Houses of Religious Worship

Best Practices for
Utility Co$t Reduction

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Presentation Outline

- Utility Pricing & Production Data
- HVAC 101 and Human Comfort
- Ventilation Requirements
- Older HVAC
- Modern HVAC
- Lighting
- Renewable Energy
- Top Conservation Recommendations
- Q & A

Utility Pricing and Production Data

Monetary Fuel Prices

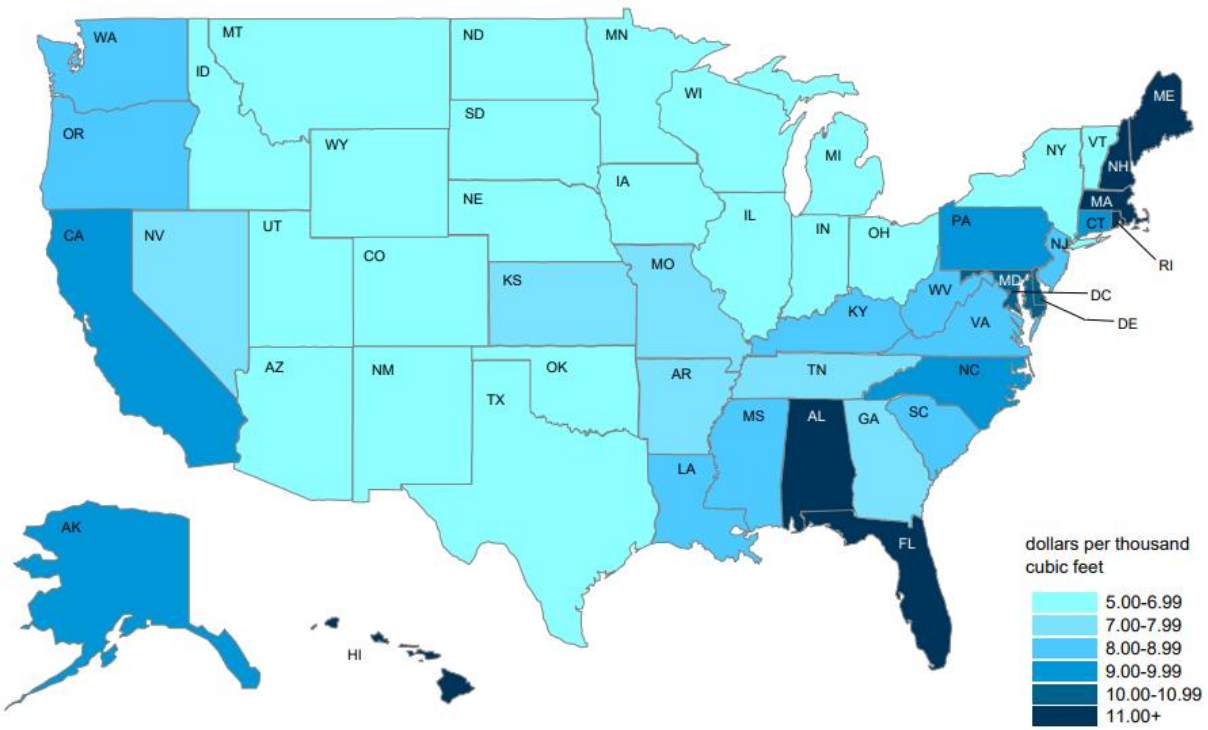
Fuel Type	Unit Price	Heating Value [Btu/unit]	Fuel Unit	Efficiency	Monetary Value ($/MMbtu)	Index Price Ranking	Index Factor
Electricity	$ 0.250	3,412	KWH	100%	**$ 73.27**	100%	**4.1**
Propane	$ 3.80	91,500	Gallon	80%	$ 51.91	71%	**2.9**
Propane	$ 3.80	91,500	Gallon	95%	$ 43.72	60%	**2.4**
#2 Oil	$ 4.69	140,000	Gallon	84%	$ 39.88	54%	**2.2**
Heat Pump	$ 0.25	3,412	KWH	300%	$ 24.42	33%	**1.4**
Wood Pellet	$ 5.98	328,000	40 lb Bag	70%	$ 26.05	36%	**1.5**
Cord Wood	$ 325.00	24,000,000	cord	60%	$ 22.57	31%	**1.3**
Natural Gas	$ 1.70	100,000	Therm	80%	$ 21.25	29%	**1.2**
Natural Gas	$ 1.70	100,000	Therm	95%	$ 17.89	24%	**1.0**
				Max:	**$ 73.27**		

*Note: A COP of 3.0 = 300% Efficiency

Natural Gas

[Source: U.S. Energy Administration (EIA)]

Figure 21. Average price of natural gas delivered to U.S. commercial consumers, 2020
(dollars per thousand cubic feet)



Note: Prices are in nominal dollars.
Sources: U.S. Energy Information Administration (EIA), Form EIA-176, *Annual Report of Natural and Supplemental Gas Supply and Disposition*, and Form EIA-910, *Monthly Natural Gas Marketer Survey*.

U.S. Energy Information Administration | Natural Gas Annual

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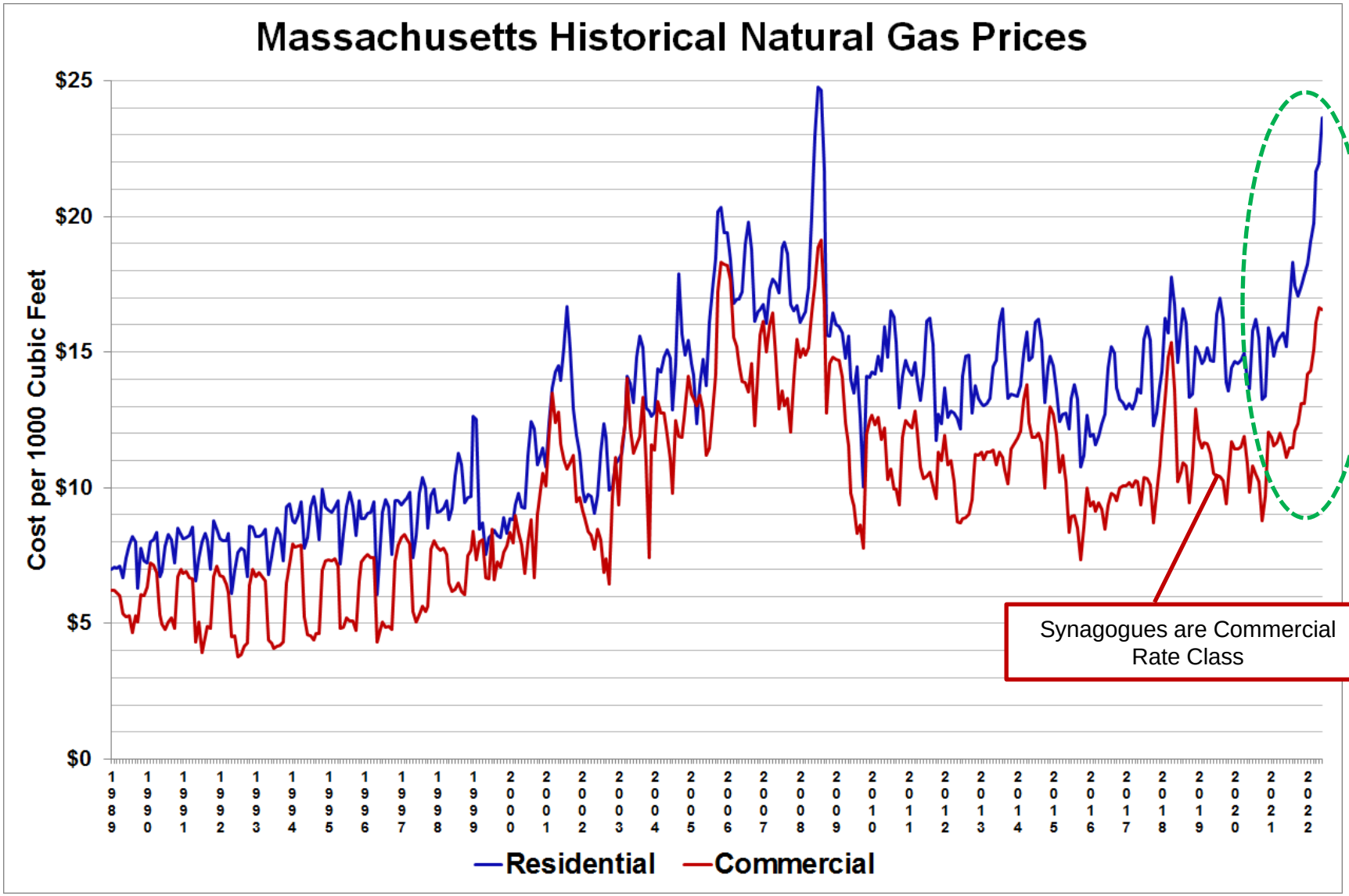
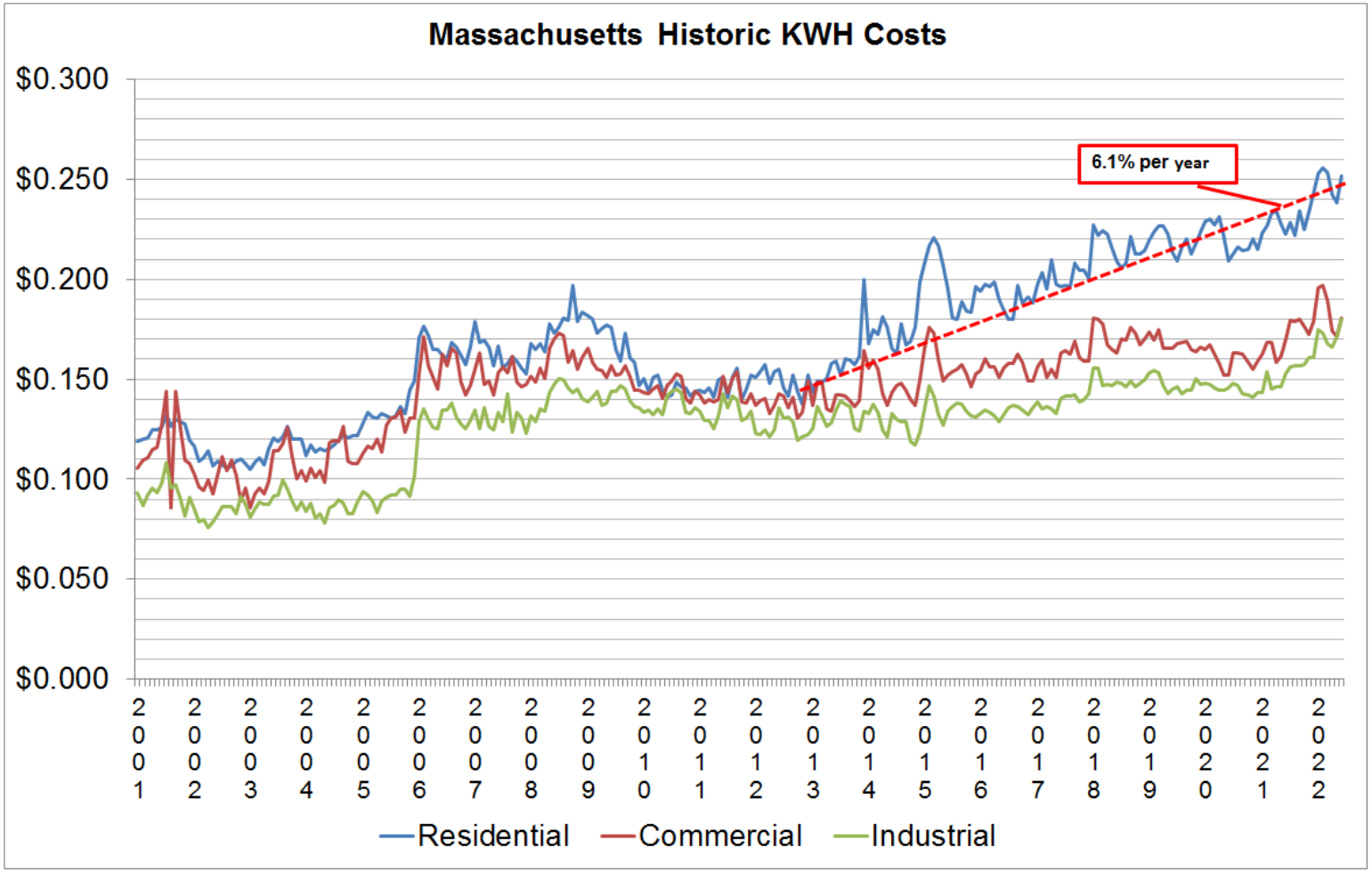

Massachusetts Historical Natural Gas Prices
Cost per 1000 Cubic Feet
$25
$20
$15
$10
$5
$0
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
Residential
Commercial
Synagogues are Commercial Rate Class

Residential Electric Rates

Approximately **80%** of Synagogues are "Residential" Rate Class

(Average Rates: **Jan 2022 - June 2022**, Source: EIA)

1	Hawaii	$ 0.407
2	California	$ 0.262
3	**Connecticut**	**$ 0.253**
4	**Massachusetts**	**$ 0.249**
5	**Maine**	**$ 0.229**
6	Alaska	$ 0.229
7	**Rhode Island**	**$ 0.228**
8	**New Hampshire**	**$ 0.226**
9	New York	$ 0.213
10	**Vermont**	**$ 0.199**
11	Michigan	$ 0.175
12	New Jersey	$ 0.167
13	Wisconsin	$ 0.154
14	Pennsylvania	$ 0.150
15	Illinois	$ 0.148
16	Indiana	$ 0.143
17	Maryland	$ 0.141
18	Alabama	$ 0.138
19	Colorado	$ 0.138
20	District Of Columbia	$ 0.138
21	Minnesota	$ 0.138
22	South Carolina	$ 0.136
23	Florida	$ 0.136
24	Kansas	$ 0.135
25	New Mexico	$ 0.134
26	Nevada	$ 0.134
27	Georgia	$ 0.133
28	Ohio	$ 0.132
29	Delaware	$ 0.131
30	West Virginia	$ 0.130
31	Arizona	$ 0.129
32	Texas	$ 0.128
33	Virginia	$ 0.127
34	Iowa	$ 0.125
35	Mississippi	$ 0.125
36	Kentucky	$ 0.123
37	South Dakota	$ 0.119
38	North Carolina	$ 0.118
39	Tennessee	$ 0.117
40	Oklahoma	$ 0.116
41	Louisiana	$ 0.116
42	Missouri	$ 0.114
43	Arkansas	$ 0.113
44	Oregon	$ 0.112
45	Montana	$ 0.109
46	Wyoming	$ 0.109
47	North Dakota	$ 0.108
48	Utah	$ 0.107
49	Nebraska	$ 0.106
50	Idaho	$ 0.102
51	Washington	$ 0.102


Massachusetts Historic KWH Costs
$0.300
$0.250
$0.200
$0.150
$0.100
$0.050
$0.000
6.1% per year
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Residential
Commercial
Industrial

GHG Power Production in our Region:

	Power Use (TWH)	Population (Millions)	Annual MWH/capita	¢ per KWH	Nat Gas	Oil	Biomass	Coal	GHG Total
Connecticut	41.2	3.61	11.4	22.4	57.0%	0.0%	3.3%	0.0%	**60%**
Maine	10.4	1.37	7.6	18.0	16.9%	0.4%	23.4%	0.0%	**41%**
Massachusetts	**18.3**	**6.98**	**2.6**	**23.5**	**76.1%**	**0.2%**	**8.3%**	**0.0%**	**85%**
New Hampshire	16.7	1.39	12.0	20.7	21.8%	0.2%	6.5%	0.0%	**29%**
Rhode Island	8.0	1.10	7.3	23.4	91.8%	1.0%	2.6%	0.0%	**95%**
Vermont	2.4	0.65	3.7	19.5	0.0%	0.0%	17.8%	0.0%	**18%**
New England	97.0	15.1	6.4	21.9	**51.7%**	0.2%	7.3%	0.0%	**59%**
New York	132.0	19.84	6.7	20.5	40.1%	0.2%	2.0%	0.1%	**42%**
New Jersey	61.5	9.27	6.6	16.3	49.9%	0.1%	2.4%	1.4%	**54%**
Pennsylvania	231.0	12.80	18.0	14.1	52.1%	0.0%	2.6%	8.9%	**64%**

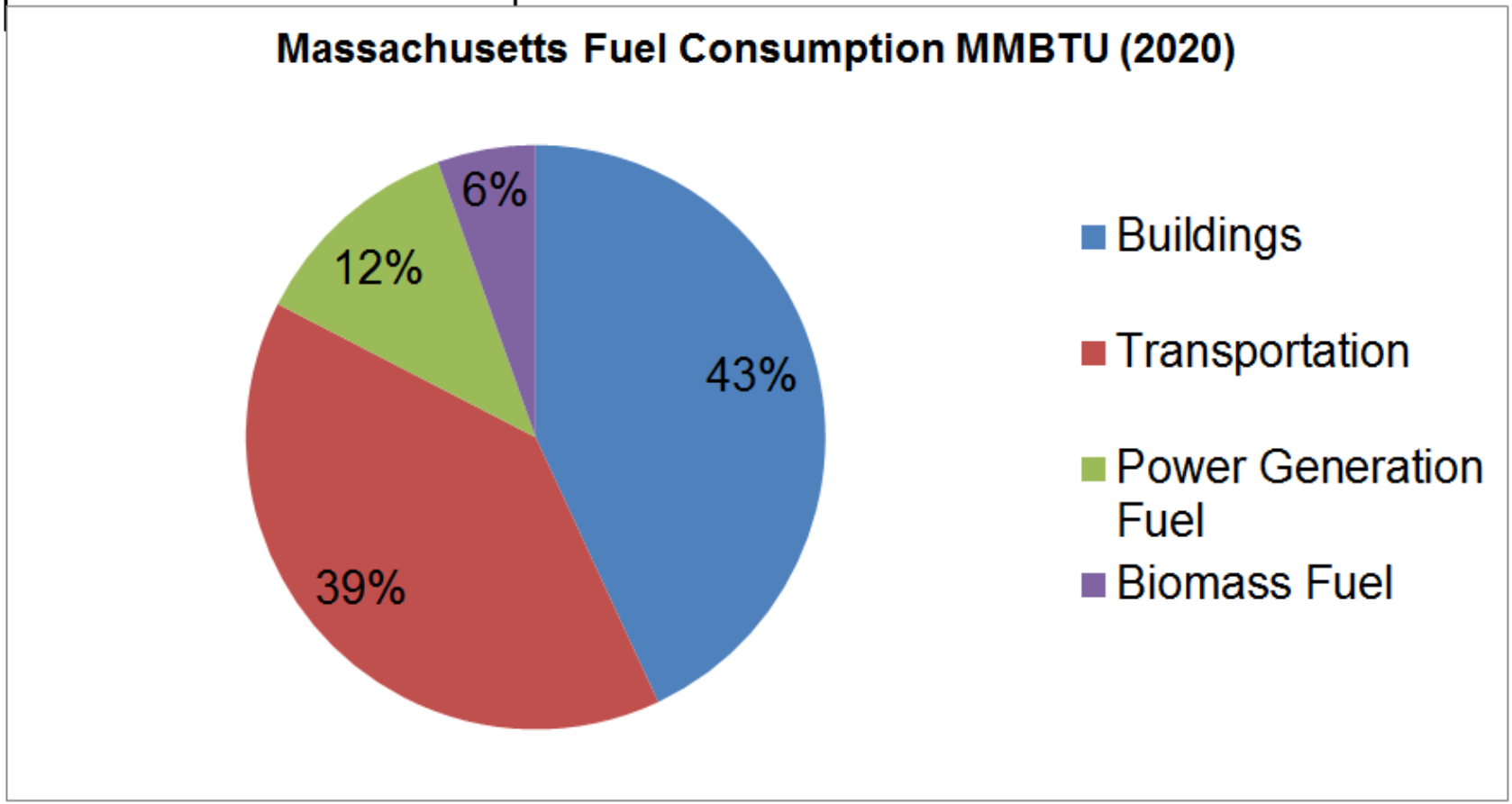
Note: 1 TWH = 1,000,000 MWH

Non-GHG Power Production in our Region:

	Hydro	Solar	Wind	Nuclear	Non-GHG Total
Connecticut	1%	0.6%	0.0%	38.2%	**40%**
Maine	34.4%	0.3%	24.0%	0.5%	**59%**
Massachusetts	**5.4%**	**8.5%**	**1.5%**	**0.0%**	**15%**
New Hampshire	8.9%	0.0%	3.1%	59.0%	**71%**
Rhode Island	0.0%	2.6%	2.9%	0.0%	**6%**
Vermont	57.8%	8.0%	16.2%	0.0%	**82%**
New England	8.1%	2.3%	4.0%	26.4%	**41%**
New York	23.8%	0.8%	3.8%	29.1%	**58%**
New Jersey	0.0%	2.6%	0.0%	43.5%	**46%**
Pennsylvania	1.5%	0.1%	1.7%	33.1%	**36%**

	MMBTU
Buildings	459,738,440
Transportation	421,693,000
Power Generation Fuel	127,992,120
Biomass Fuel	58,600,000
	1,068,023,560

Notes



Comments

Our dominant source of energy for continuous electricity generation is natural gas, oil, and biomass, only 8% is truly renewable.

The renewable sources do not operate 24/7.

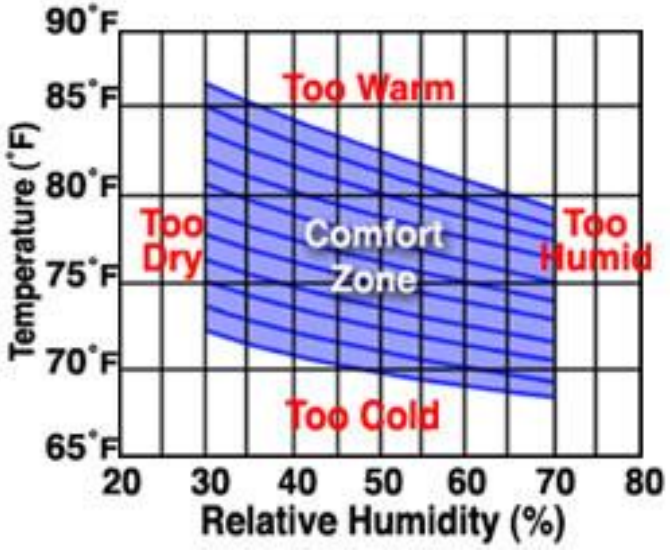
We are therefore dependent on renewables to supplement our energy needs and will continue to depend on fossil energy until fusion and/or hydrogen become the dominant fuel source.

Electrification

- Conversion from fossil fuel to resistive electric will result in greater release of GHG due to the dominant use of gas/oil/wood for electricity generation, the poor overall efficiencies of power plants, and the power line transmission losses.

HVAC 101
Comfort & Air Balance

HVAC Systems, Comfort & Air Balance Equipment



The purpose of HVAC systems is to add/remove heat, moisture, and air pollutants from a controlled space and provide conditions to promote human comfort/health.

Human Comfort

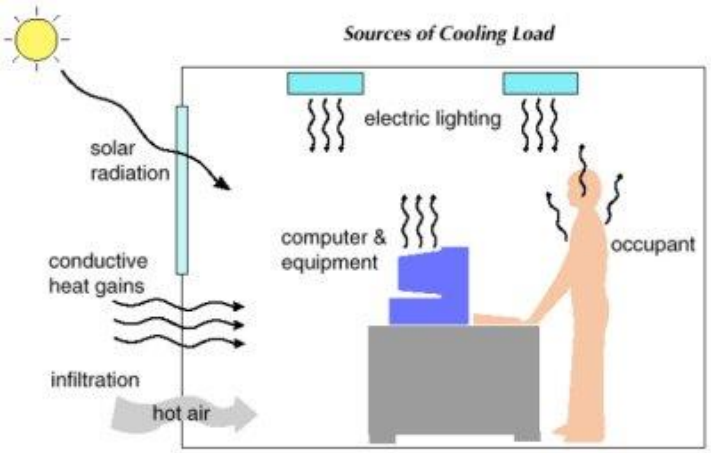
- Dry bulb temperature
- Relative humidity
- Air velocity
- Fresh Air
- Noise
- Pollutants

Types of HVAC Systems

The purpose of HVAC systems is to add/remove heat, moisture and air pollutants from a controlled space and provide conditions to promote human comfort.

Types of heating systems:

- Direct Fired
- Furnaces, duct distribution
- Hydronic Baseboard
- Hydronic Fan-coil
- Hydronic Unit Heater
- Heat Pump
- Steam Radiator
- Unit Ventilator
- Variable Air Volume



Ventilation of an Assembly Space

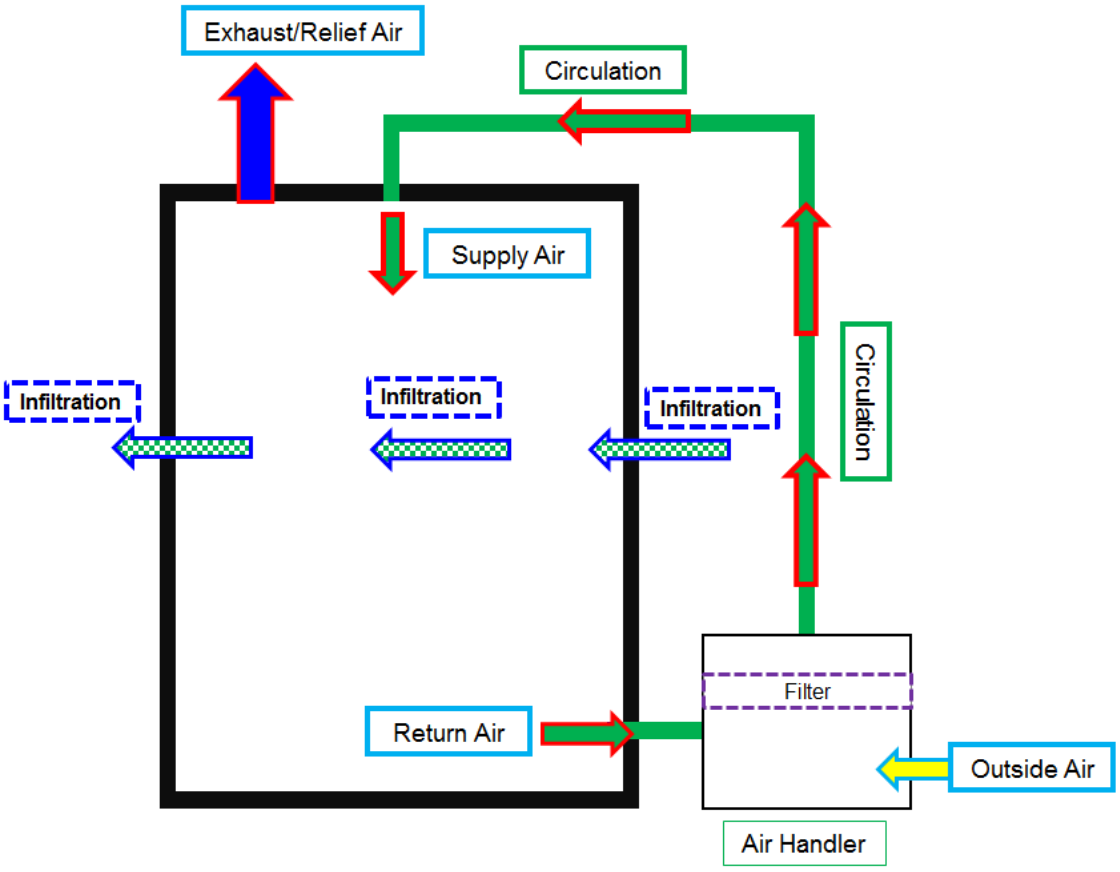
Circulation:

Rooms of Assembly require constant air circulation

Outside Air:

Activation of louvers, MUAU, or exhaust fan

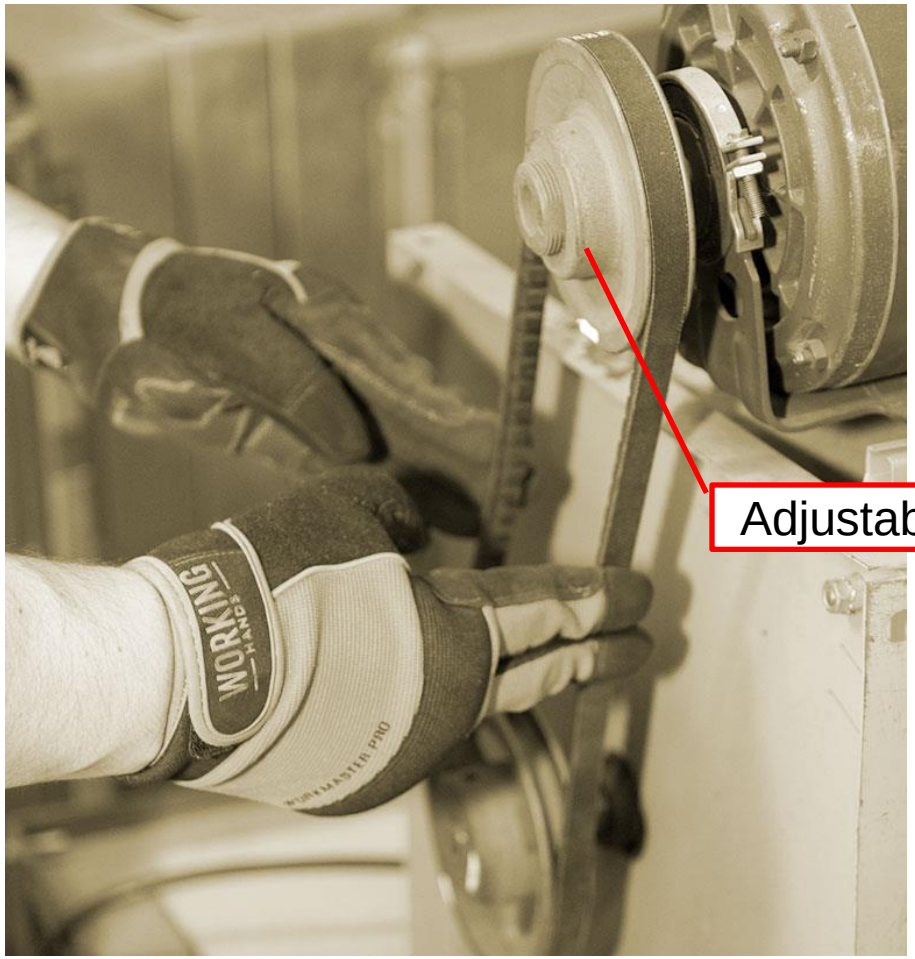
Infiltration: Normally occurring air flow through walls/windows



Air Balance Testing Equipment

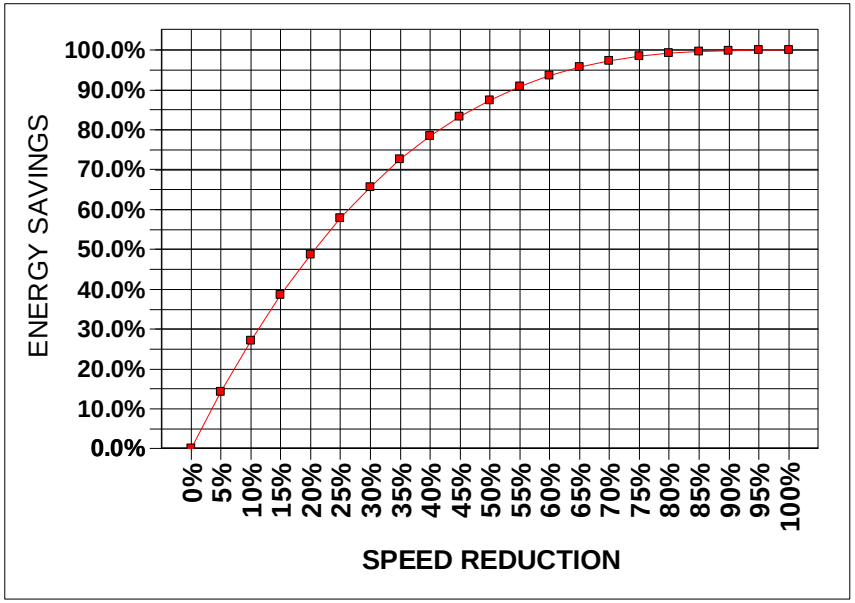
Measures air velocity in ducts and building openings

Typical Cog V-belt with Adjustable Motor Sheave



Adjustable Motor Sheave

Variable Frequency Drive (VFD) for control of blower/pump speeds

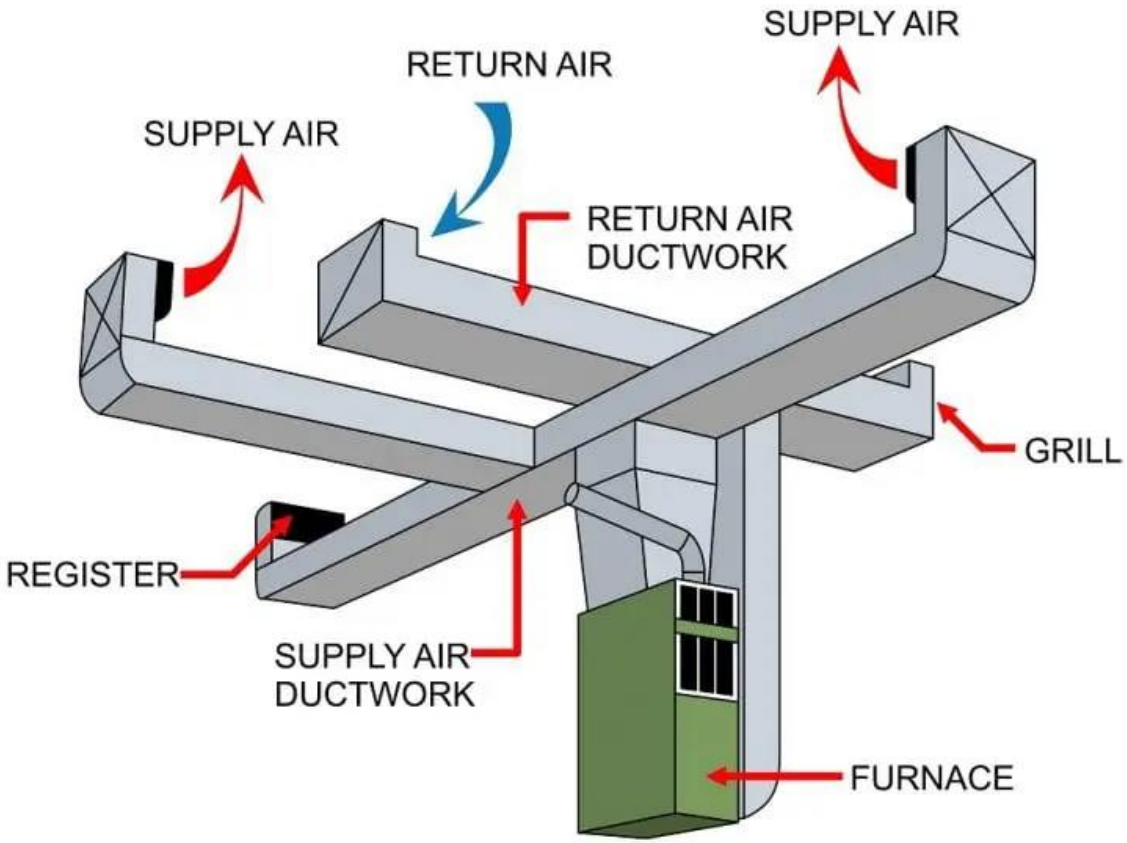


Mechanical Systems

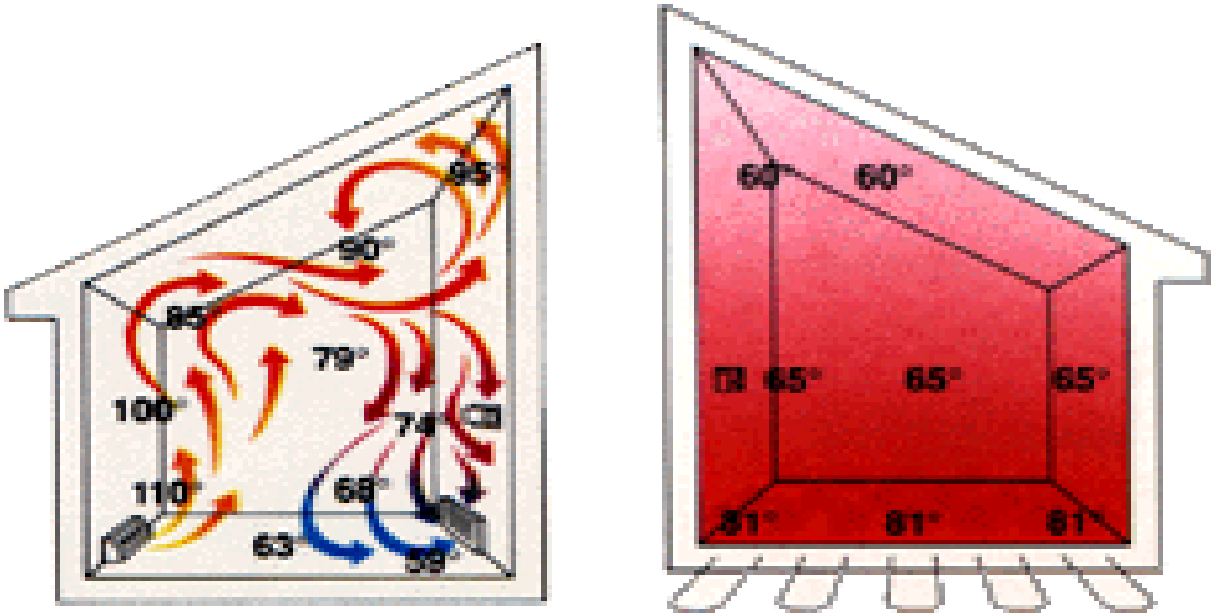
Hydronic System

Rooftop Exhaust

Typical Duct Distribution System



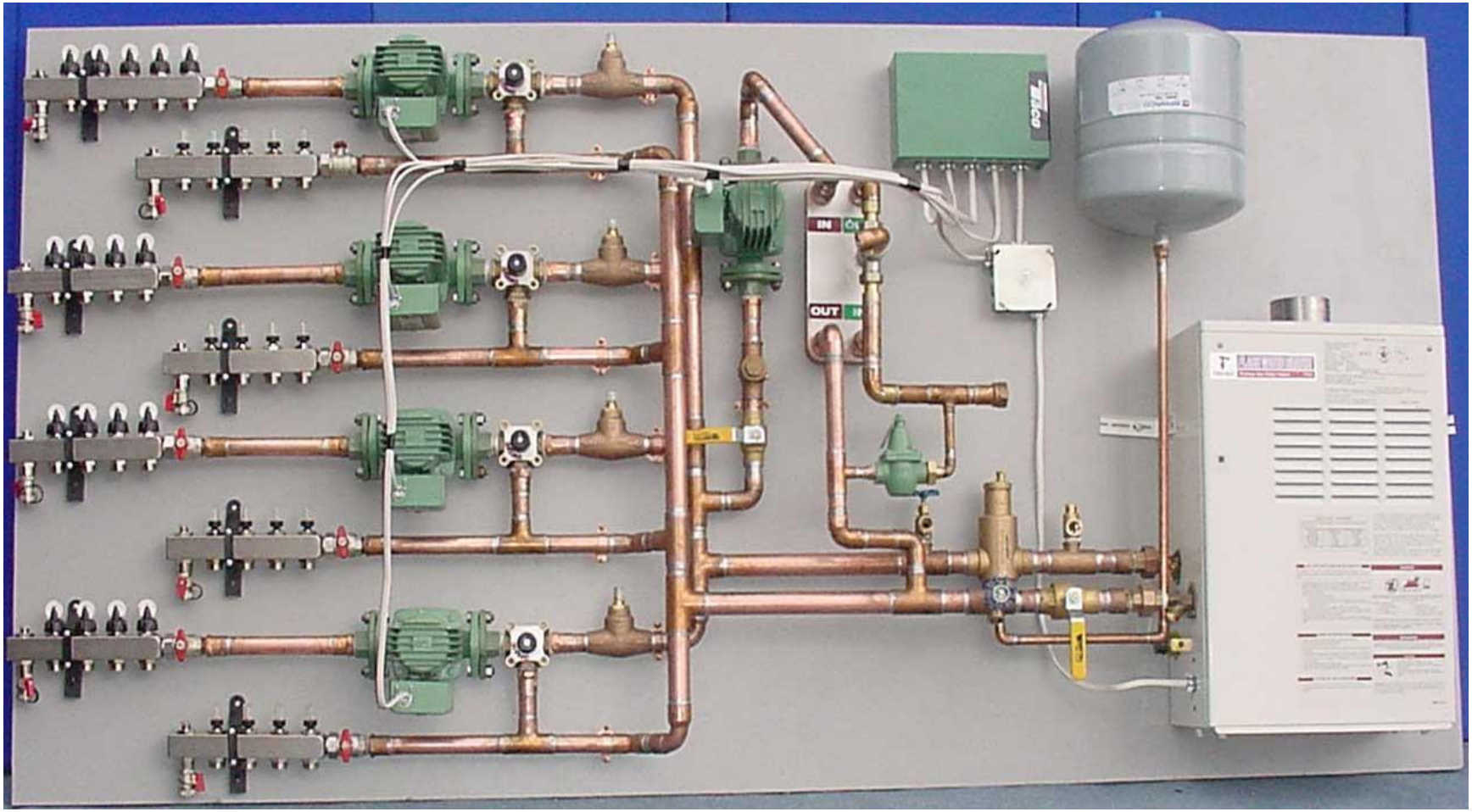
Hot Air v. Radiant/Baseboard



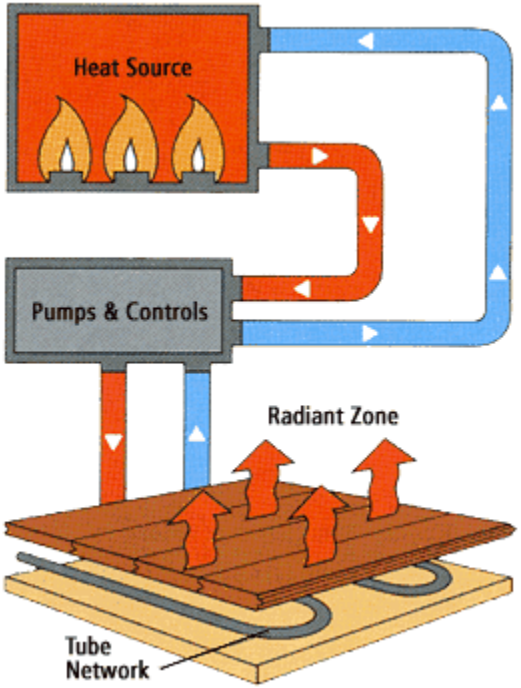
Forced Air

Radiant Floor

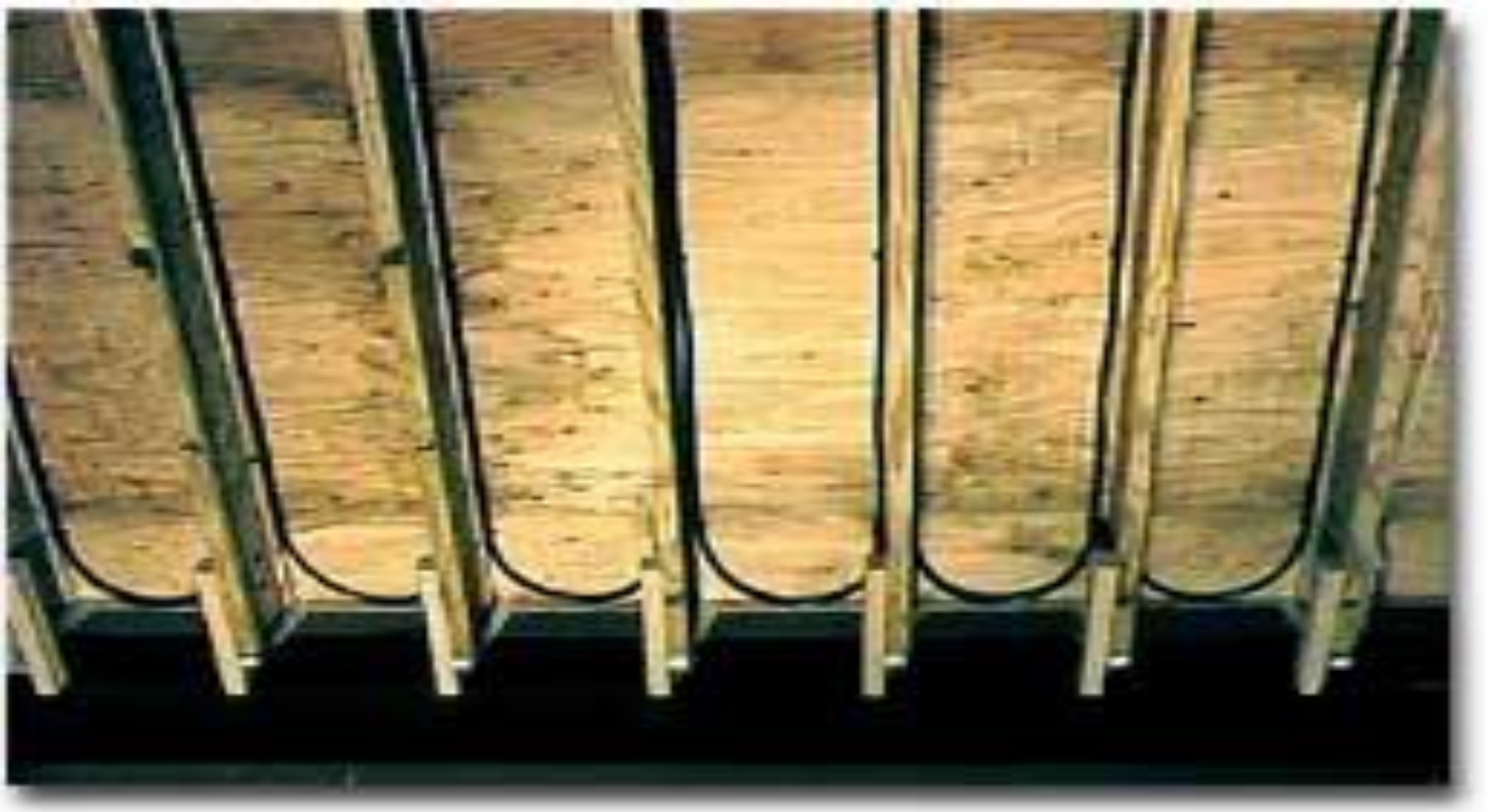
Hydronic Radiant System



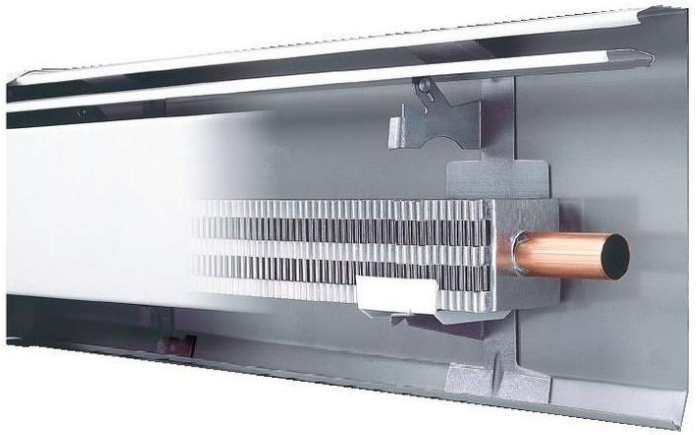
Radiant Heat



Under Floor Heating



Hydronic Baseboard Heat



Assorted Unit Ventilators

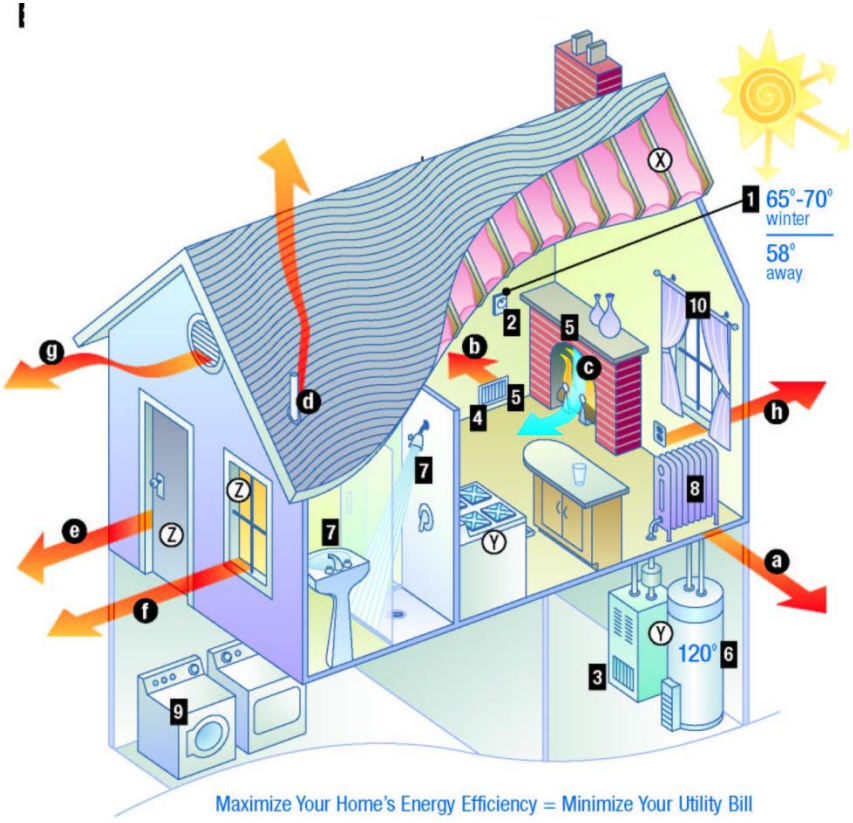
Hydronic Boilers

What is the Building Heating Load Are the Systems Sized Properly?

- U=1/R
- U has units of: [BTU/(hr-SF-ºF)]

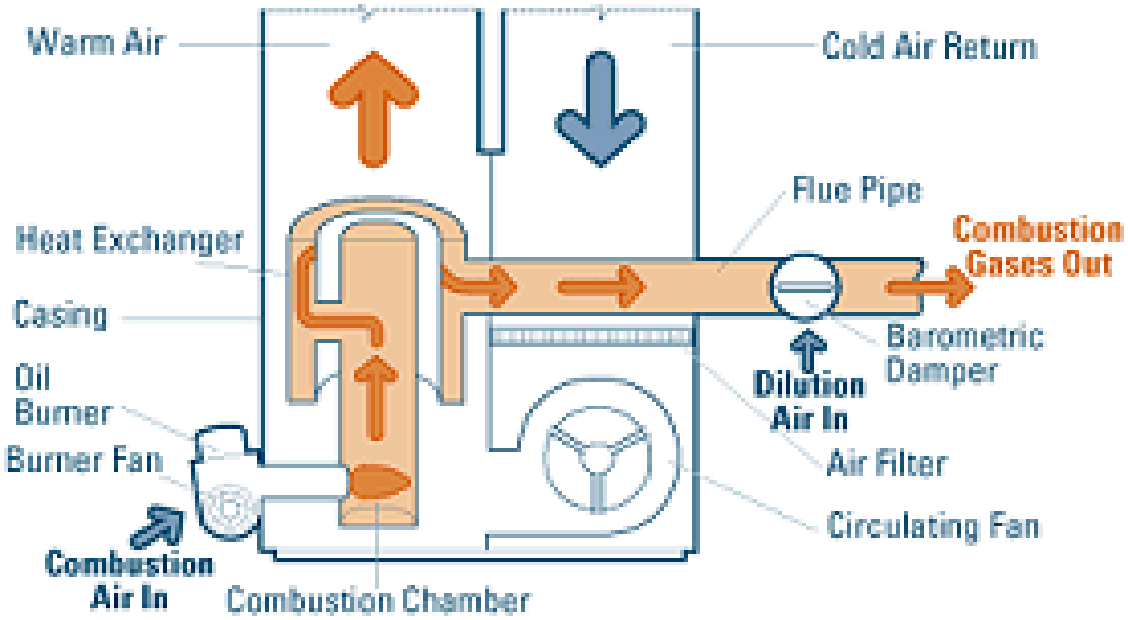
  Q = U x Area x (Tin – Tout) (Btu/hr)

Qenvel= $\Sigma(UxA)_{overall}$ x (ΔT) (Btu/hr)



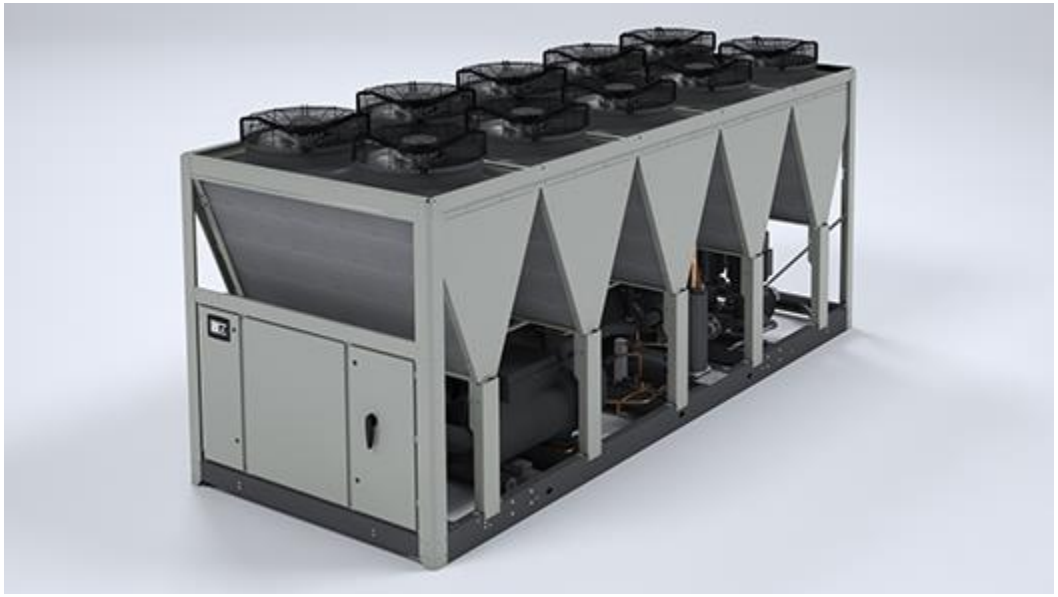
Traditional Boiler Room

Typical Oil-Fired Hot Air Furnace



Hydronic Coils

Air-Cooled Chiller



What is your Equipment Efficiency?

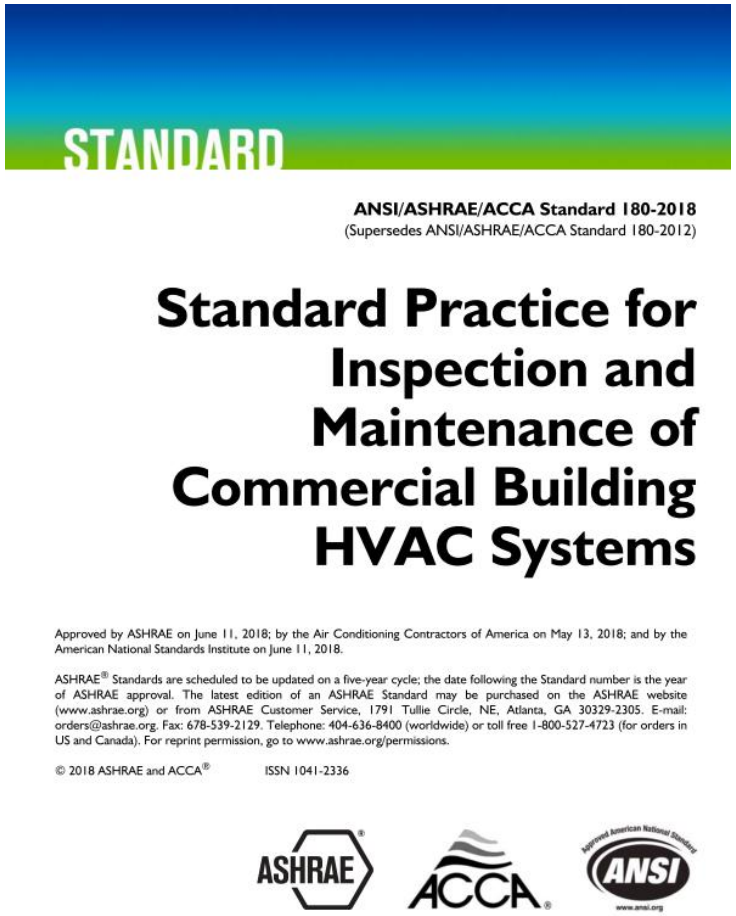
- Efficiency = Useful energy/Total energy

- Boilers:
- AFUE
- Combustion Efficiency

- Chillers:
- COP
- EER, SEER
- EER = COP x 3.412

HVAC Maintenance, Commissioning ASHRAE 180-2018

- HVAC Mechanical systems should be recommissioned at least once each year.
- Hydronic fan-coil systems that circulate boiler water must be protected with anti-freeze to prevent freezing in cold weather climates.



Ventilation Requirements

Fresh Air Requirements

- ANSI/ASHRAE Standard 62.1-2004 (Indoor Air Quality)

Previous: **6** CFM /person

Present: **20** CFM/Person (New CDC Requirement)

Infiltration ~ Air Changes

- ACH ~ **A**ir **C**hanges per **H**our
- ACH= f (Envelope, Wind Velocity, Temp Gradient, Building Height)

- Tight: 0.25 ACH
- Average: 0.50 ACH
- High leakage : ≥1.0 ACH

CDC:

"***Ensure that ventilation systems operate properly and increase circulation of outdoor air as much as possible by opening windows and doors, using fans, etc.***"

CDC – June 2, 2021

https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

"***One potential target benchmark for good ventilation is CO_2 readings below 800 ppm.”***

- ***800 ppm = 20 cfm/person of fresh air (@ MET 1)***

❖***ASHRAE standard of only 7 cfm/person is not adequate.***

-Maximize existing O.A. capacity

3x 7 cfm/person O.A ventilation; 33% occupancy

Basis of Proposed Ventilation Rates

a) At 33% occupancy, outdoor air flowrates can be increased to provide more fresh air per person. If systems were designed for 7 cfm per person, the systems should be able to provide approximately three-times the outdoor air at 33% occupancy

b) Determine maximum COVID Occupancy

c) Determine maximum cooling capacity

d) Determine maximum heating capacity

e) If system meets energy capacity requirements, set outside air flowrates based on the following criteria:

Recommended Ventilation Rates

Air circulation:

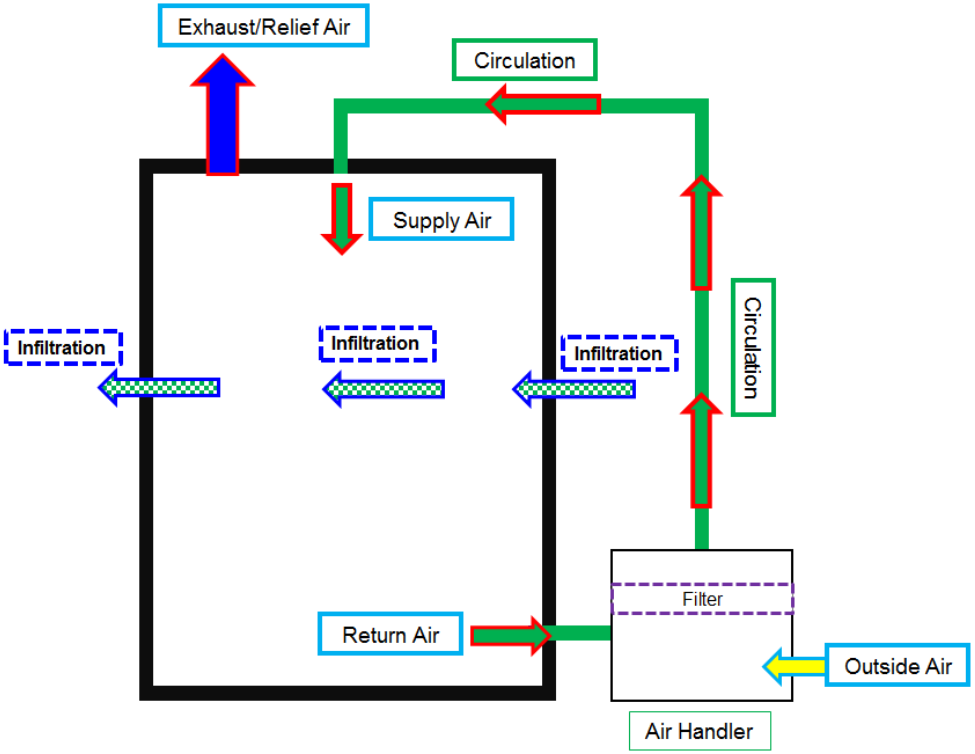
0.75 cfm per sf (1 ton/500 sf)

+ 25 cfm/person

Air circulation to be enabled **2** hours before event and **2** hours after event.

Exhaust or Outside Air:

20 cfm/person and as maintained by a carbon dioxide controller.



Carbon Dioxide Monitor/Controller

CO_2 Monitor

CO_2 Controller

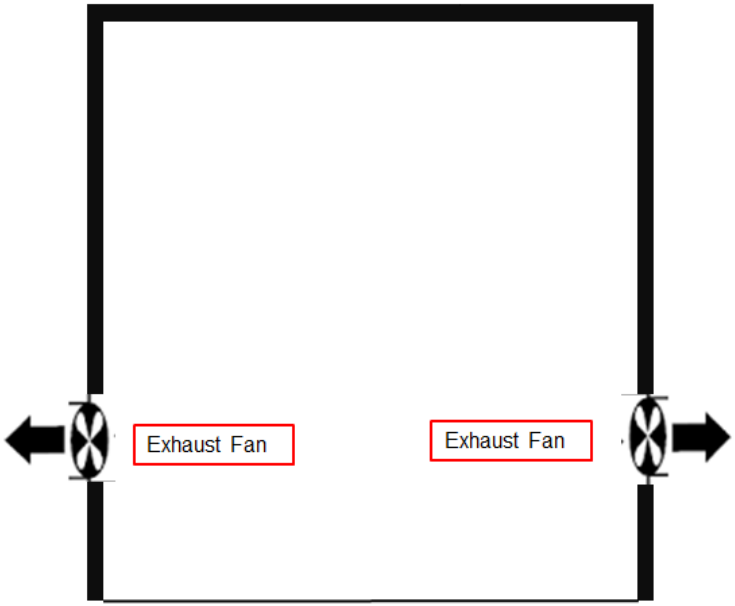
Older HVAC v Modern HVAC
COVID HVAC Preparation

COVID Preparation for Older Building HVAC
[No central HVAC duct distribution]

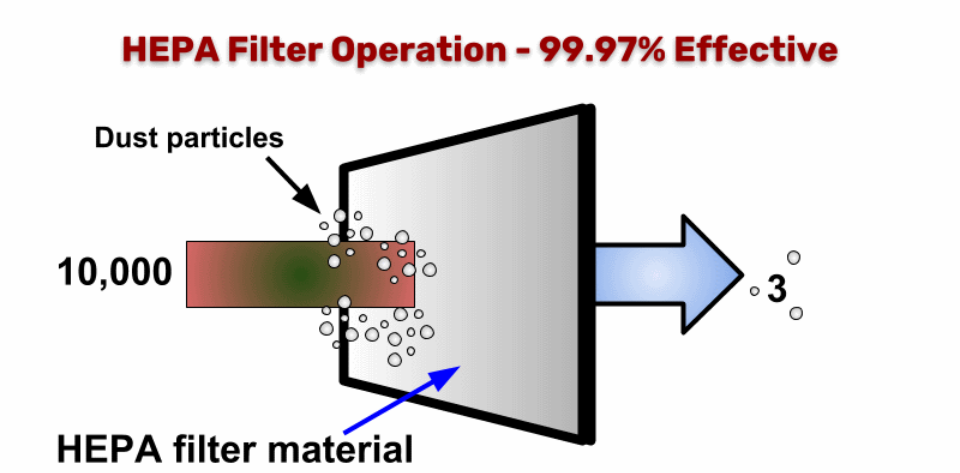
- Open Doors and Windows
- Utilize carbon dioxide monitors
- Window fans
- Ceiling fans
- Use of HEPA filters

Older Building
Steam Radiator Systems

Typical Window Fan
400 cfm, 20 persons/fan
Exhaust air out of space



Free-standing HEPA Filters



Carbon Dioxide Monitor/Controller

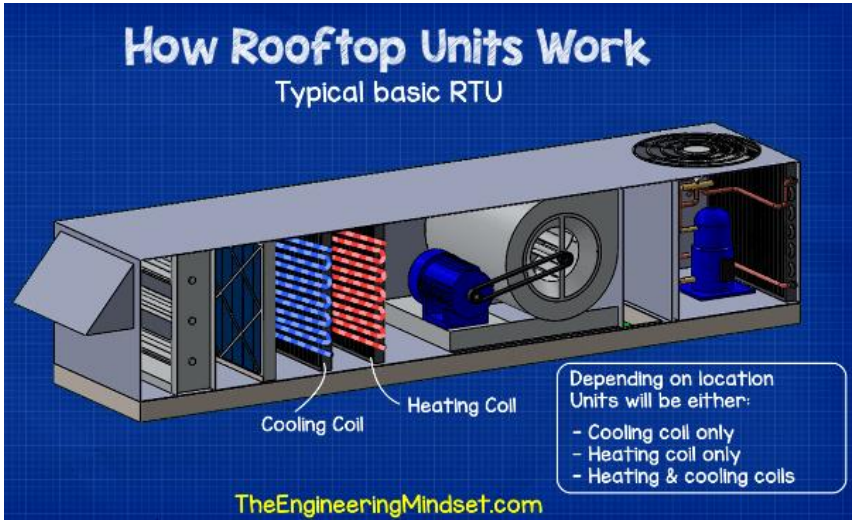
CO_2 Monitor

CO_2 Controller

COVID Preparation for Modern Building HVAC

- Carbon dioxide controller
- Carbon dioxide monitor
- Exhaust fans
- Outside air louvers
- Ceiling fans
- Energy Recovery
- MERV-13 Filters

Modern HVAC Components
Typical Heating/Cooling RTU



Duct System Components

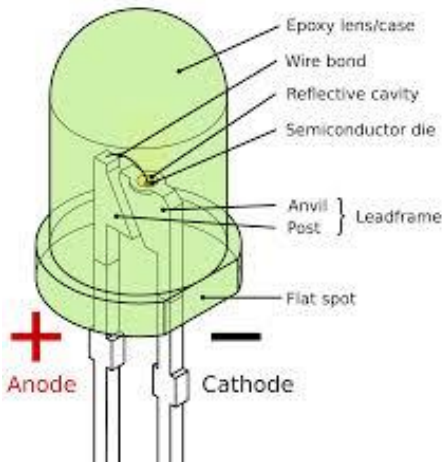
- Duct system Designs:
- Single blower: supply, return, filter
- Dual Duct: supply blower: outside air intake
- Return blower: exhaust air discharge

- Variable Air Volume

- Components
- Dampers
- Grilles
- Heat exchange surface
- Ductwork
- Control system

Lighting

Light Emitting Diode
The Nobel Prize in Physics for 2014



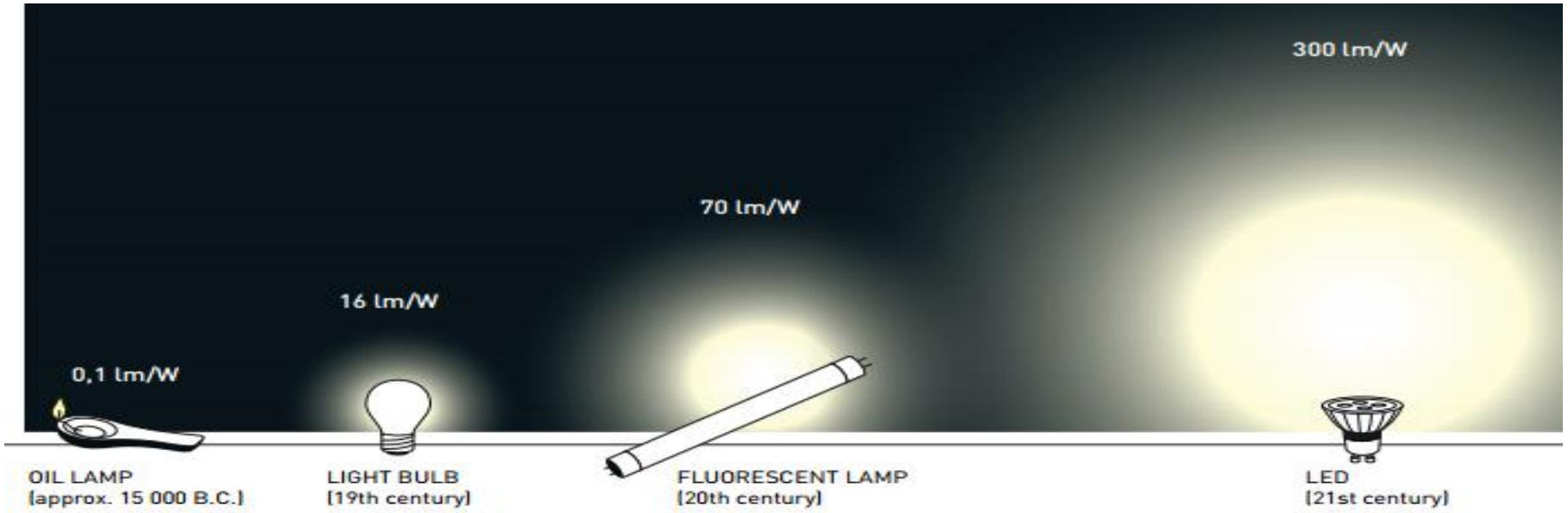
LED Lighting
The Nobel Prize in Physics for 2014

- **Isamu Akasaki**
  Meijo University, Nagoya, Japan and Nagoya University, Japan

- **Hiroshi Amano**
  Nagoya University, Japan

- **Shuji Nakamura**
  University of California, Santa Barbara, CA, USA

- *“For the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources"*


300 lm/W
70 lm/W
16 lm/W
0,1 lm/W
OIL LAMP
(approx. 15 000 B.C.)
LIGHT BULB
(19th century)
FLUORESCENT LAMP
(20th century)
LED
(21st century)


CANDLE LIGHT
EFFICIENCY
LIFESPAN
COLOR RENDERING
INCANDESCENT
EFFICIENCY
LIFESPAN
COLOR RENDERING
CFL
EFFICIENCY
LIFESPAN
COLOR RENDERING
VIRIBRIGHT
LED
EFFICIENCY
LIFESPAN
COLOR RENDERING

Compact Fluorescent Lamps
[Now Obsolete]

Lighting Occupancy Sensors

- Passive infrared (PIR) sensors react to the infrared heat energy emitted by people.
- **Ultrasonic** occupant sensors activate a quartz crystal that emits ultrasonic waves then senses the frequency of the reflected waves. Motion causes the reflected wave's frequency to shift (Doppler effect).
- Audible noise detectors
- Direct influence: foot pad, lever, or light beam.

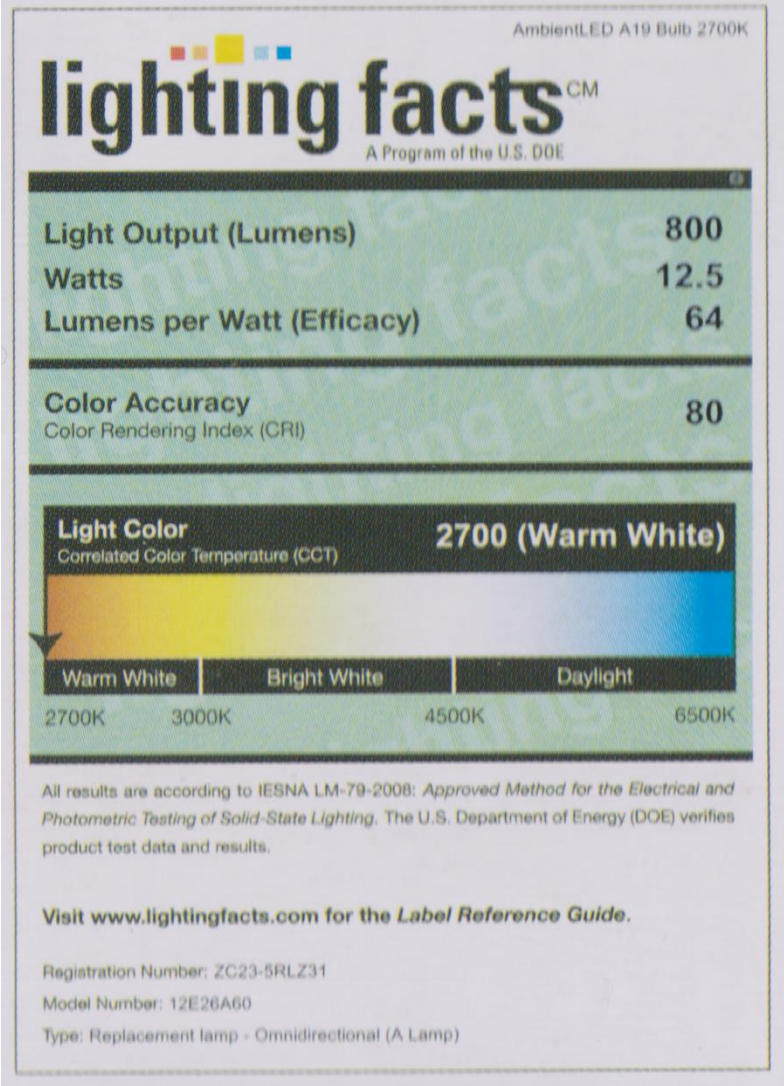
Typical Exit Sign Upgrades

- LED lamp retrofits
- Electroluminescent panels
- New LED emergency/exit signs

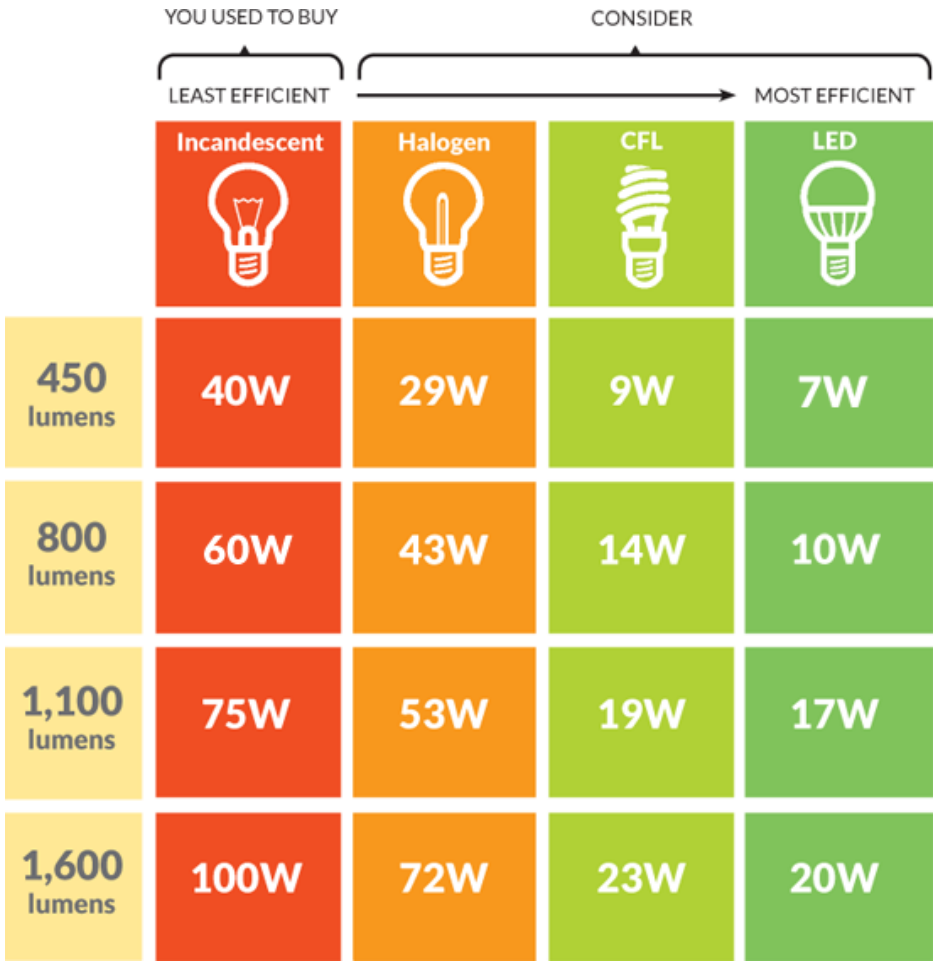
Color Rendering Index

- Left to Right: Warm – Neutral – Cool

- Incandescent/Halogen: CRI ~ 100
- Fluorescent: CRI ~ 50-90


AmbientLED A19 Bulb 2700K
lighting facts CM
A Program of the U.S. DOE
Light Output (Lumens) 800
Watts 12.5
Lumens per Watt (Efficacy) 64
Color Accuracy
Color Rendering Index (CRI) 80
Light Color
Correlated Color Temperature (CCT) 2700 (Warm White)
Warm White
Bright White
Daylight
2700K 3000K 4500K 6500K
All results are according to IESNA LM-79-2008: Approved Method for the Electrical and Photometric Testing of Solid-State Lighting. The U.S. Department of Energy (DOE) verifies product test data and results.
Visit www.lightingfacts.com for the Label Reference Guide.
Registration Number: ZC23-5RLZ31
Model Number: 12E26A60
Type: Replacement lamp - Omnidirectional (A Lamp)

Power and Performance Comparison



Lighting Audit Form

SAVING ENERGY IN COMMERCIAL BUILDINGS | Energy Audit Data Collection Form

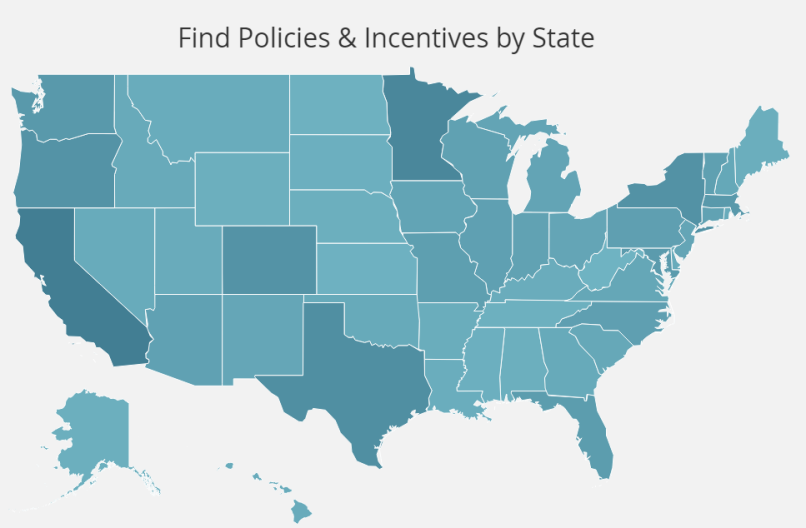
More information about identifying bulb types is available in the accompanying guidelines documents.

Lighting

Floor Name or Number	Location Description (near window, internal office, hallway, etc.)	Lamp Type	Ballast Type	Wattage	Total Number of Lamps	Number of hours lights are left on each day	Total kWh per Day	How are lights controlled?

Renewable Energy

https://www.dsireusa.org/



Primary Ownership v. 3rd Party

Roof v. Ground Mount Solar
[Advantages and Disadvantages]

Top Conservation Recommendations

#1

Tune Up Burner/Service Boiler

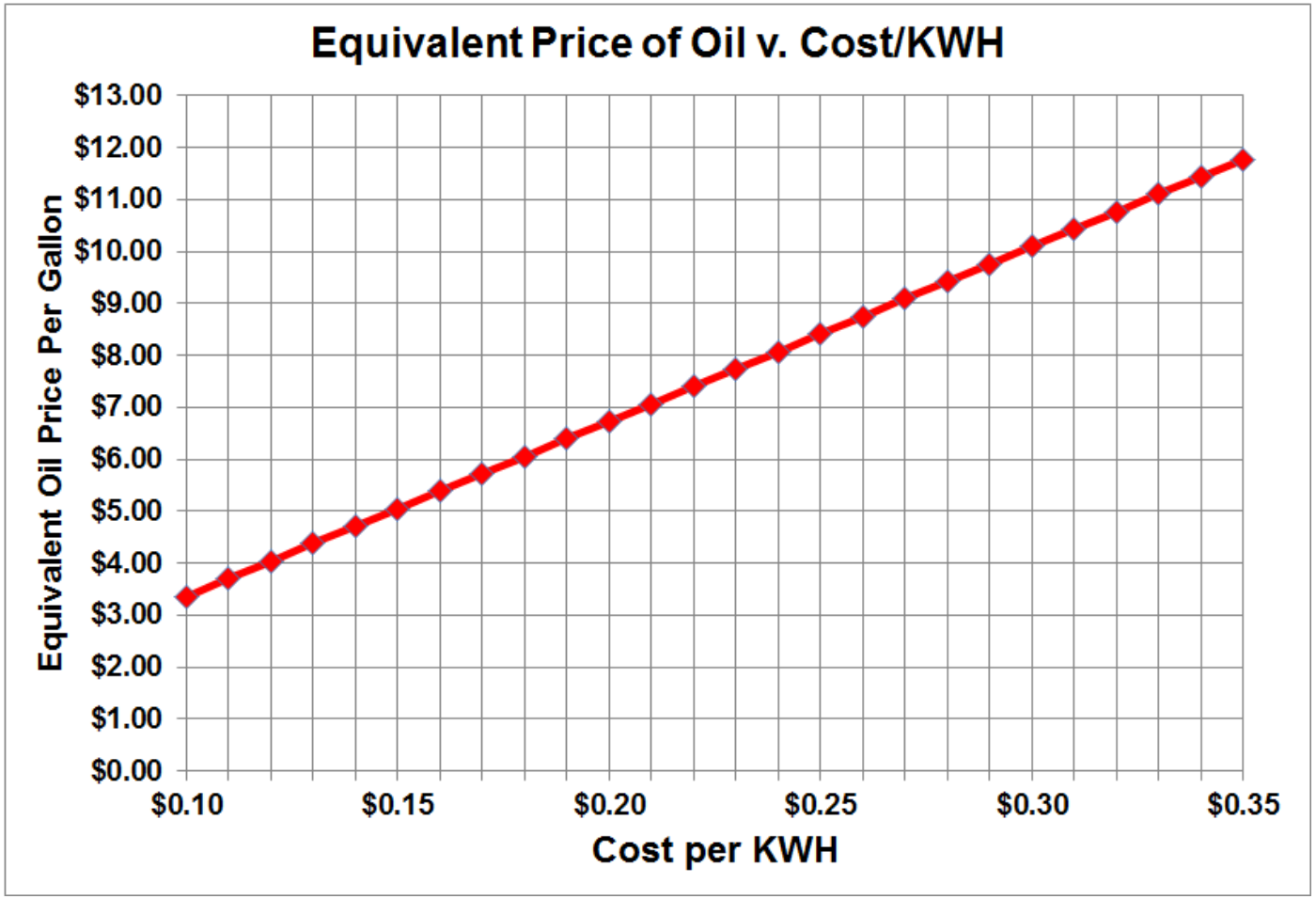
#2
Weatherize Your Building

#3
Install Energy Management Controls

- Set-back Temperatures
- Multiple Building Sensors
- Electronic Temperature Control
- Outdoor Sensor
- Install Zone Valves

#4

Convert Away From Electric Heat



Total Appliance Load: 60 kW
Convert to gas: $23,000 savings/yr
2 year R.O.I.

#5
Monitor Boilers

~Install water meter on make-up

~Install oil meter or hour meter on burner(s)

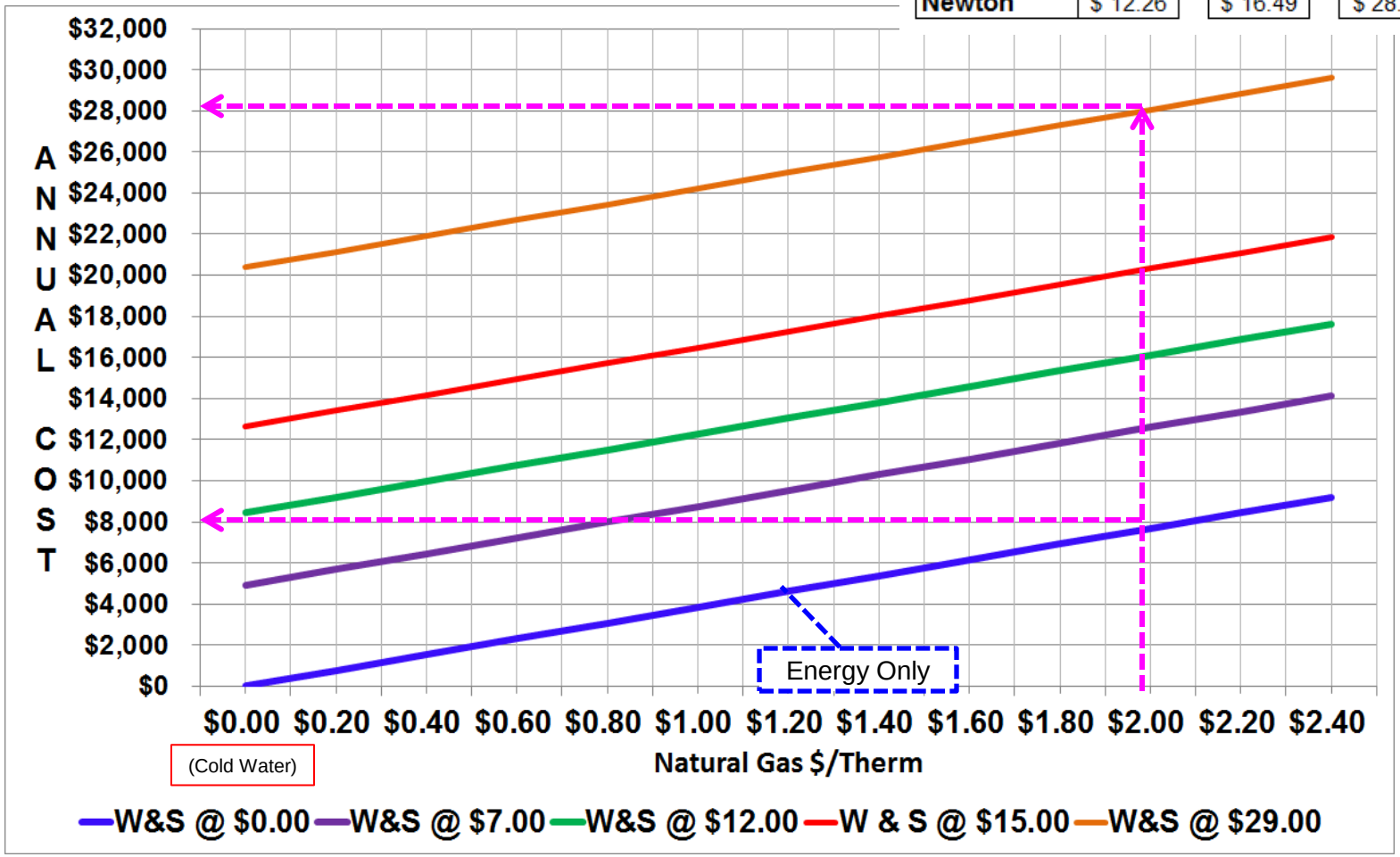
- What is you combustion efficiency?
- What is your steam leakage rate?
- What is your steam/fuel ratio?

#6
Reduce Water Use

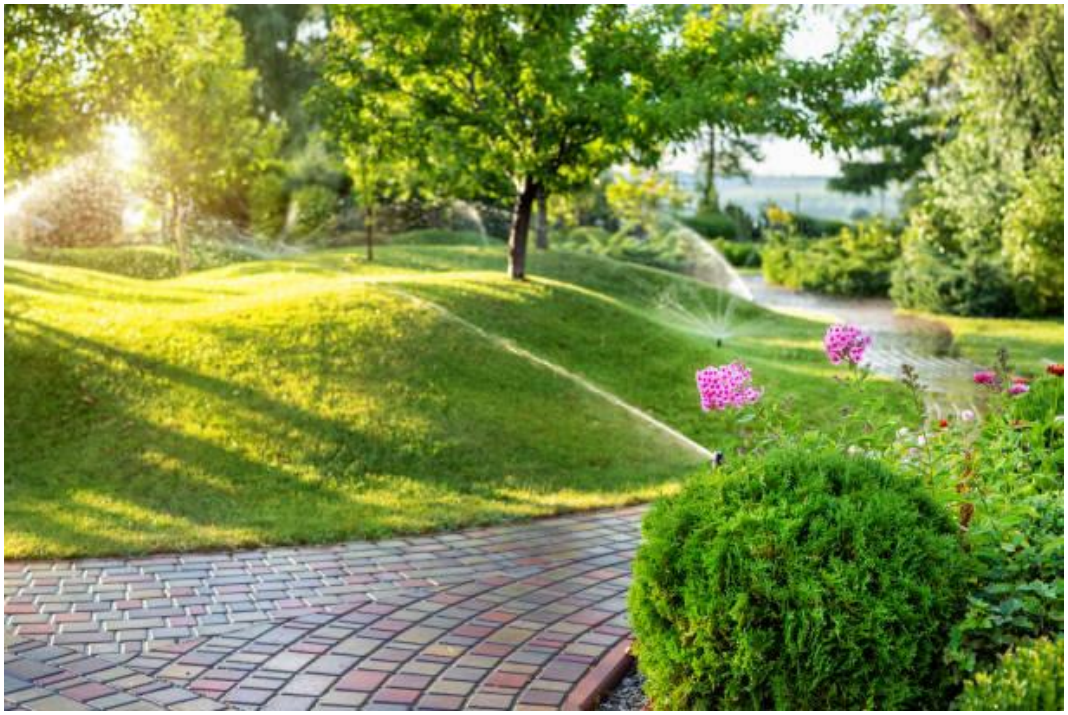
- **Plug leaks!**
- Install pressure regulators to reduce building pressure
- Install aerators
- Install low flow toilets

Water Leak @ 1 gpm

	Water ($/ccf)	Sewer ($/ccf)	Total ($/ccf)
Lawrence	$ 3.10	$ 3.35	$ 6.45
Springfield	$ 2.14	$ 7.47	$ 9.61
Worcester	$ 3.67	$ 8.48	$ 12.15
Boston	$ 7.40	$ 10.06	$ 17.46
Newton	$ 12.26	$ 16.49	$ 28.75



Conserve drinking water for irrigation. Consider well water.

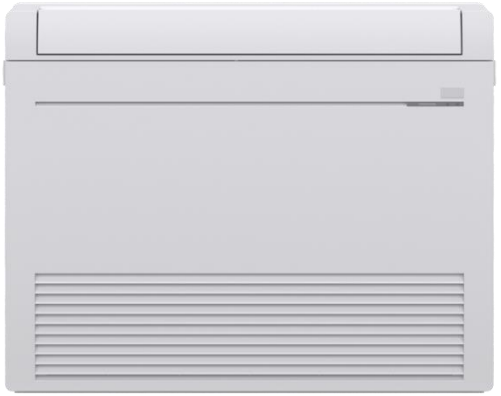


#7

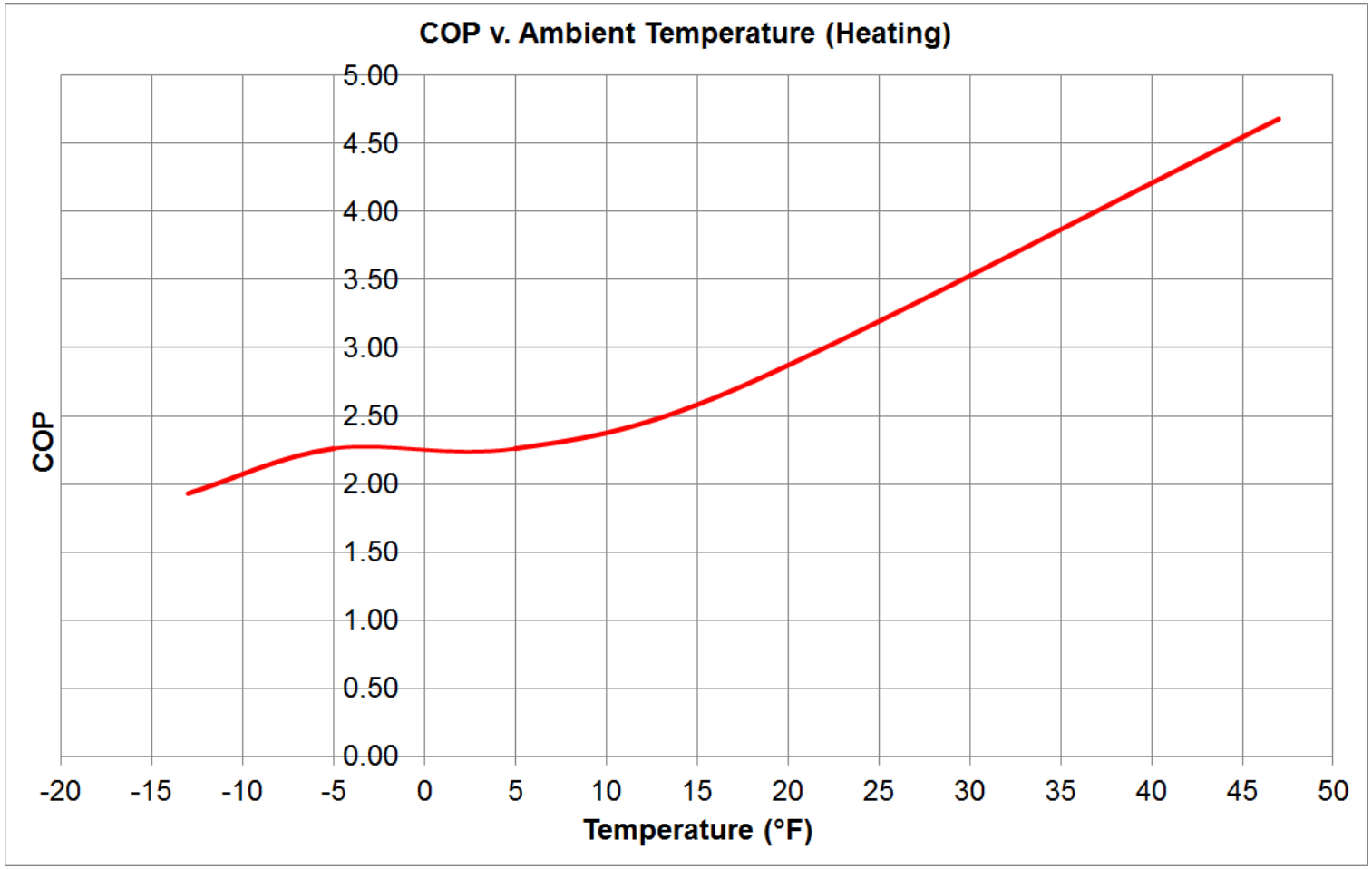
Shut off commercial refrigeration equipment when not in use; use residential units.

#8 Supplement Heating/Cooling with Ductless Heat Pumps

(Wall, Floor, Ceiling mounted)



Heat Pump COP



#9
Apply for Utility Rebates

- VFDs;
- Heat Pump Rebates
- Weatherization
- LED Lighting & Controls
- Custom Measures

BTU = 

- www.masssave.com/rebates
- www.masssaveapplicationportal.com/resource/1642551439000/BusinessIncentives

- Pays for **70%** of project costs.
- Pays for **$2,500** per ton for heat pumps.

Questions