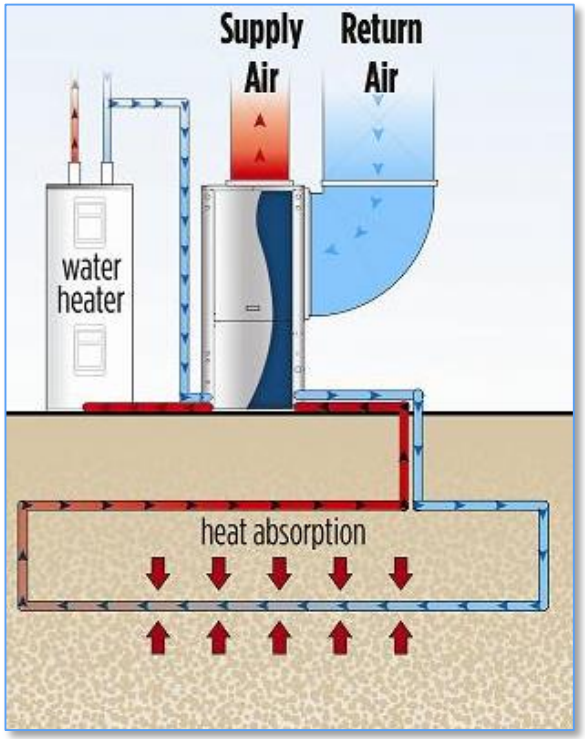
Commercial Boiler

- Large and complex
- Requires costly and extensive maintenance

Geothermal Water Heating

Requires back-up sources

- Beneath the earth's surface, the temperature is a constant 50 to 60 °F, a natural and everlasting source of heat. The **geothermal heat** pump takes advantage of this constant heat source by transferring and concentrating the heat to provide: a source of heat energy for space heating, ... a source of heat for domestic **hot water**.

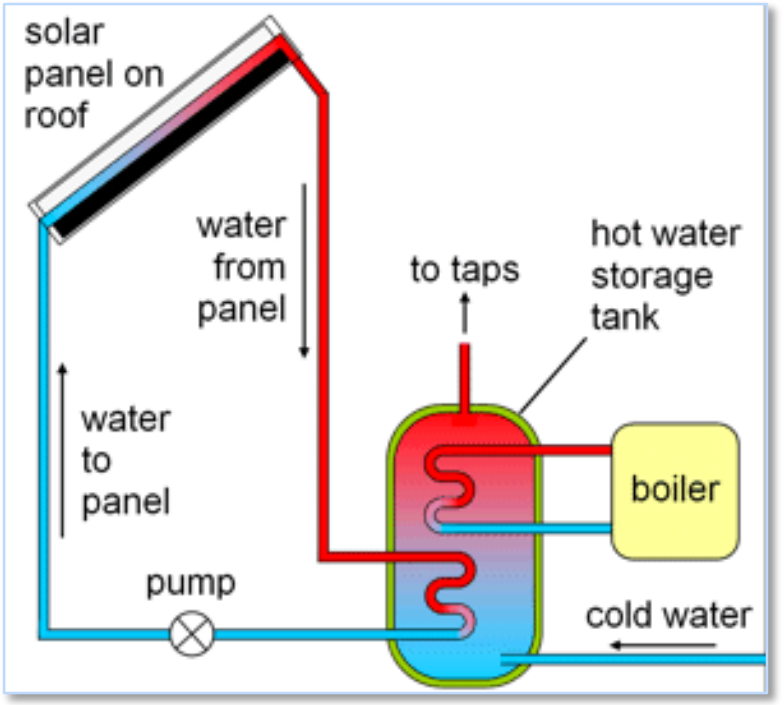


Source: www.energyhomes.org/renewable-technology/howgeoworks.html

Solar Water Heating

Requires back-up sources

- Solar thermal energy heats fluid in the solar collectors. ... Direct systems circulate water through the collectors where it is heated by the sun. Heated water is stored in a tank, sent to a tankless water heater, or used directly. These systems are preferable in climates where it rarely freezes.



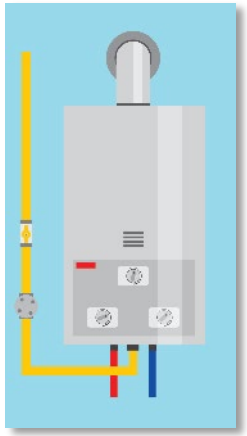
Source: https://www.energystar.gov/products/water_heaters/water_heater_solar/how_it_works

Tankless Water Heating

- Fuel type: gas or electric
- Construction
  - Wetted components consist of brass/copper, stainless steel, or engineered plastic
  - Control boards, relays, various electronic components
  - Exteriors vary by type and manufacturer
- Heat transfer method
  - Electric: heating elements, sheathed or bare wire
  - Gas: heat exchanger with flue
- Flow activated, heating water only on demand

Electric Tankless

Gas Tankless



A Side-by-Side Comparison

Tankless Electric Water Heater

- Heats water only as needed
- Simplified system designs
- Lower energy cost over time
- No venting required
- Compact, can be wall mounted
- Flexible installation options
- Easy to maintain
- 20 year design life

All others

- Store & heat gallons of water
- Complex integrated systems
- Higher energy cost over time
- Venting required
- Large foot print & buffer space
- Typically require long pipe runs
- Costly maintenance
- 8 – 10 year lifespan

Pros, Cons, and Considerations

	Pros	Cons	Considerations
Tank	Readily available Wide selection	Large and inefficient	Use the appropriate technology for the application to design a well-balanced system for performance and efficiency.
Indirect	Multi functional Can handle massive projects	Trade knowledge is a MUST Requires system integration and controls	
Renewable	Free resource Incentives	Subject to resource availability EXPENSIVE Needs backup	
Tankless	Compact and efficient Wide selection Readily available	May require a different approach Lack of familiarity	

Tankless Electric Water Heaters (TEWH)

TEWH Design Benefits – Sustainability

Desired results

- Lower operating costs
- Healthy and comfortable
- Conserve energy and water
- Reduce waste to landfills
- Environmental stewardship
- TEWHs that are certified by AHRI to LEED efficiency standards (≥99%), help earn a 2-point credit (12 kW and under)

TEWH Advantages

- Water is heated only on demand
- Power is only drawn when needed
- Virtually no stand-by heat loss
- Up to 99% energy efficient
- Compact size
- Easy installation
- No venting
- Longer product life
- Improved hot water delivery
- Safe and reliable
- Low maintenance
- Eliminates unnecessary recirculation

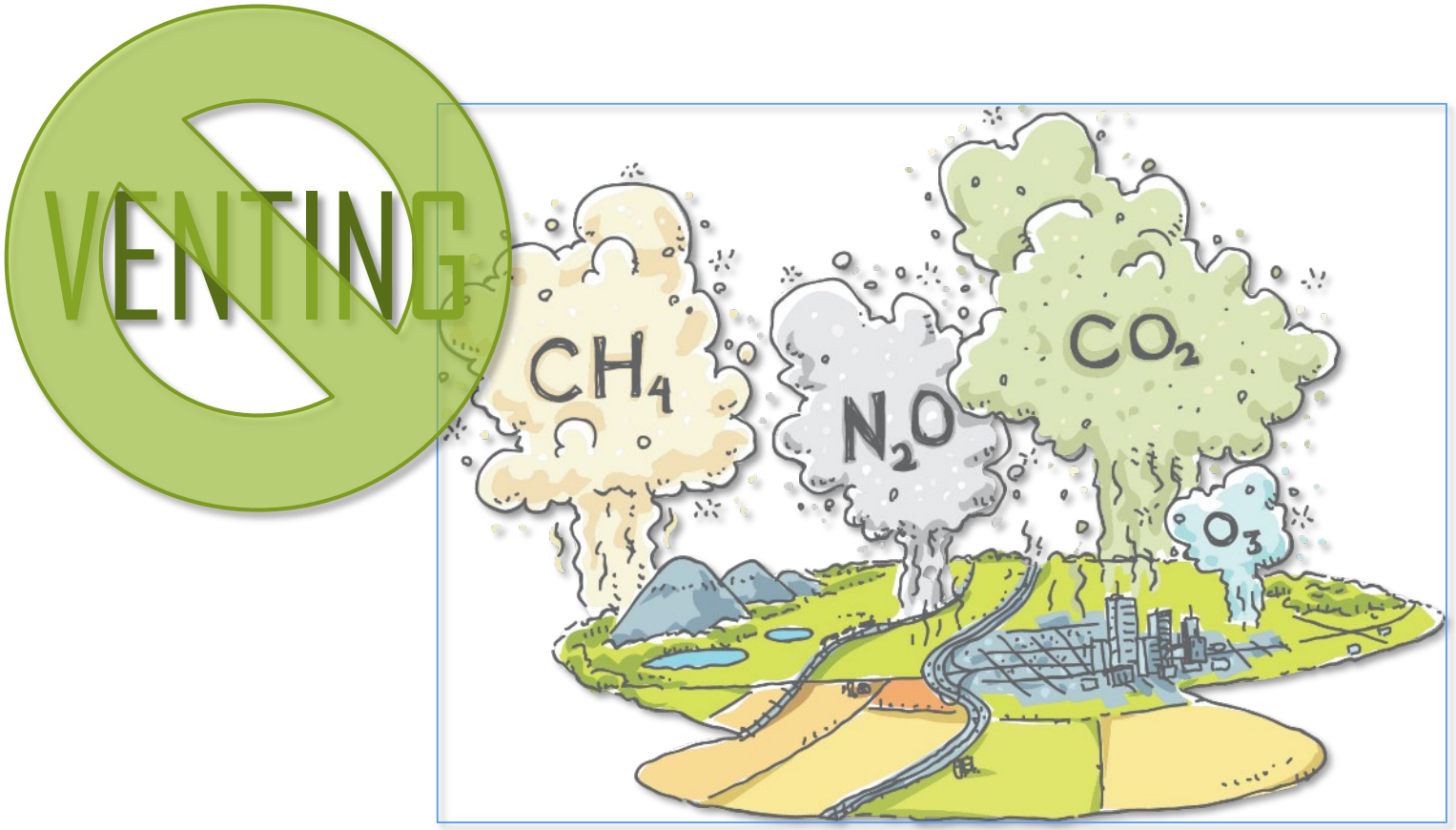
TEWH Attributes

- Delivered flow rate of 0.2 to 40 GPM
- Residential, commercial, industrial applications
- Power range: 1.8 kW to 150 kW **(6.1 kBTU to 511.8 kBTU)**
- Voltage range: 120 V to 600 V (Single Phase and Three Phase)
- Temperature range: 60 °F to 180 °F
- Customizable: wide range of design options

TEWH Savings

- Money
- Water
- Energy
- Space

Did We Mention



Sizing and Applications

Sizing Guidelines

- Use formulas at right to determine correct kW
- GPM = gallons per minute
- Rise in temp = outlet temp – inlet temp

Formulas

$$\text{Flow Rate (GPM)} = \frac{\text{kW rating x 6.83}}{\text{rise in temp (°F)}}$$

$$\text{Rise in temp (°F)} = \frac{\text{kW rating x 6.83}}{\text{flow rate}}$$

$$\text{kW Rating} = \frac{\text{GPM x rise in temp (°F)}}{6.83}$$

Common Applications and Sizing

Handwashing

- Inlet temperature: 55 °F
- Outlet temperature: 105 °F
- Flow rate: 0.35 GPM
- Public or Private: Private

$$\text{kW Rating} = \frac{\text{GPM x rise in temp (°F)}}{6.83}$$

(0.35 X 50) / 6.83 = 2.56 kW required

Amperage:

2.56 kW x 1000 = 2560 watts

2560/120 = 21.3 amps required
2560/208 = 12 amps required
2560/277 = 9.2 amp required

Remember what we talked about earlier

TEWHs can meet **public** handwashing codes

Delivered Set Temperature

- Meets UPC and IPC codes
- ASSE 1070 mixing valve
- Flow rate range 0.2 – 2.5 GPM
- Lead-free
- Single and multi-lavatory applications

Common Applications and Sizing

Kitchen Sink

- Inlet temperature: 55 °F
- Outlet temperature: 120 °F
- Flow rate: 1.5 GPM
- Public or Private: Private

$$\text{kW Rating} = \frac{\text{GPM x rise in temp (°F)}}{6.83}$$

(1.5 X 65) / 6.83 = 14.2 kW required

Amperage:

14.2 kW x 1000 = 14200 watts

14200/120 = 118 amps required
14200/208 = 68 amps required
14200/277 = 51 amp required
14200/480/1.73 = 17 amps required

Did You Know

UL 499 | Edition 14, Section 30

No T&P Valve

UL 499 covers instantaneous heaters, strap-on-type heaters, heaters for sink or water-cooler mounting, and other water heaters not covered under Household Water Heaters, Storage Tank, Commercial Storage Tank and Booster Water Heaters or Immersion Water Heaters.

Common Applications and Sizing

Safety Shower/Eyewash

- Inlet temperature: 55 °F
- Outlet temperature: 80 °F
- Flow rate: 23 GPM
- Public or Private: Private

$$\text{kW Rating} = \frac{\text{GPM x rise in temp (°F)}}{6.83}$$

(23 X 25) / 6.83 = 84 kW required

Amperage:

84 kW x 1000 = 84000 watts

84000/208/1.73 = 233 amps required
84000/480/1.73 = 101 amps required
84000/600/1.73 = 81 amps required

Remember what we talked about earlier

IPC Section 411.3

Tepid Water

International Plumbing Code (IPC)

- 2018 IPC section 411.3 indicates that where both cold and hot water (≥110 °F) are supplied to an emergency shower, the water temperature (discharged by the shower/eyewash) is to be controlled by an ASSE 1071 mixing valve.
- The **set** temperature for the shower/eyewash is determined by the person (building designer, industrial safety expert) who specified the installation of the shower/eyewash.

Source: 2018 IPC Update, based on 2018 International Plumbing Code

Misunderstandings vs Reality

TANKLESS ELECTRIC WATER HEATERS

TEWHs | Do not draw more power.

- A marathon is 26.2 miles long—no matter if you walk or sprint.
  - A meter will spin the same number of times to generate hot water regardless of technology (tank or tankless).
- Other tankless benefits can outweigh any additional costs associated with increased electrical infrastructure.
- The key is getting in at the design level. Tankless water heaters are not an 11th hour product!

National Electrical Code (NEC)

Did You Know

NEC 422.10 and 422.11

Per NEC 422.10 and 422.11 tankless water heaters **are valued at 100%** of the marked rating due to the fact they do **not** fall into a "continuous load" category. Continuous load is described by NEC as a maximum current draw that exceeds 3 hours.

TEWHs | Do save money.

5 Year Loop Heat Losses

$9,400.00

Based on calculations at right

Recirculation Supply & Return Loop					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Loop length (ft) *(include supply out and loop return)*	200	200	200	200	200
Pipe OD (in) *(average supply and return pipe diameters)*	0.875	0.875	0.875	0.875	0.875
outer radius pipe (in)	0.4375	0.4375	0.4375	0.4375	0.4375
Pipe ID (in) *(average supply and return pipe diameters)*	0.785	0.785	0.785	0.785	0.785
inner radius of pipe (in)	0.3925	0.3925	0.3925	0.3925	0.3925
insulation thickness (in)	1	1	1	1	1
temp of hot water (°F)	120	120	120	120	120
ambient air temp (°F)	70	70	70	70	70
change in temp (°F)	50	50	50	50	50
thermal conductivity of copper pipe (Btu-ft/hr*ft2*°F)	223	223	223	223	223
thermal conductivity of Polyurethane insulation (W/ (m*K)	0.03	0.03	0.03	0.03	0.03
Resistance of insulation "Rb" (hr-ft-°F/Btu)	10.92	10.92	10.92	10.92	10.92
Resultant Resistance	10.92	10.92	10.92	10.92	10.92
Account for lagging	1.10	1.10	1.10	1.10	1.10
Adjusted resultant resistance	12.01	12.01	12.01	12.01	12.01
Q (Btu/hr)	5230.49	5230.49	5230.49	5230.49	5230.49
Heat Loss Q (kW)	1.53	1.53	1.53	1.53	1.53
Heat Loss Q (Btu/hr)	5,230	5,230	5,230	5,230	5,230
electricity cost kW-hr ($)	$0.140	$0.140	$0.140	$0.140	$0.140
Time (hr/yr)	8760	8760	8760	8760	8760
Cost to hold loop at temperature for 1 year	**$1,880**	**$1,880**	**$1,880**	**$1,880**	**$1,880**
$/ month	$156.67	$156.67	$156.67	$156.67	$156.67

Remember what we talked about earlier

Hot Water Delivery

International Energy Conservation Code (IECC)

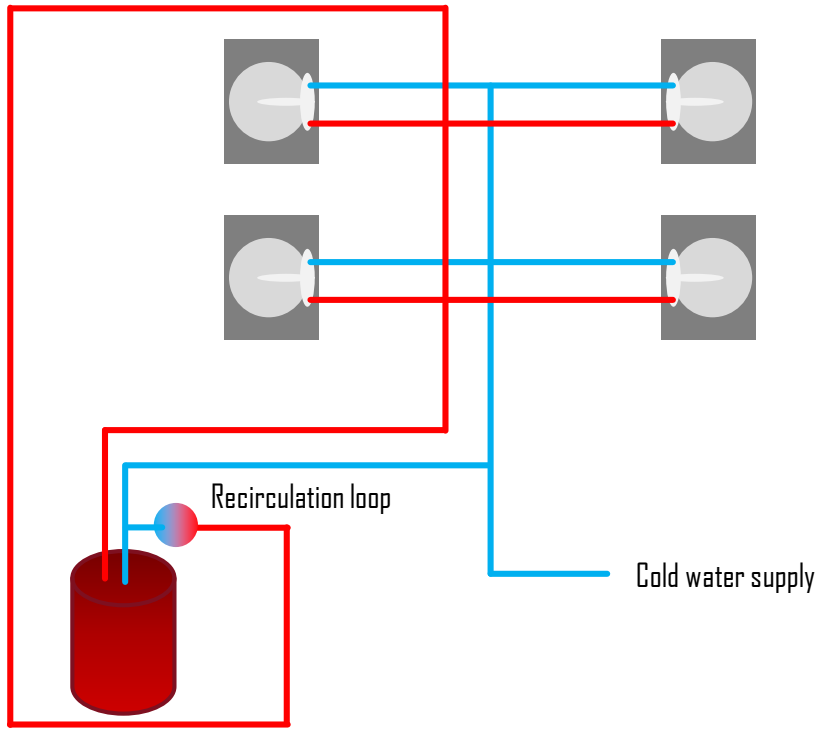
SERVICE WATER HEATING

- C404.5
- C404.5.1
- C404.5.2

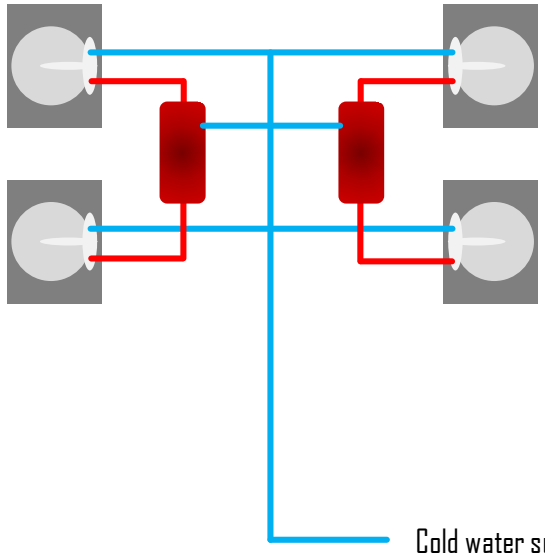
Hot Water Distribution

Any application 0.2 to 40.0 GPM

Traditional Design with Recirculation



Distributed Point-of-Use



In Summary

- Understanding Codes & Regulations
- Water Heating Technologies
- TEWH Advantages & Attributes
- TEWH Applications and Sizing

Which Technology

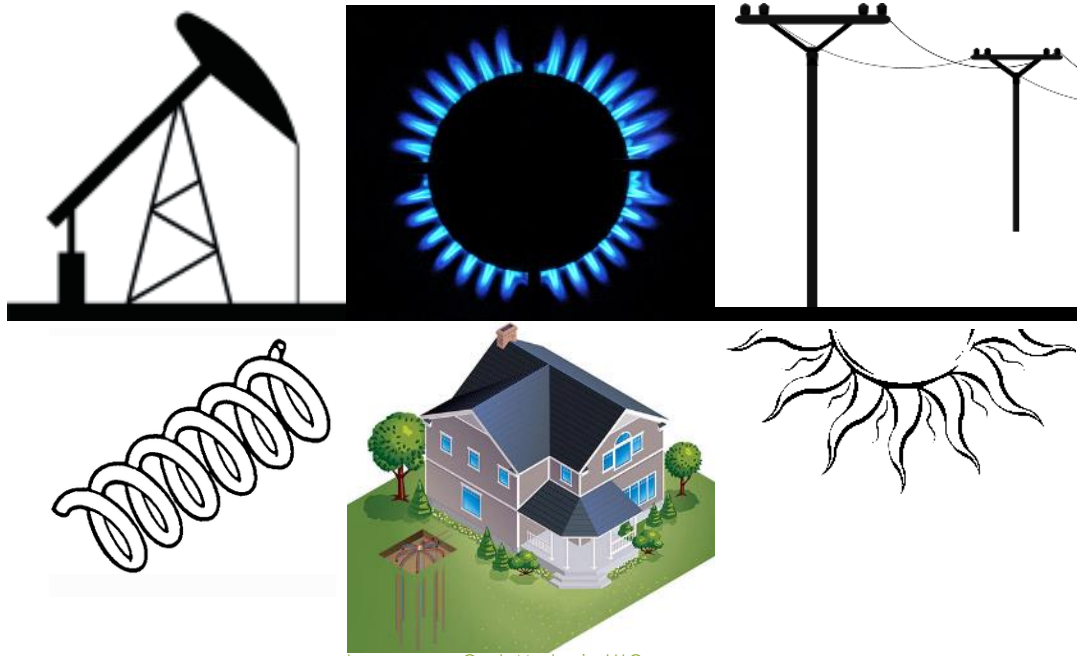
SAVES SPACE

SAVES ENERGY

SAVES WATER

All of Them

- Understanding the products available, where to apply them to create a well-balanced system, while delivering a level of performance and efficiency that the world has come to demand.



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Questions

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