Solstice Air to Water Heat Pump

Why Water Works

- Flexibility, supports multiple types of terminal units simultaneously
- Ease of zoning
- Water carries more BTUs for less energy than air
- Integrate with existing hydronic, solar, geothermal
- Simpler maintenance - Water vs DX.. No reclaiming
- Not restricted in length and lift of line set

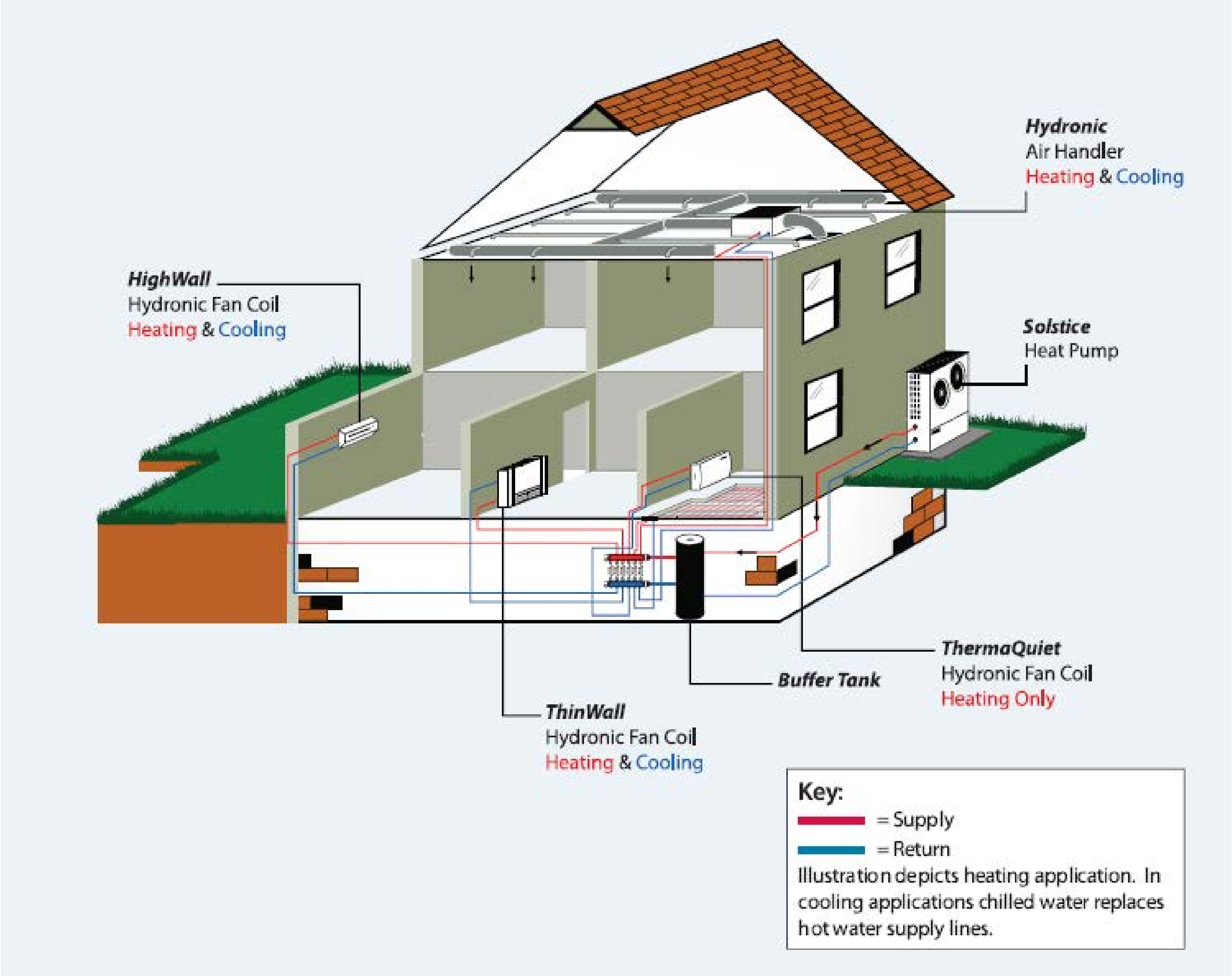
Air to water Solution

- No refrigerant in occupied space
- Refrigerant volume 25% to 33% of conventional DX
- No refrigerant charge on site, no refrigeration license required
- Outdoor chiller runs independent of indoor blower
- Better humidity control – vary air flow & water temperature. Precise delivered air temperature control

Specifier's Guide
Selecting the AWHP

1. Primarily/Exclusively heating or cooling?
2. Emitters: Radiant Floor/Ceiling/Panel, Fan Coil, Conventional Ducted, Low Temp Baseboard, Snow Melt
3. Geographic location, design conditions
4. Back-up (heat) available/planned

Typical system and critical components




Solstice SE Air to Water Heat Pumps, 36 & 60 MBH

Solstice Extreme AWHP
40 MBH at 0ºF

Ratings

Cooling

3 Ton SpacePak Chiller, Cooling Operation				
44 Deg F water				
Ambient Temp Deg F	Capacity BTU/hr	Chiller Power Watts	Chiller COP	Chiller EER
82	38,500	3.208	3.6	12.0
95	36,000	3,750	2.8	9.6
105	28,600	4,912	1.7	5.8

5 Ton SpacePak Chiller, Cooling Operation				
44 Deg F water				
Ambient Temp Deg F	Capacity BTU/hr	Chiller Power Watts	Chiller COP	Chiller EER
82	57,500	5,227	3.2	11.0
95	48,000	5,517	2.5	8.7
105	32,000	6,643	1.4	4.8

Solstice Extreme LAHP48, Cooling Operation				
44 Deg F water				
Ambient Temp Deg F	Capacity BTU/hr	Chiller Power Watts	Chiller COP	Chiller EER
82	44,000	4,341	3.0	10.1
95	40,000	4,790	2.4	8.4

Heating

3 Ton SpacePak Chiller, Heating Operation				
Ambient Temp Deg F	Water Supply Temp.	Capacity BTU/hr	Chiller Power Watts	Chiller COP
47	120	36,840	4,230	2.7
32	120	26,295	3,472	2.2
17	120	20,160	3,103	1.6

5 Ton SpacePak Chiller, Heating Operation				
Ambient Temp Deg F	Water Supply Temp.	Capacity BTU/hr	Chiller Power Watts	Chiller COP
47	120	52,200	5,770	2.7
32	120	42,770	5,927	2.1
17	120	28,560	4,125	1.6

Solstice Extreme LAHP48, Heating Operation				
Ambient Temp Deg F	Water Supply Temp.	Capacity BTU/hr	Chiller Power Watts	Chiller COP
47	120	64,680	5,963	3.2
17	120	46,680	5,927	2.7
0	120	40,000	5,850	2.0

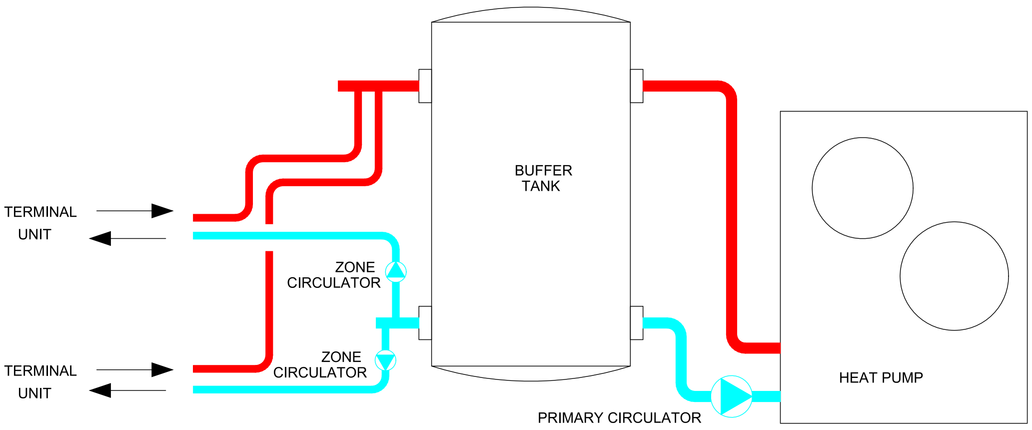
System Design Considerations

- Site Location
- Plumbing material and layout
- Freeze Protection
- Back-up heating measures
- Cooling use, summer comfort or year-round
- Defrost requirements and configuration
- System volume, thermal storage and turndown requirements
- Control integration

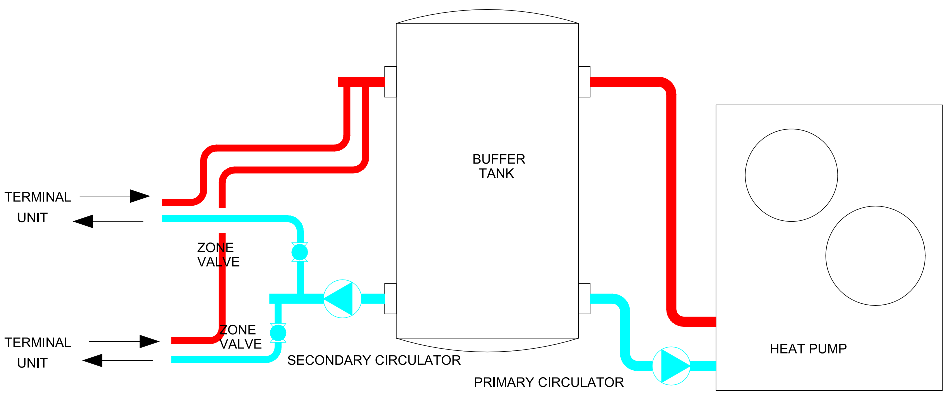
Proximity to the building

Consideration for local conditions

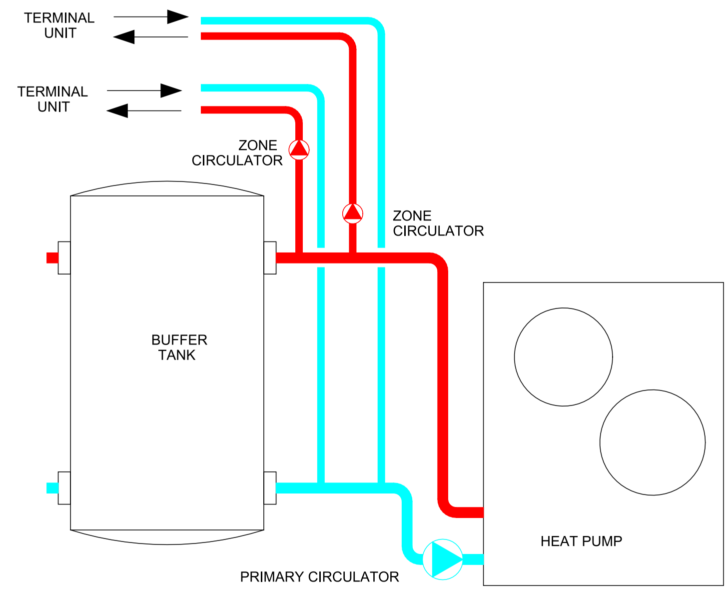
Piping and Pumping schemes



Primary/Secondary with zone circulators



Primary/Secondary with zone valves



Primary/Secondary with zone valves

Neatness Counts

System Volume & Buffer Tanks

1. Minimum volume of 5 gallons per ton of capacity at Max Turndown
2. More volume allows closer temperature differential control, longer run times.
3. System volume also provides heat for defrost operation.

SPACEPAK SYSTEM INTERFACE CONTROL - SSIC

- Takes Inputs from up to 5 Air Handlers

- Outputs: Boiler, Chiller Enable, Chiller Reversing Valve, Pump

- Air Handlers Receive Calls from Tstats, Outputs Heating or Cooling Call to Interface Control

- Includes Outdoor Air Temp Sensor & Water Temp Sensor
- Buffer Tank option

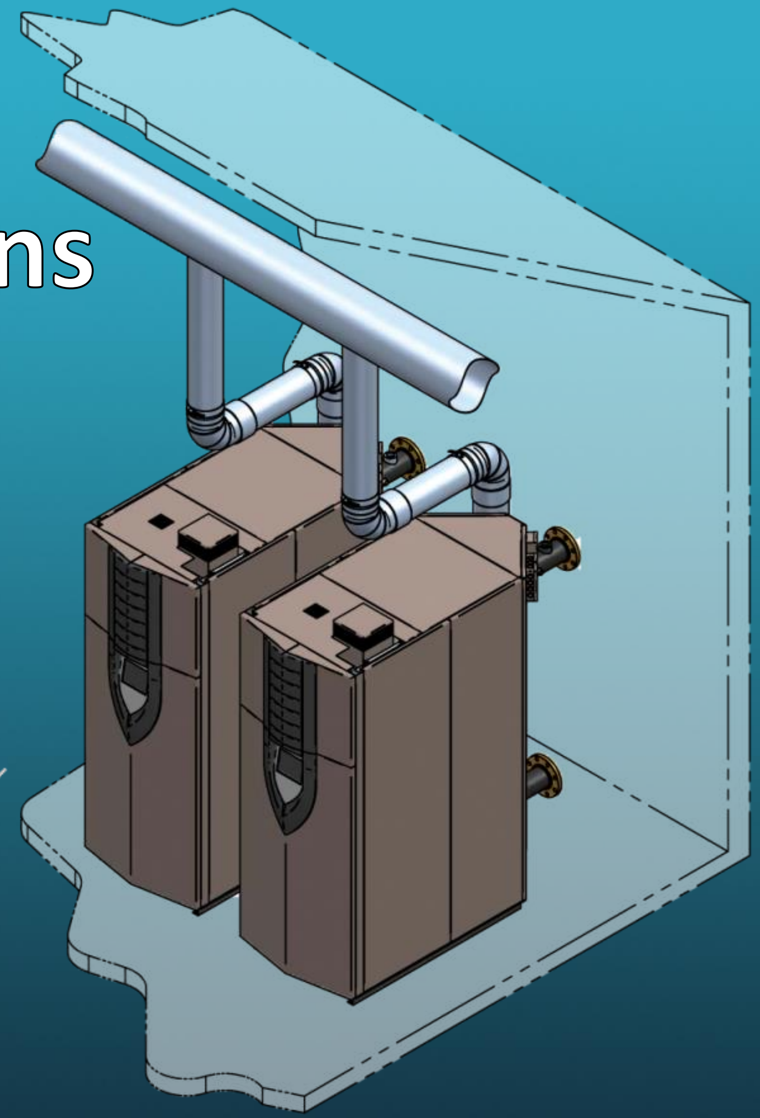
- Firmware Updates through USB

Interface Controls

Hydronic Heat Source Specifications

Lochinvar®

HIGH EFFICIENCY BOILERS & WATER HEATERS



Paul Rohrs- National Trainer
Prohrs@Lochinvar.com

2017 AHR EXPO JAN 30-FEB 1 Las Vegas

RPA RADIANT PROFESSIONALS ALLIANCE

Specifying Hydronic Heating Sources

- Engineering Scope
  - Application/System Approach
- Product
  - Design Flexibility
    - Multiple Temp
    - Piping Methods
    - First Cost
  - Control
  - Support
    - Recommended Options
    - Submittal Package
    - CAD Drawings
- Specification

Specifying Hydronic Heating Sources

- Engineering Scope
  - Application/System Approach
  - Frustration?....

    Deadlines

    Smaller Footprint

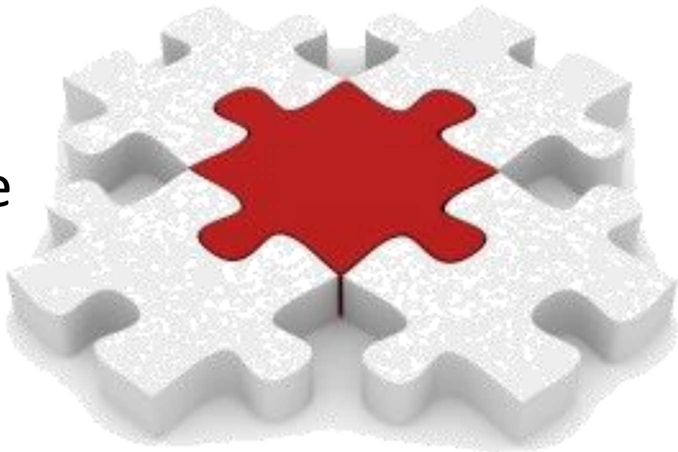
    First Cost Constraints/Budget

Specifying Hydronic Heating Sources

- Product
  - Design Flexibility
- Example System Criteria: (Variables)
  - Domestic hot water
  - Cold climate/large temperature rise
  - Not a lot of room dimensionally
  - Venting is going to be an issue
  - Water chemistry is questionable

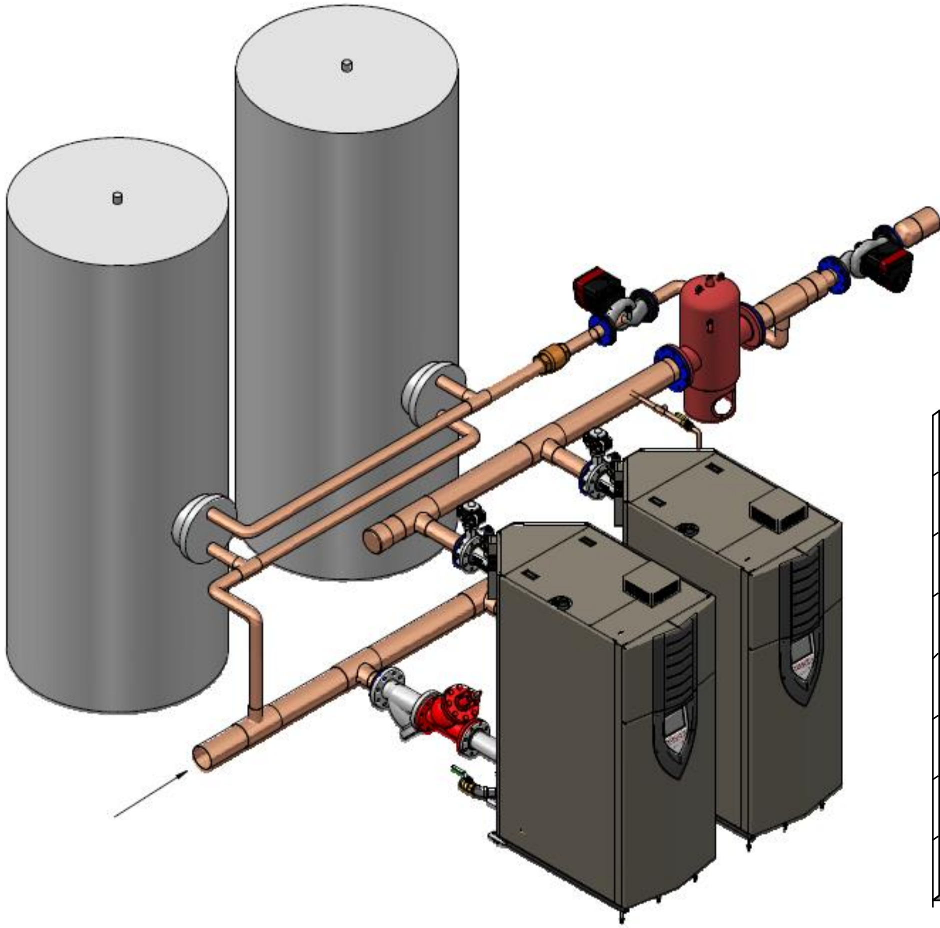
    Hardness/TDS

    Indirect Heating

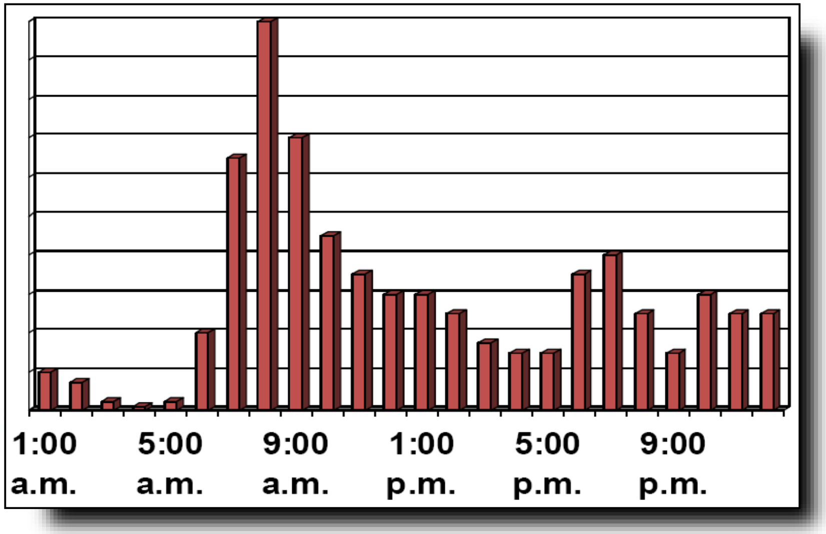


➢ System Criteria

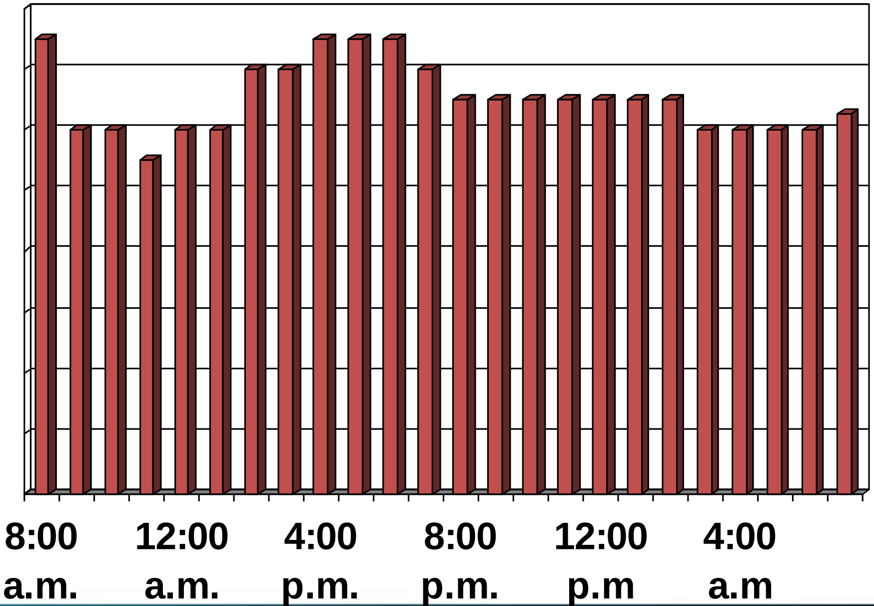
➢ Usage Pattern/Hunter Curve



Traditional "Peak Load" sizing with storage

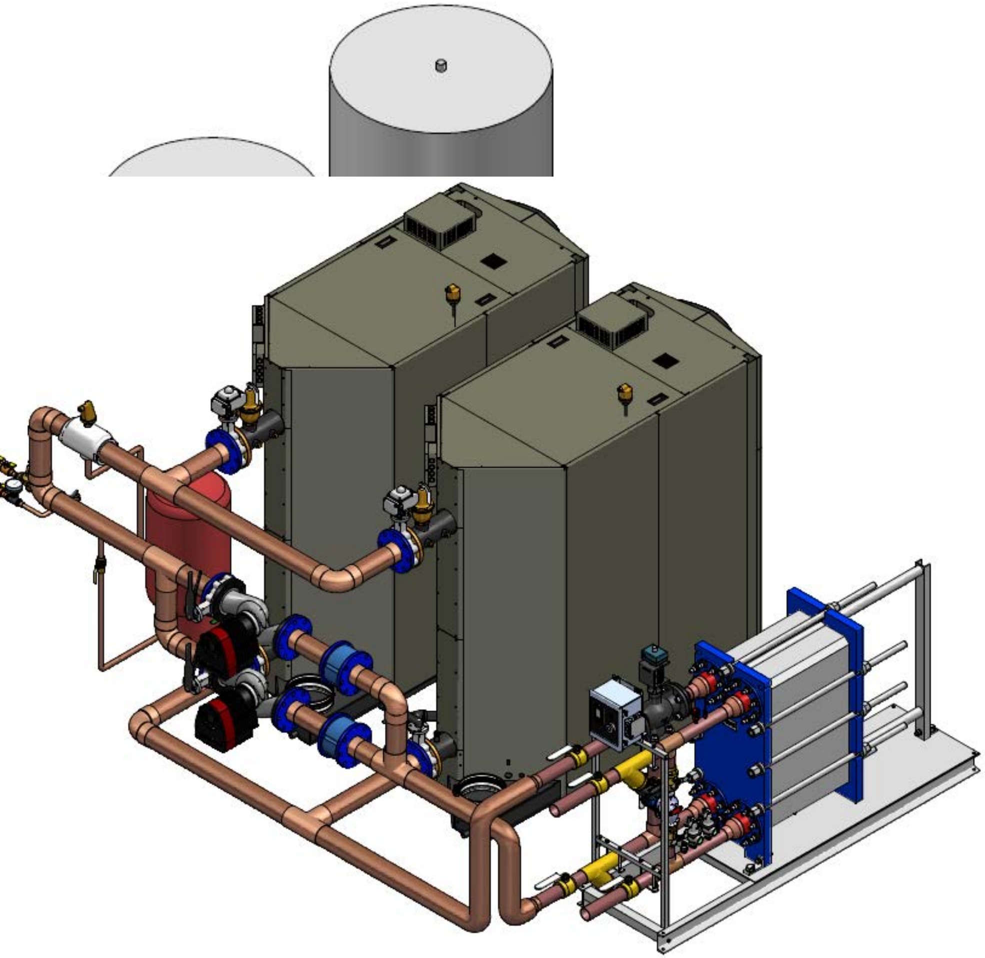


"Constant Load" sizing w/w-out storage

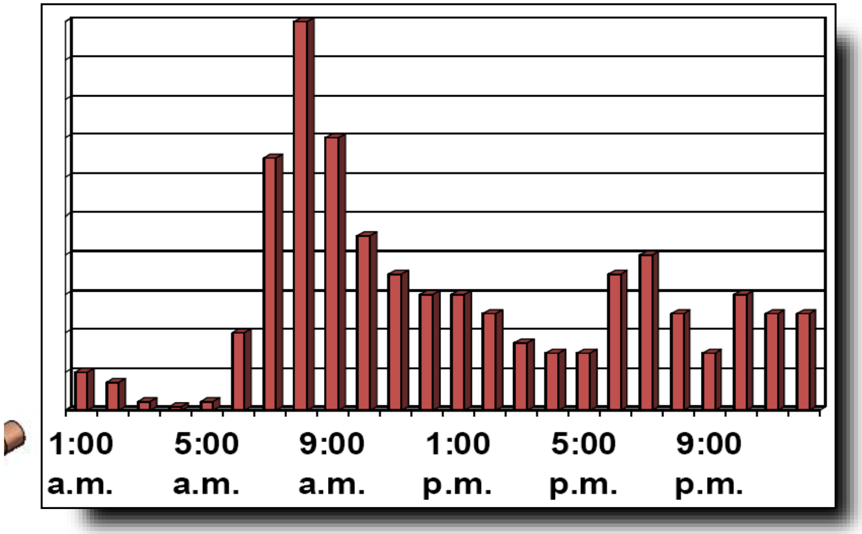


➢ System Criteria

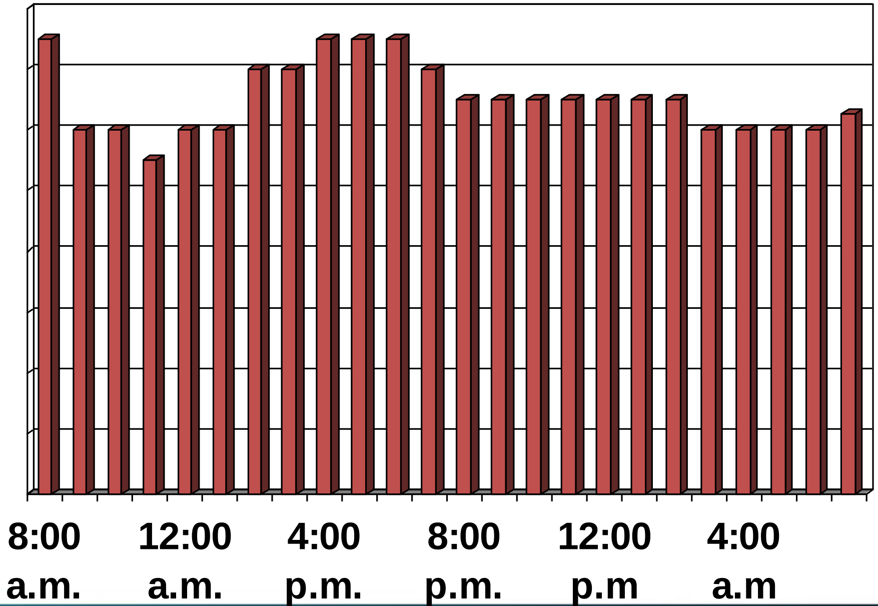
- ➢ Usage Pattern/Hunter Curve



Traditional "Peak Load" sizing with storage

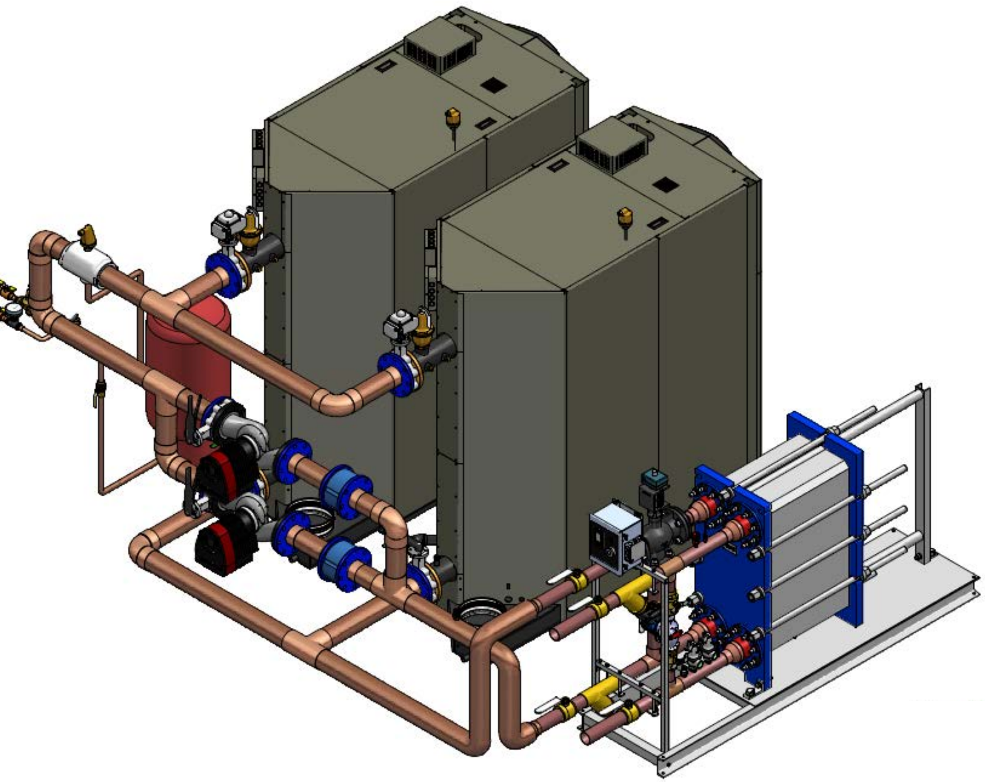


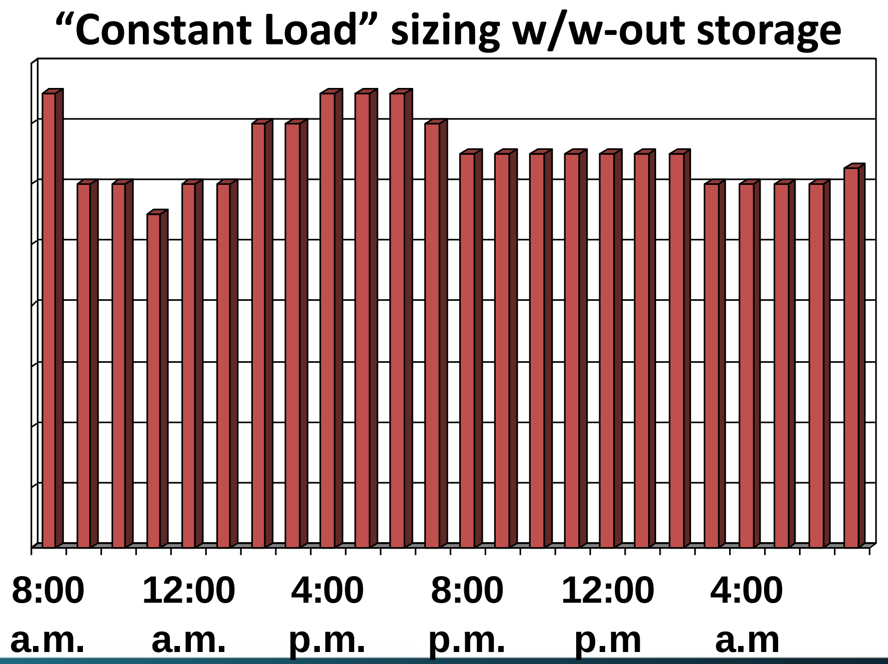
"Constant Load" sizing w/w-out storage



➢ System Criteria

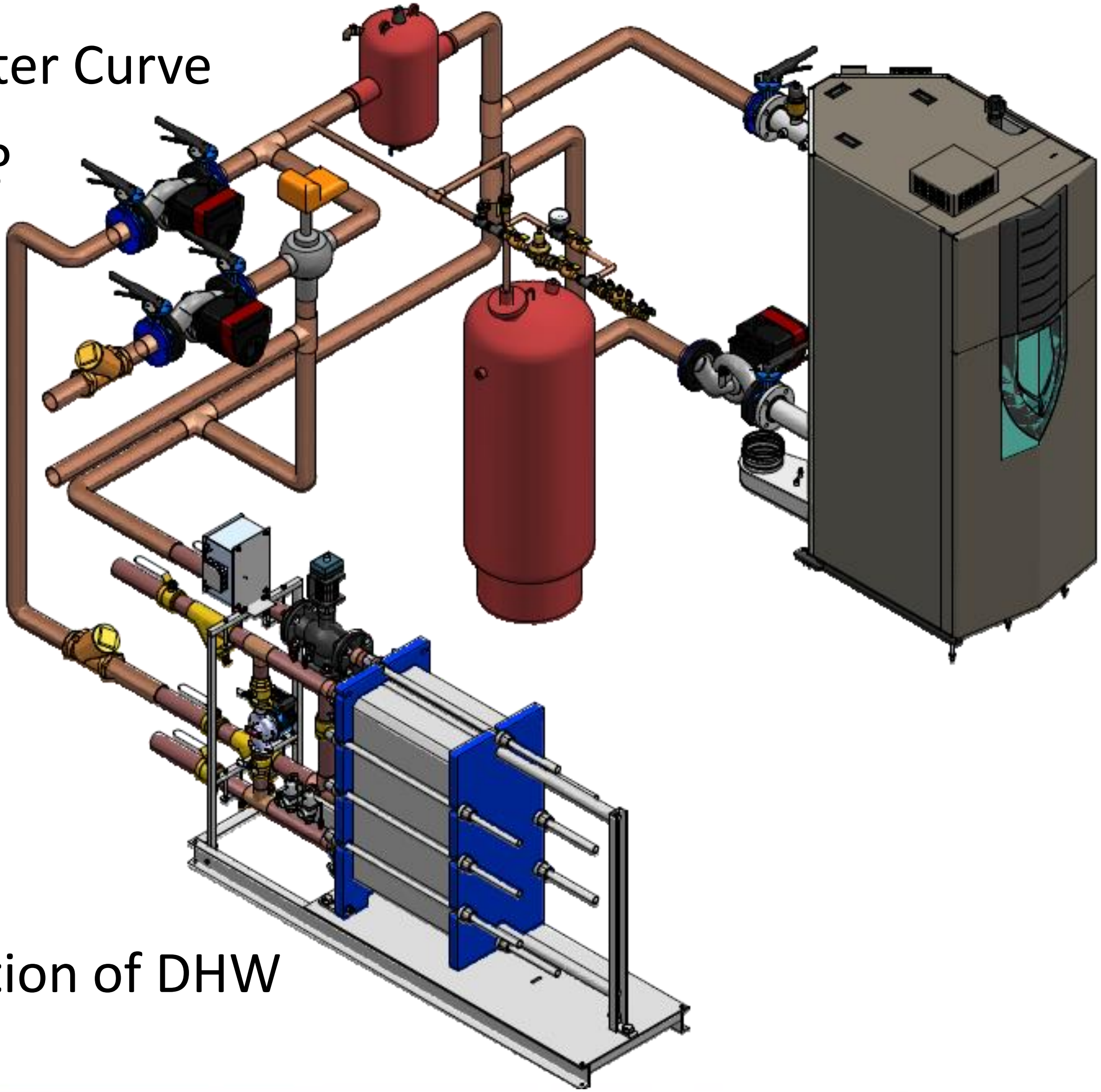
- ➢ Usage Pattern/Hunter Curve
- ➢ Space heating load?



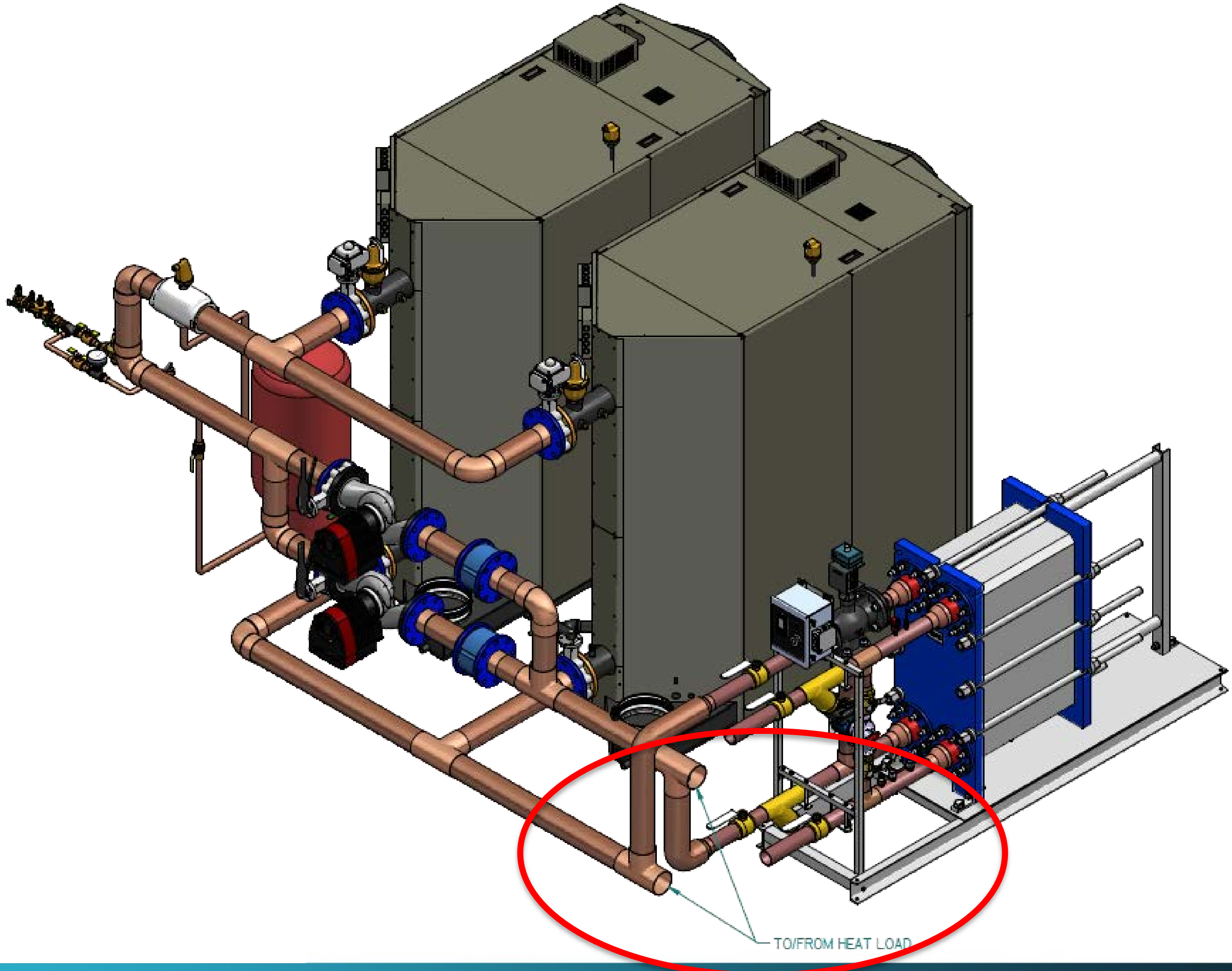


System Criteria

- Usage Pattern/Hunter Curve
- Space heating load?



- Primary secondary
- Multiple temps
- Simultaneous operation of DHW and Space Heat


TO/FROM HEAT LOAD

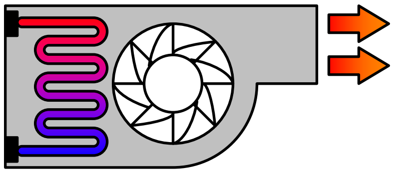
Specifying Hydronic Heating Sources

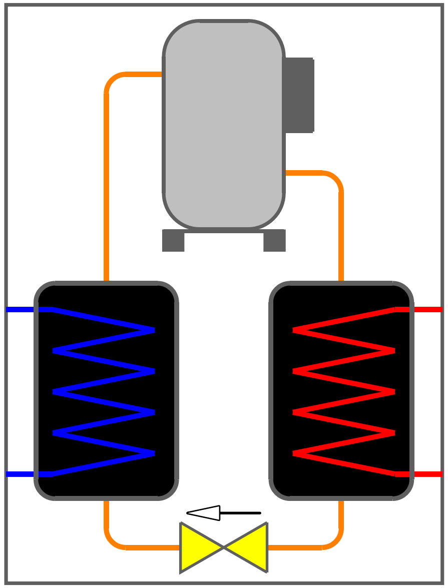
- Engineering Scope
  - Application/System Approach
- Product
  - Design Flexibility
    - Multiple Temp
    - Piping Methods
    - First Cost

Specifying Hydronic Heating Sources

- Design Flexibility for Best System Efficiency
- Low Mass **MUST** be Primary Secondary
  - Closely Spaced Tee's
  - Low Loss Header
  - Hydraulic Separator
  - Buffer Tank

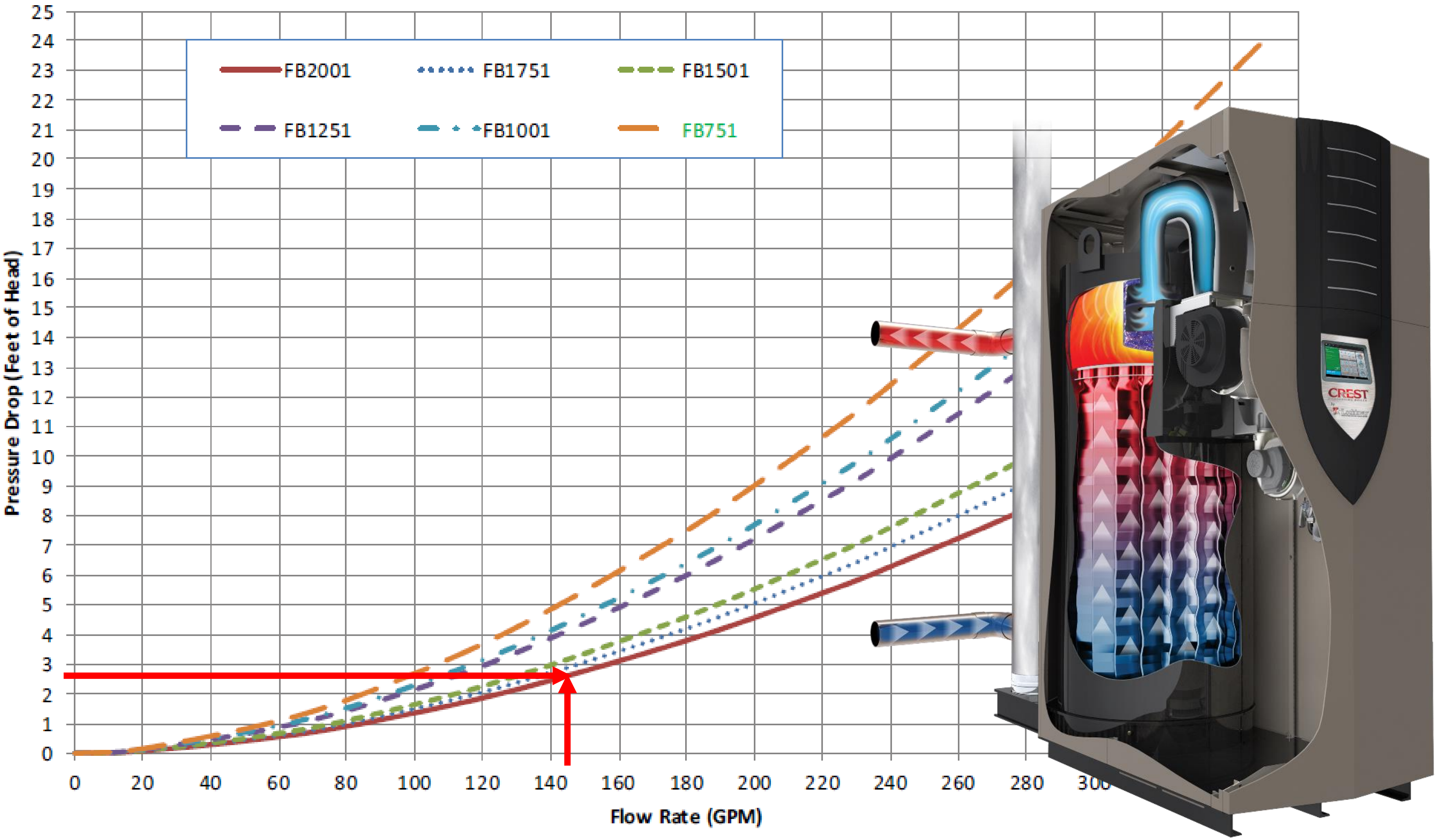
    Best System Efficiency achieved when pairing low mass HX with low mass heat emitter



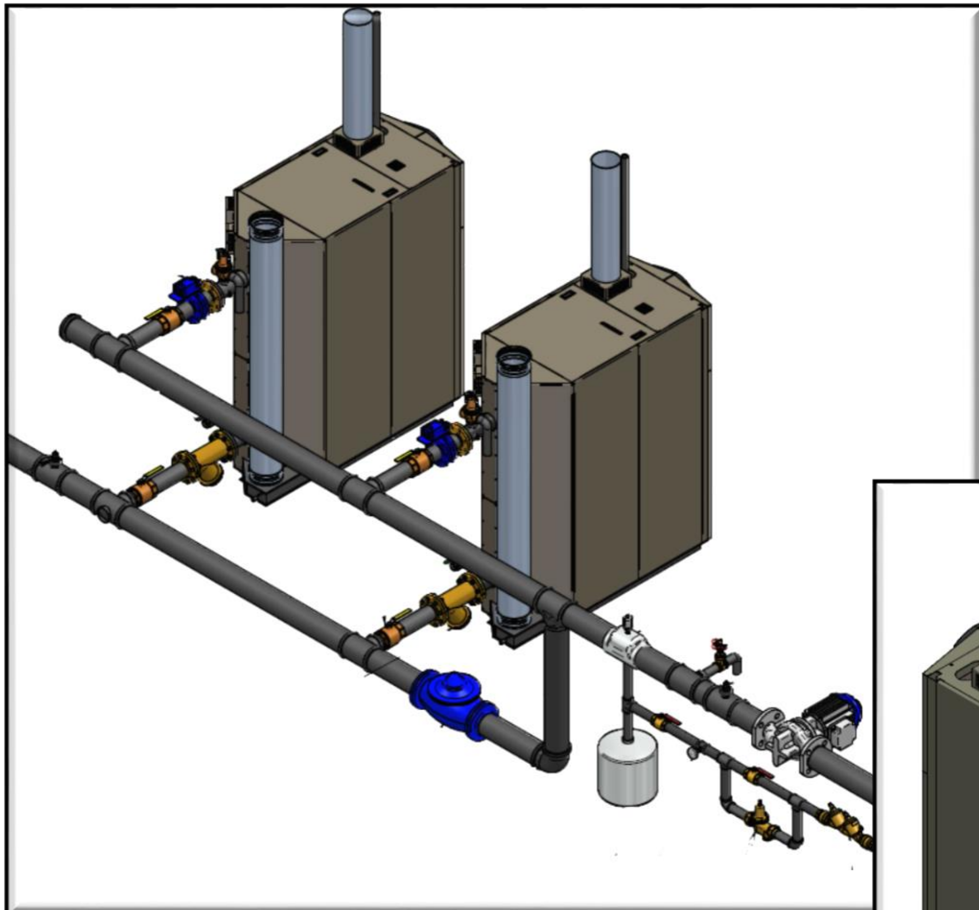


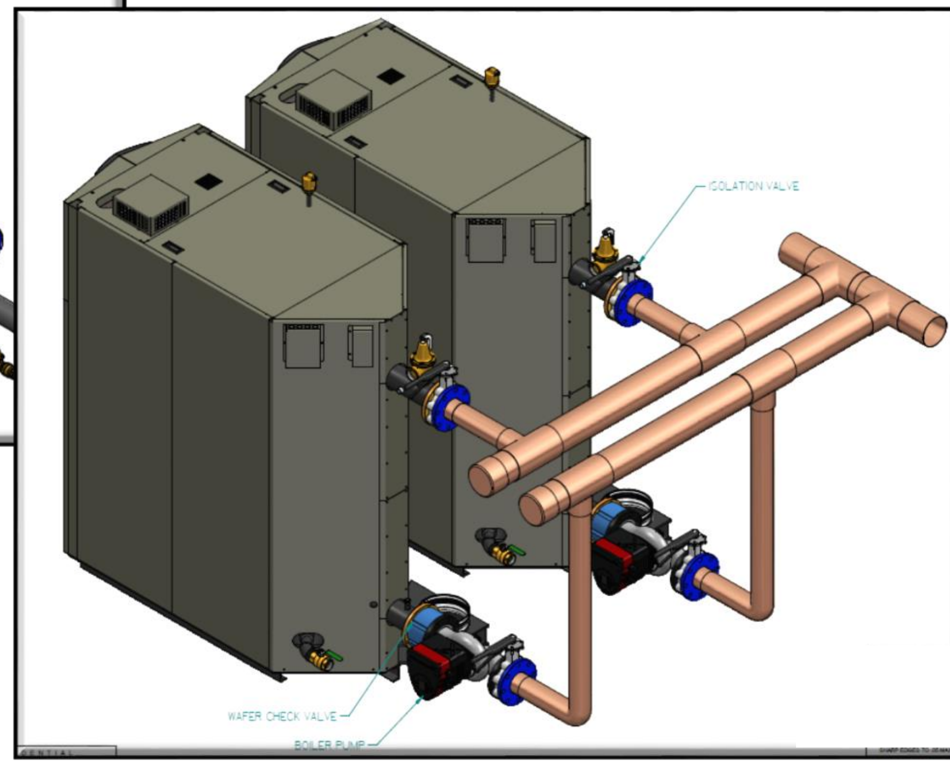
- High Mass
  - Allows for **Full Flow (vs Pri/Sec)**

CREST Pressure Drop Curve



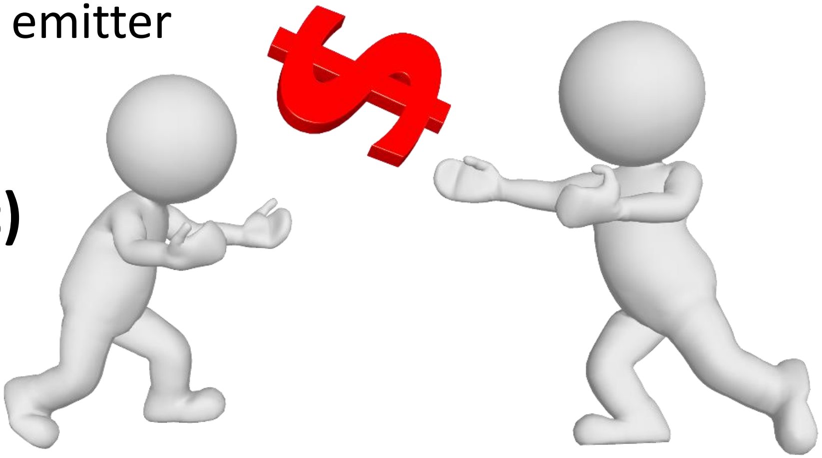
30°F ΔT = 144 GPM @ 2.5' Hd




ISOLATION VALVE
WAFER CHECK VALVE
BOILER PUMP

Specifying Hydronic Heating Sources

- Design for Best System Efficiency
- Low Mass **MUST** be Primary Secondary
  - Closely Spaced Tee's
  - Low Loss Header
  - Hydraulic Separator
  - Buffer Tank
    - Best System Efficiency achieved when pairing low mass HX with low mass heat emitter
- High Mass
  - Allows for **Full Flow (vs Pri/Sec)**
  - Lower first cost



Specifying Hydronic Heating Sources

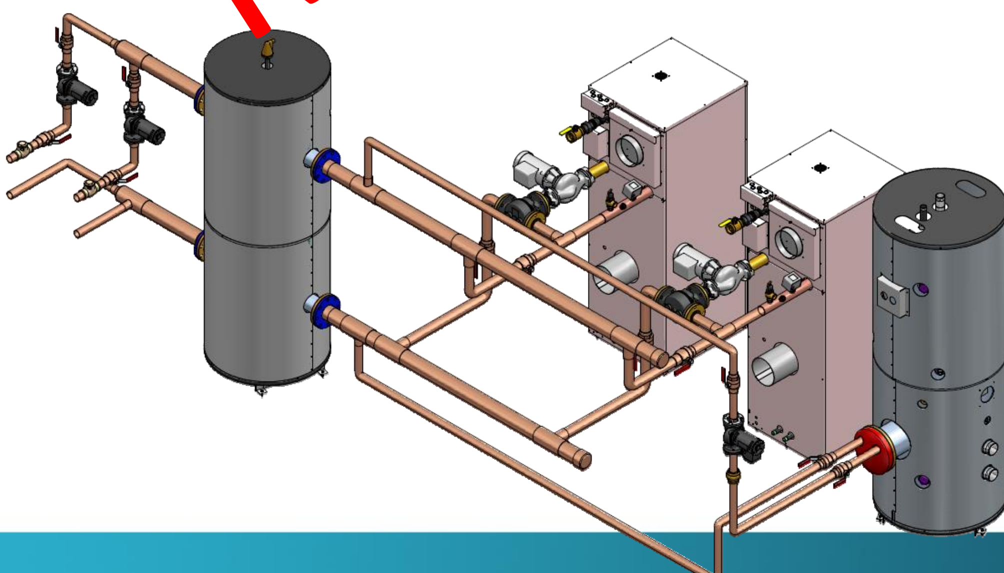
- Engineering Scope
  - Application/System Approach
  - Frustration?....

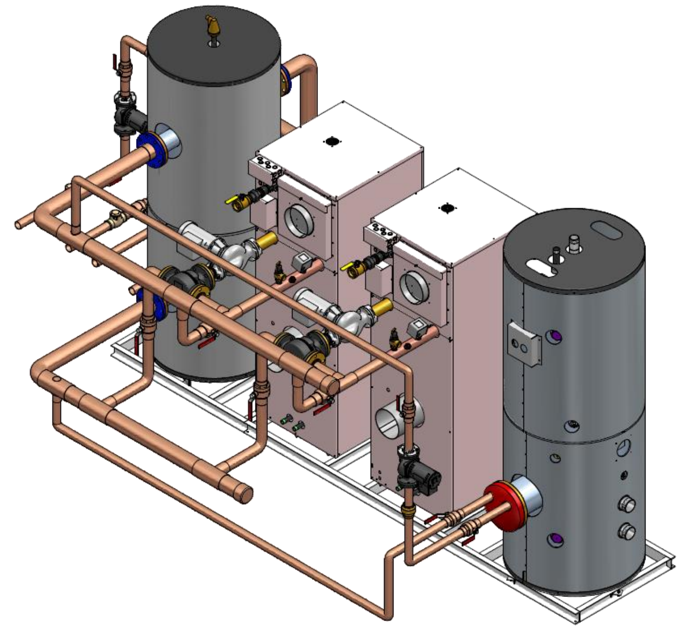
    Deadlines

    Smaller Footprint

    First Cost Constraints/Budget

Metrics





Specifying Hydronic Heating Sources

- Engineering Scope
  - Application/System Approach
- Product
  - Design Flexibility
    - Multiple Temp
    - Piping Methods
    - First Cost
  - Control

Specifying Hydronic Heating Sources

- Control
- 8" touchscreen and multi-color interface
- Standard w/BACnet MSTP protocol & Modbus
- Can be integrated into a Building Automation System via ModBus, BACnet and other communications protocols

Unequaled Control and Monitoring Functions that are Easy to Use

Specifying Hydronic Heating Sources

- Control

BACnet Modbus

Unequaled Control and Monitoring Functions that are Easy to Use

Specifying Hydronic Heating Sources

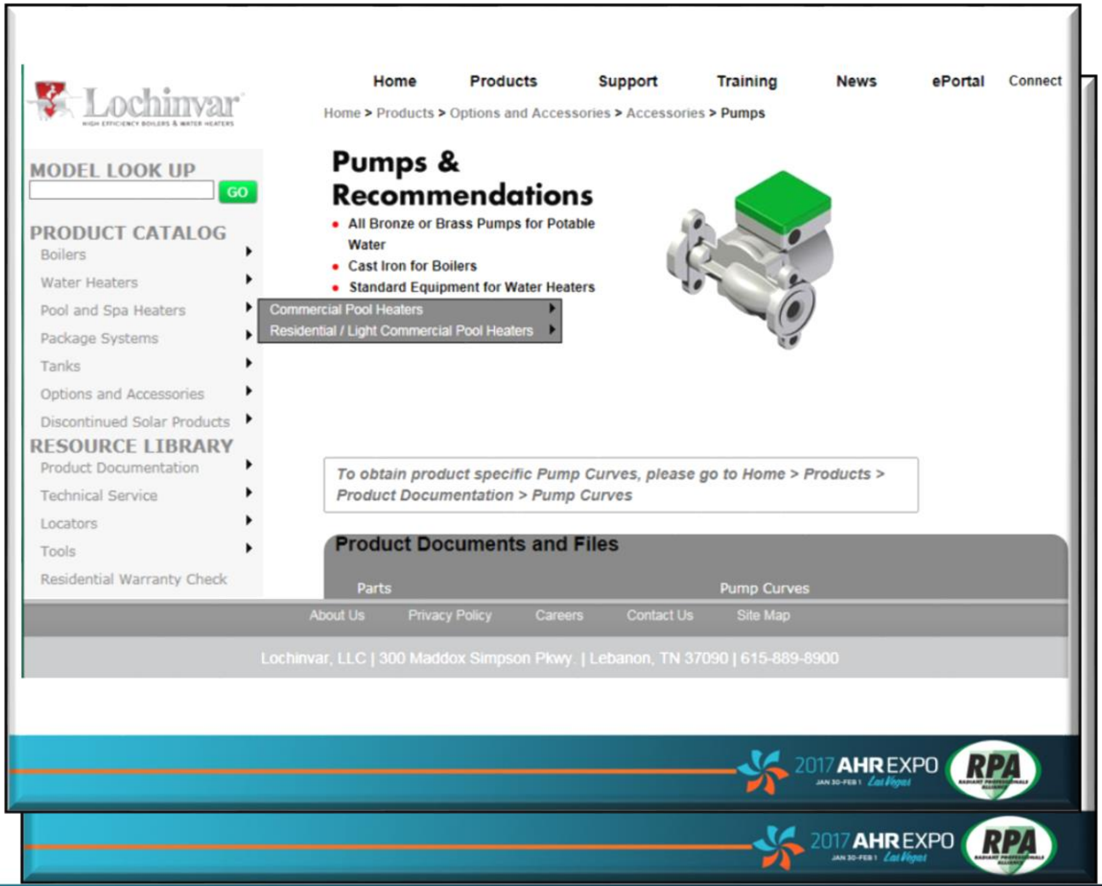
- Engineering Scope
  - Application/System Approach
- Product
  - Design Flexibility
    - Multiple Temp
    - Piping Methods
    - First Cost
  - Control
  - Support
    - Recommended Options
    - Submittal
    - CAD Drawings

Specification Support

- Recommended Options:
  - Motorized Isolation Valves

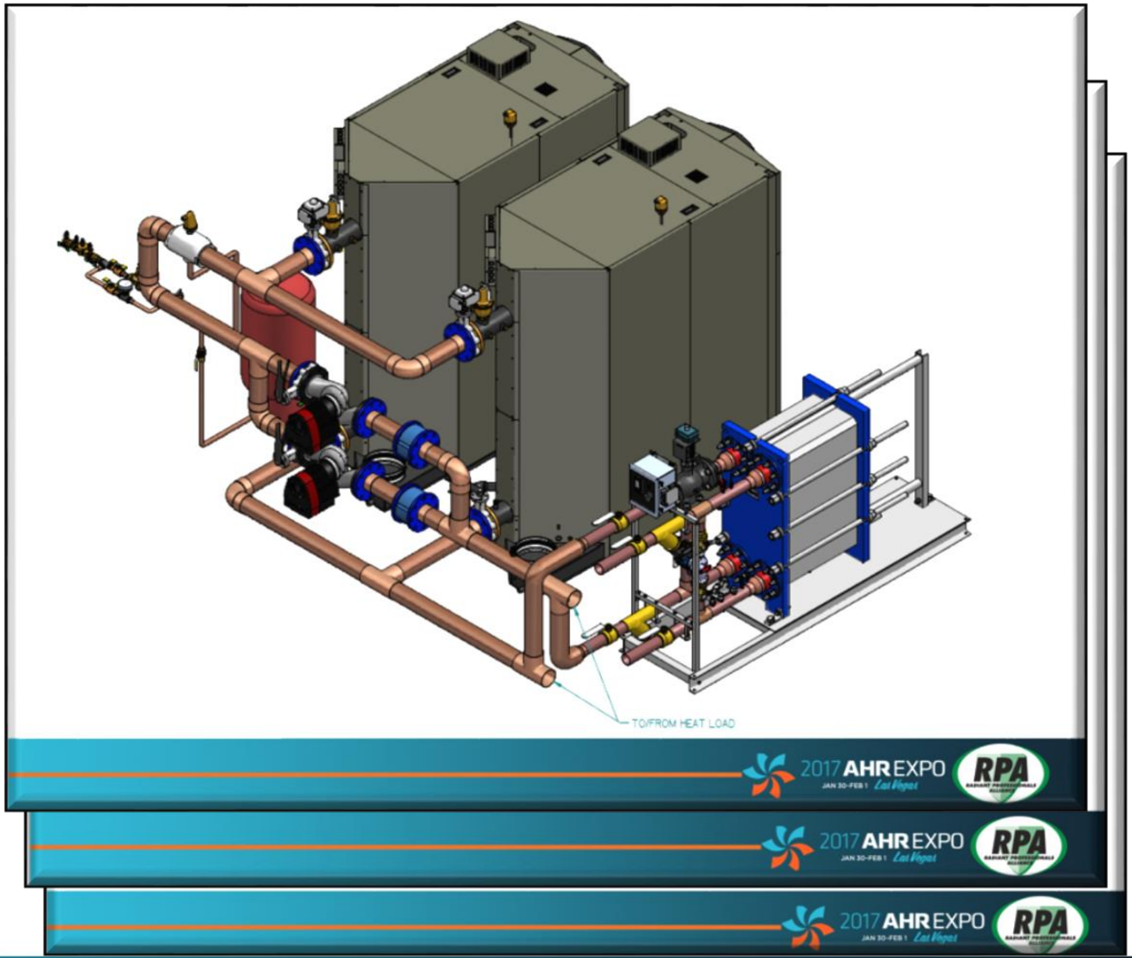
    ASHRAE 90.1 Compliant -“No flow thru a boiler when not firing”
  - Circulator

    Fixed vs Variable Speed



Specification Support

- CAD Drawings:
  - Piping Arrangements
  - Revit Stencils
  - Project Specific CAD Drawings



Specification Support

- Submittal Package Consists of:
  - Cover letter
  - Product submittal
  - Dimensions and shipp
  - Piping schematics
  - Product summary
  - Wiring diagram
  - Venting
  - Brochure
  - Warranty

COMMERCIAL BOILER

Lochinvar

HIGH EFFICIENCY BOILERS & WATER HEATERS

10 YEAR LIMITED WARRANTY

EFFECTIVE:

For 10 Years, Lochinvar warrants this product against defects in materials or workmanship and failure due to thermal shock as described in this document, if installed within the United States or Canada, and provided the product remains at its original place of installation.

Warranty coverage begins on the date of installation OR the date of manufacture if installation cannot be verified. *Note: The date of manufacture can be determined using the Serial Number, located on the silver rating label (Example: D12H0024168).*

WHAT IS COVERED:

Subject to these terms, in the event of a defect in materials or workmanship appearing during the first year, Lochinvar will repair, or at our discretion, replace any part of the product covered under this warranty.

After 1 year, Lochinvar will repair or, at our discretion, replace the defective heat exchanger, for a period of **9 more years. You are responsible for all labor, shipping, delivery, installation, and handling** costs.

Unless authorized in writing, all products must be returned to the factory for warranty determination, at the owner's expense.

Any replacement part or product will be warranted only for the unexpired portion of the original product's limited warranty period.

If an identical model is no longer available due to a change in law, regulation, or standard, Lochinvar will replace the product with one having at least the same capacity and of equal input. In these instances, you will have the option of paying the difference between what you paid for the original model and the new model with the additional features, or receiving a refund of the portion of the purchase price allocable, on a pro-rata basis, to the unexpired portion of the warranty period.

OWNER'S RESPONSIBILITIES:

Owners are responsible for selecting a qualified service provider. Visit www.Lochinvar.com for a list of service providers in your area.

- Follow all instructions enclosed with the product.
- Retain all bills of sale or receipts for proof of installation.
- Provide copies of all service and maintenance records.
- Contact your installer or dealer as soon as any problem or defect is noticed.

FOR SERVICE OR WARRANTY INQUIRIES:

Call your local installer or dealer. Be ready to provide the following information: your name, address and telephone number; the model and serial number of your Lochinvar product; proof of installation; and a clear description of the problem.

WHAT IS NOT COVERED, PROBLEMS CAUSED BY:

- Problems caused by improper: gas supply line sizing, gas type, venting, connections, combustion air, voltage, wiring, or fusing
- Improper installation, sizing, delivery, or maintenance
- Failure to follow printed instructions enclosed with the product
- Abuse, misuse, accident, fire, flood, Acts of God
- Improper venting and air intake materials, length, construction, or operations
- Claims related to rust, excessive noise, smell, or taste of water
- Failure to conduct authorized factory start up as required
- Failure to properly perform maintenance, as outlined in the instruction manuals provided by the manufacturer
- Damages due to a failure to allow for thermal expansion
- Alterations that change the intended or certified use of the product
- Failure to follow applicable codes
- Improper chemical addition
- Service trips to explain proper installation, use, or maintenance of the product/unit or to describe compliance requirements under applicable codes and regulations
- Charges related to accessing the product including but not limited to door/wall removal, equipment rental, etc.
- Replacement parts after expiration of this warranty
- Premium associated with after hours or overtime labor

LIMITATIONS:

NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, THIS IS YOUR SOLE AND EXCLUSIVE WARRANTY. ALL OTHER WARRANTIES, INCLUDING A WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY DISCLAIMED. SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES. TOTAL LIABILITY ARISING AT ANY TIME SHALL NOT EXCEED THE PURCHASE PRICE PAID WHETHER BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER LEGAL THEORY.

Specifying Hydronic Heating Sources

- Engineering Scope
  - Application/System Approach
- Product
  - Design Flexibility
    - Multiple Temp
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  - Control
  - Support
    - Recommended Options
    - Submittal
    - CAD Drawings
- Specification

Radiant Heating and Cooling with Ground Source Heat Pumps

Alternative Designs for Superior Comfort and Energy Efficiency

Al Wallace, President
Maya Kadi, Systems Engineering Manager

Energy Environmental Corporation

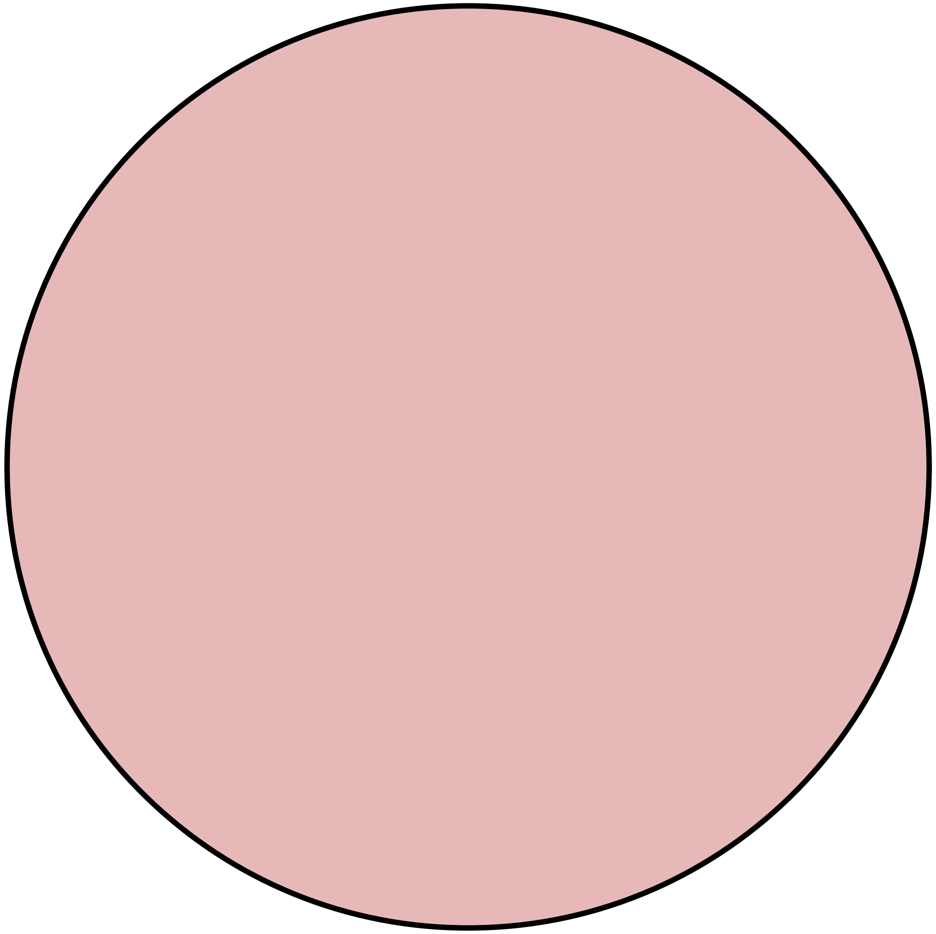
January 30, 2017

Overview

- **Design drives Efficiency of Geothermal & Radiant Floor Systems**
  - Water outperforms Air – Thermodynamics 101 + 210
  - Systems Design takes precedent over equipment for efficiency
- **Radiant Floor Cooling System Requirements and GSHP Options**
  - Dew Point Tracking, Comfort Metrics, Systems Requirements
  - Variable Speed GHPs and VS Pumps, and High Temp GSHPs
- **Geothermal Heat Pump Capabilities and Designs which Exceed Industry Standards**
  - High Temperature Vapor Injection Water-Water heat pumps
  - Variable Speed Compressor Water-Air heat pumps for comfort and efficiency
  - Simple-to-Implement Controls which integrate GHPs with Radiant Systems
  - Alternative Designs for Ground Heat Exchangers for Superior Energy Efficiency

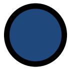
Air versus Water

43% Energy Savings



Two Feet - 24 inch Duct Diameter
3541 CFM ÷ 425 CFM/Ton x 12,000 BTU/ton

100,000 BTU/hr



1 ½ inch Pipe Diameter
20 GPM x 10 deg ΔT x 500

100,000 BTU/hr

Energy Savings of VAV vs. Radiant Cooling

Item	% Power in VAV	% Power in Radiant Cooling
Fan and motor	37.5%	1.5%
Load from lights	18.8%	9.4%
Air transport load	9.3%	1.9%
Other loads	34.4%	34.4%
Pumps	---	1.5%
Total	**100%**	**57.7%**

Peak HVAC Energy Consumption Comparison, VAV Versus Radiant Cooling [Stetiu, 1997, 7]

Comfort

- ✓ Room-by-Room Sensors and Control
- ✓ Uniform Temperature
- ✓ Ideal Indoor Humidity

Indoor Climate

- ✓ Fresh Filtered Air
- ✓ Lower Allergens
- ✓ No Indoor Combustion

Environment

- ✓ Less Energy Use
- ✓ Zero Carbon Emissions
- ✓ Zero Greenhouse Gas Emissions

Value

- ✓ 50% Total Savings
- ✓ 8-12% Simple IRR
- ✓ 12-15 Year Payback
- ✓ Low Maintenance
- ✓ Lowest Operating Cost

Benefits of Ground Source Heat Pumps with Radiant Floor Heating/Cooling versus Conventional Forced Air …

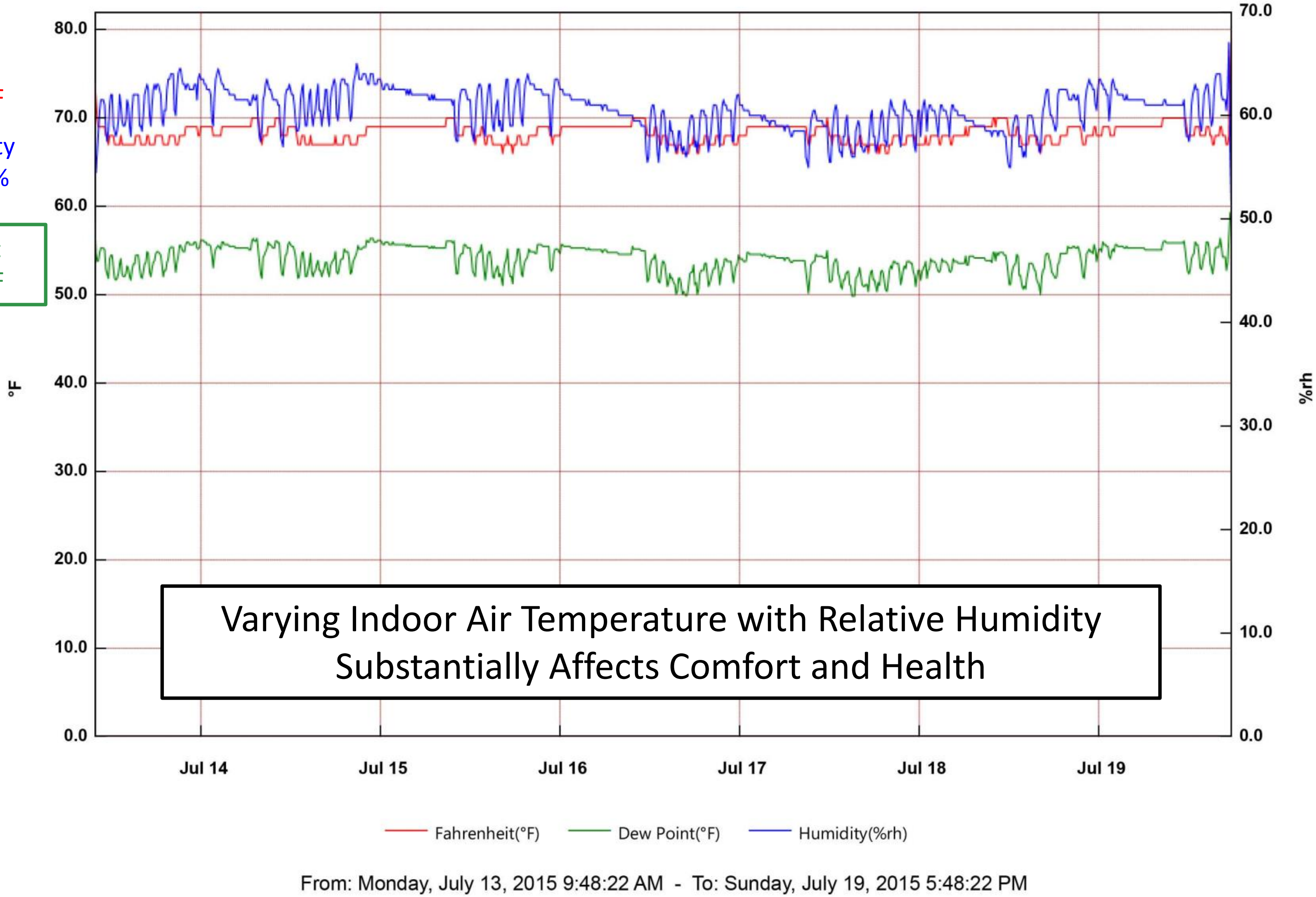
Forced Air Cooling: Temperature, RH, and Dew Point

68º F Setpoint, Summer, Leaky Home, OAT – 85º F, $RH_{OUTSIDE}$ - 70%, Denver

Air Temp
67 to 70º F

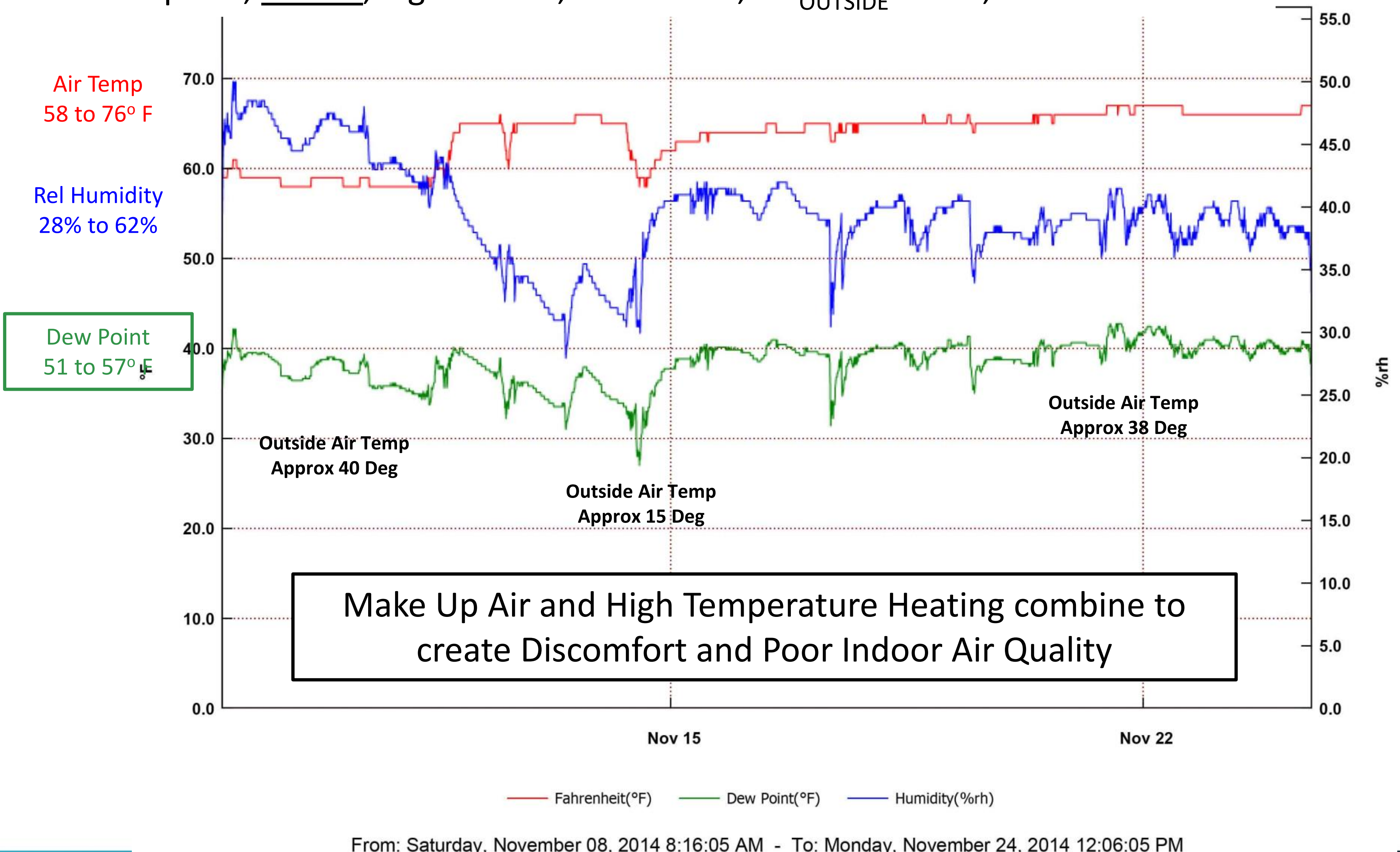
Rel Humidity
55% to 65%

Dew Point
52 to 57º F



Forced Air Heating – Make Up Air - Basement

65° F Setpoint, Winter, Tight Home, OAT Varies, $RH_{OUTSIDE}$ - 25%, Denver



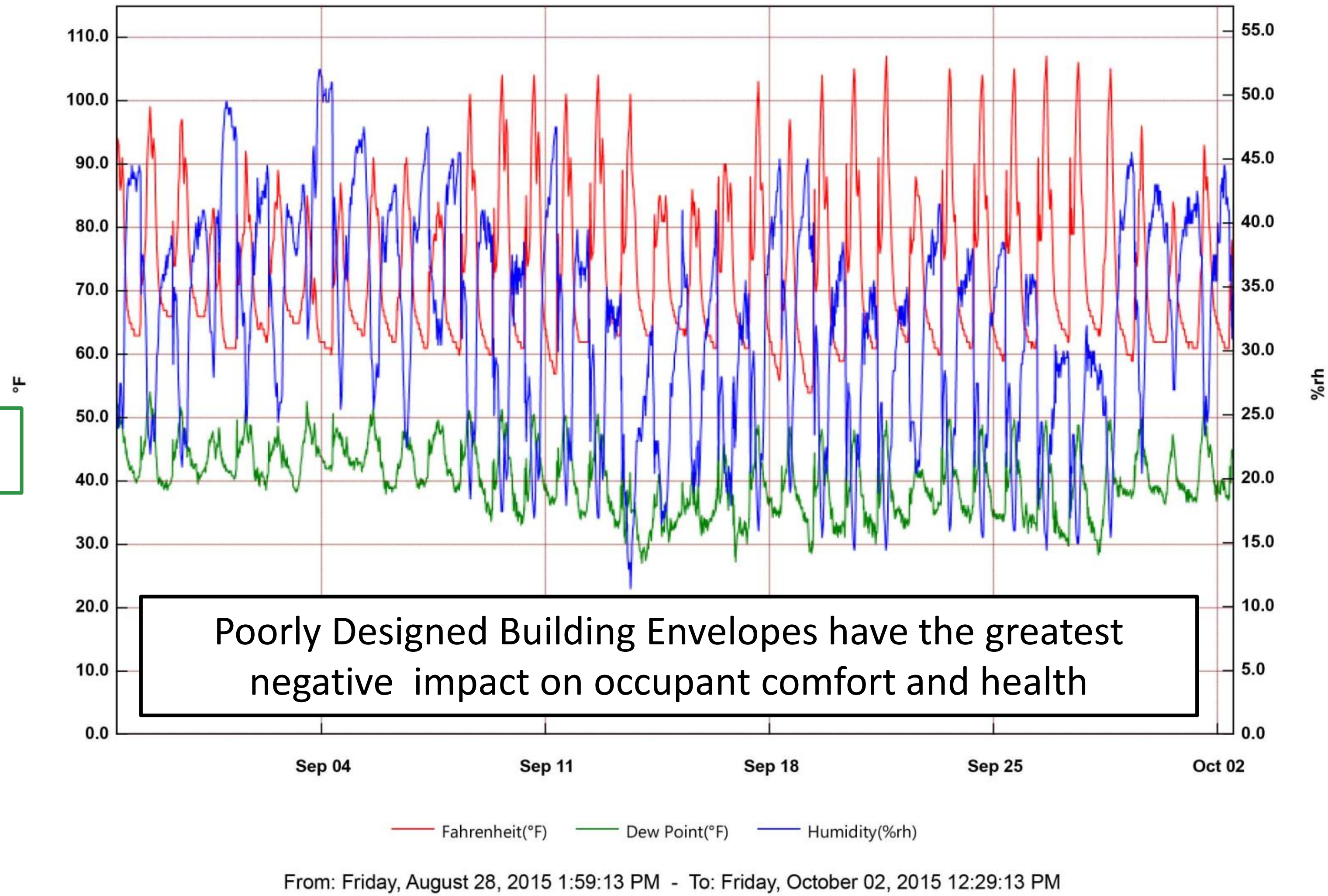
Solar Heat Gain, 1" from Pane, South-East Kitchen

74º F Setpoint, Fall, Tight Home, OAT – 75º F, $RH_{OUTSIDE}$ - 45%, Evergreen

Air Temp
53 to 108º F

Rel Humidity
12% to 54%

Dew Point
28 to 52º F



Poorly Designed Building Envelopes have the greatest negative impact on occupant comfort and health

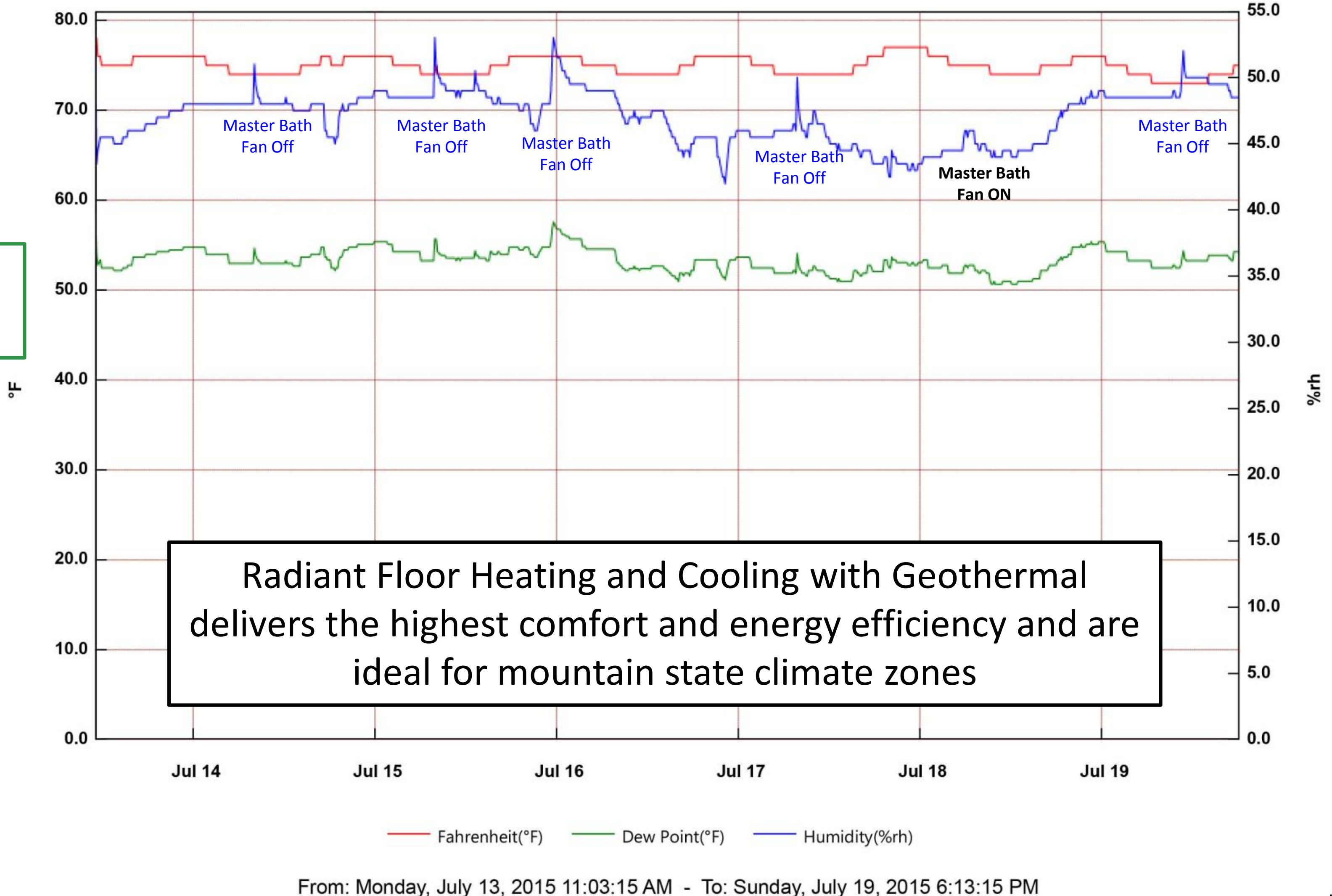
Radiant Floor Cooling – Master Bedroom West-Facing

74º F Setpoint, Summer, Tight Home, OAT – 85º F, $RH_{OUTSIDE}$ - 70%, Evergreen

Air Temp
73 to 75º F

Rel Humidity
44% to 65%
44% to 48%

Dew Point
51 to 57º F
51 to 55º F



Radiant Floor Heating and Cooling with Geothermal delivers the highest comfort and energy efficiency and are ideal for mountain state climate zones

RFC®: Commercial Efficiency versus Residential Comfort

Radiant Floor Cooling can be implemented anywhere in the world …

the climate zone determines the cost, complexity, and energy efficiency.

About **half of net-zero energy buildings use radiant cooling** to help them achieve the balance between energy consumption and renewable energy creation.

"**Radiant cooling has more awareness in the commercial sector**. In larger buildings, the energy dollars are much higher and more significant than residential applications.

Developers and engineers are on a constant mission to reduce cost, which makes radiant heating and cooling more attractive.
In residential applications, the driving force is comfort.

ACHRNEWS.com, Publication date: 1/19/2015

RFC®– Fort Carson Net Zero Energy Barracks Project

Predicted Radiant Floor Cooling Efficiency Based on Climate Zone

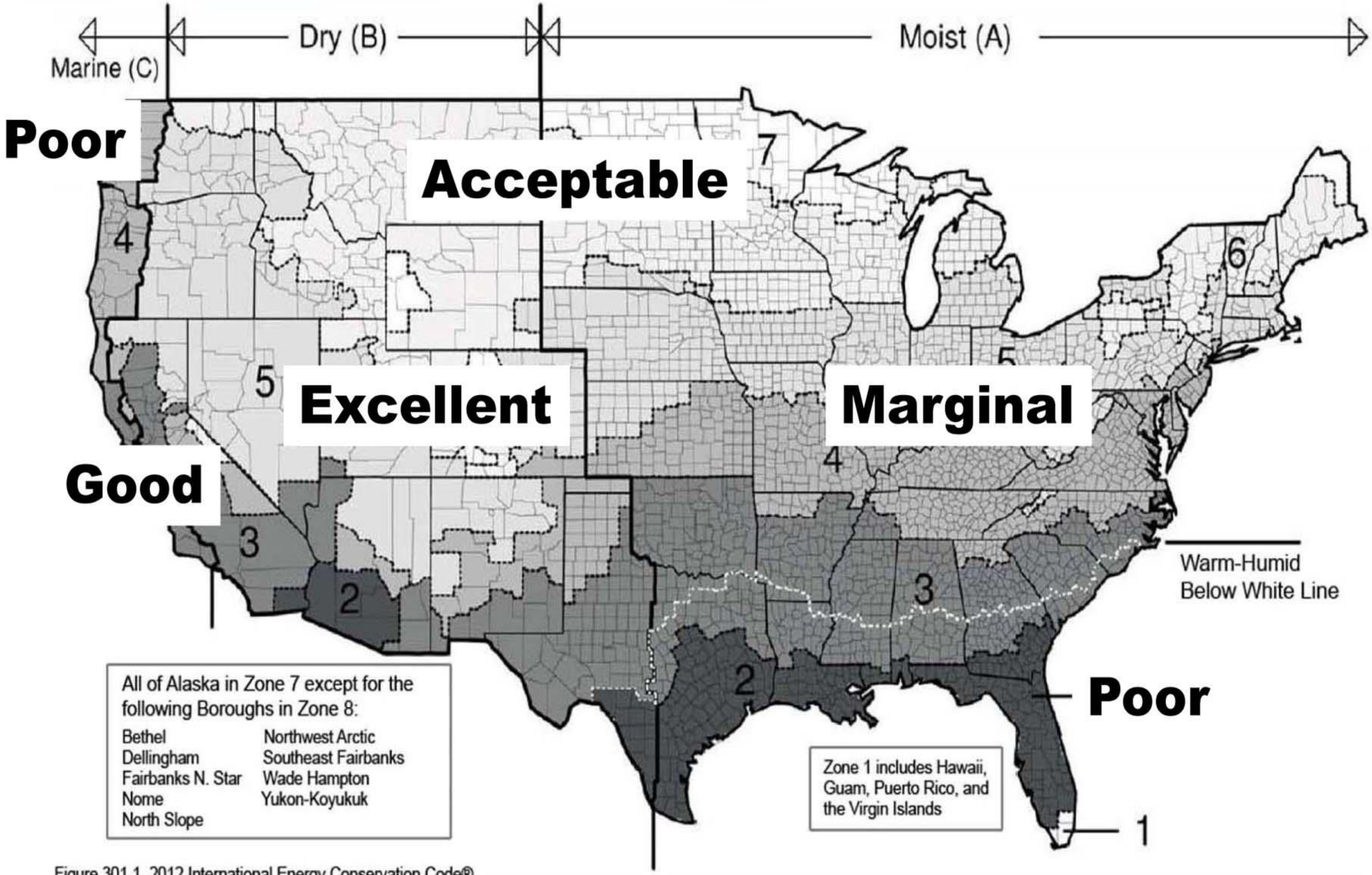
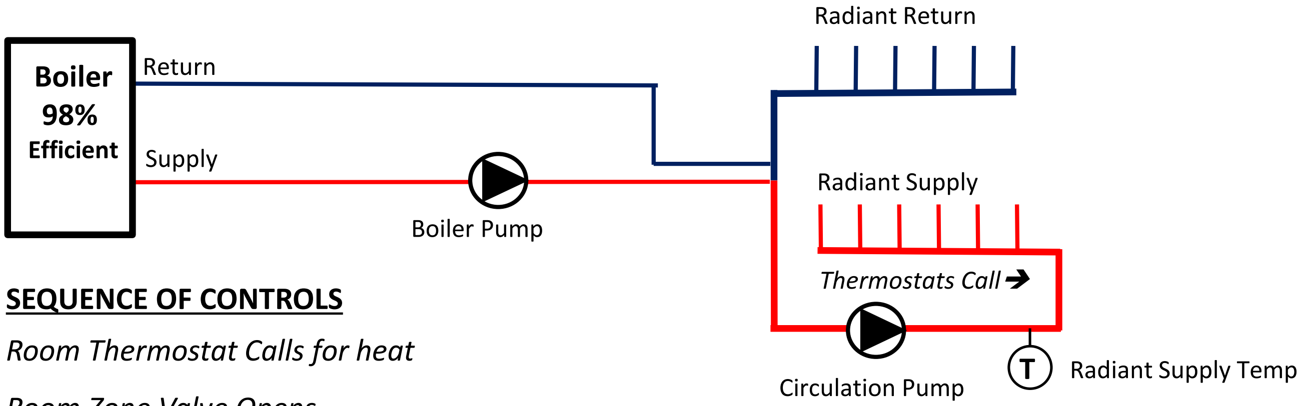


Figure 301.1, 2012 International Energy Conservation Code®

Boiler with Zoned Radiant Heating System



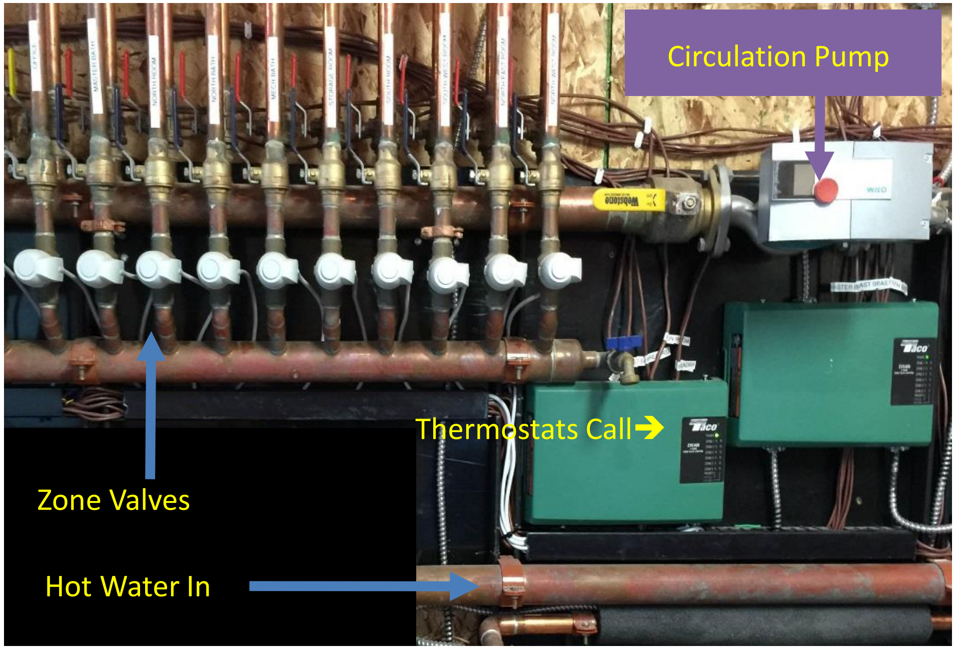
SEQUENCE OF CONTROLS

Room Thermostat Calls for heat

Room Zone Valve Opens

Boiler and Pump Turns On

Temperature Regulated by (T)

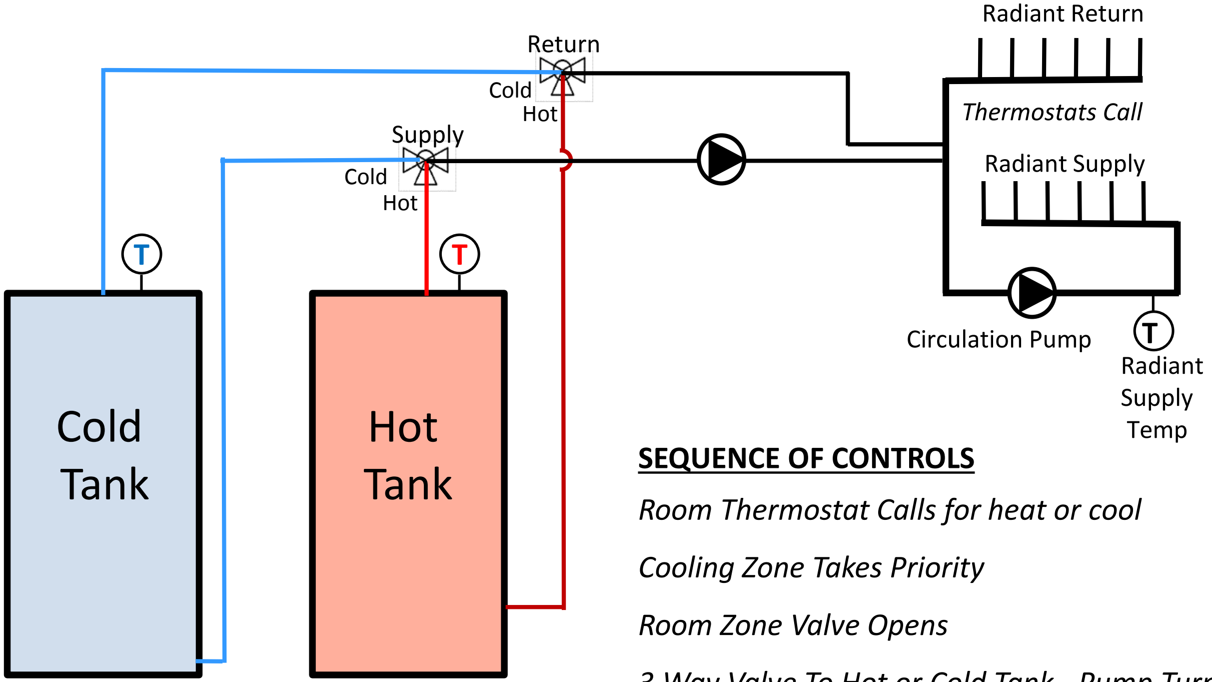


Coefficient of Performance (COP)

$$\frac{\textbf{Power Out (kWh)}}{\textbf{Power In (kWh)}} = .85$$

Best Boiler = 85% Energy Efficiency at high altitude (Aspen, Colorado)

Hot Tank and Cold Tank with Radiant Injection System with EEC RADIANT FLOOR COOLING ARCHITECTURE (RFC®)



SEQUENCE OF CONTROLS

Room Thermostat Calls for heat or cool

Cooling Zone Takes Priority

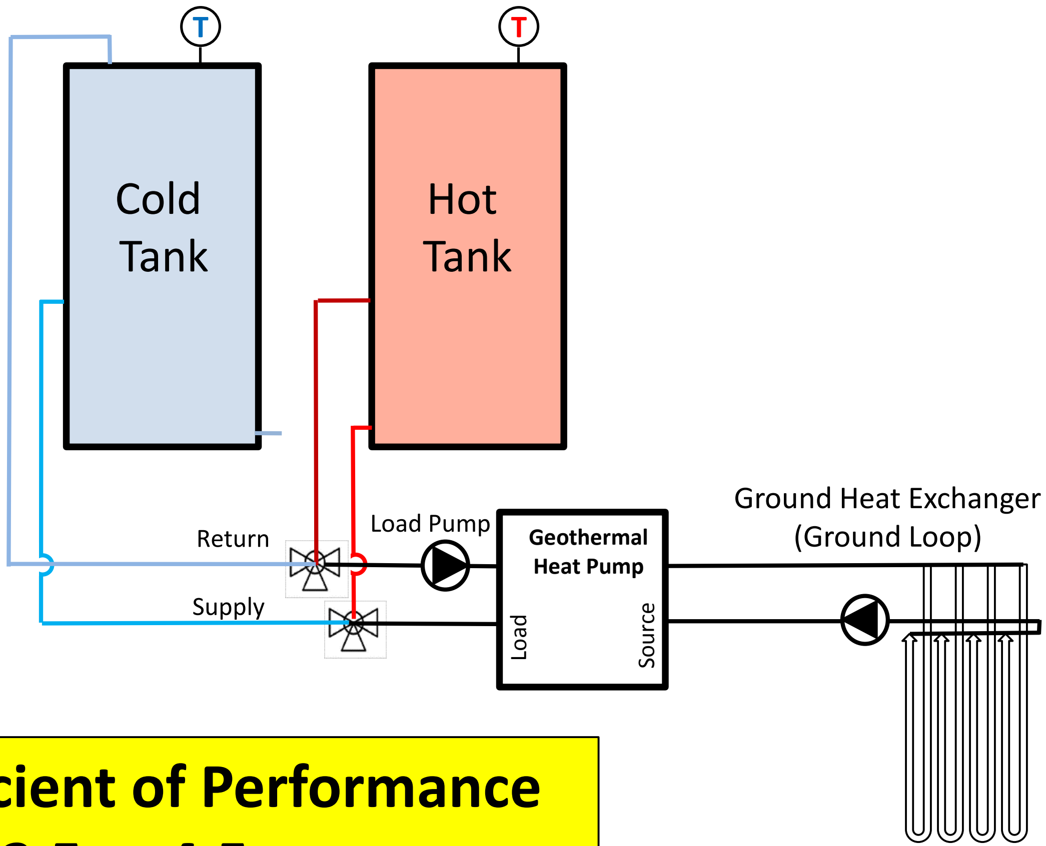
Room Zone Valve Opens

3 Way Valve To Hot or Cold Tank - Pump Turns On

Radiant Supply Temp T *Cooling uses Dew Point*

The Coefficient of Performance (COP) is undefined as heating and cooling source unknown

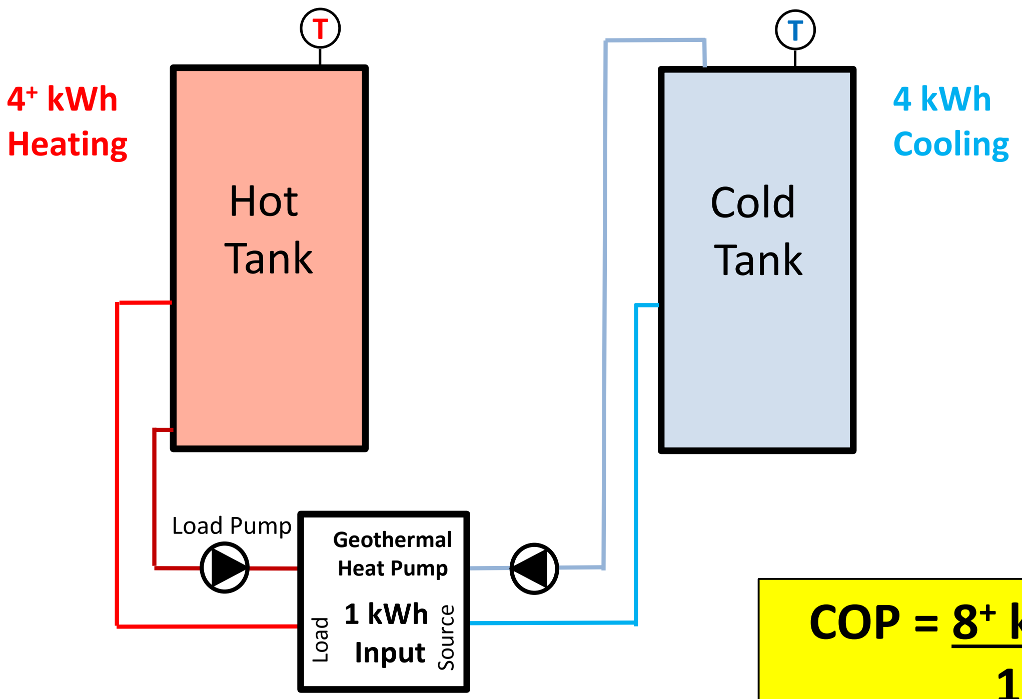
Ground Source Heat Pump with Hot and Cold Tanks with traditional Ground Heat Exchanger (Loop)



Coefficient of Performance

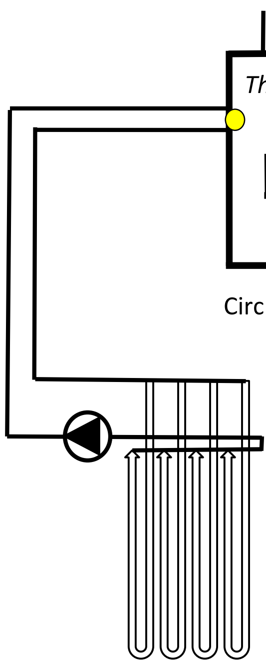
COP = 3.5 to 4.5

Ground Source Heat Pump with Hot and Cold Tanks With No Ground Heat Exchanger (Direct Transfer)



COP = $\frac{8^{+}\ \text{kWh Out}}{1\ \text{kWh In}}$ = 800%

Passive Radiant Floor Cooling (RFC®) with Radiant Injection



Power In = .4 kWh
2 x 200 watt VS Pumps = 400 watts/hour = **0.4 kWh**

Power Out (Cooling) = 21.3 kWh
BTU/hr = Flow Rate x Temp Diff x Constant (485)
15 GPM x 10 Deg Temp Diff x 485 = 72,750 BTU/hr

Conversion - 1 kWh = 3,412 BTU/hr

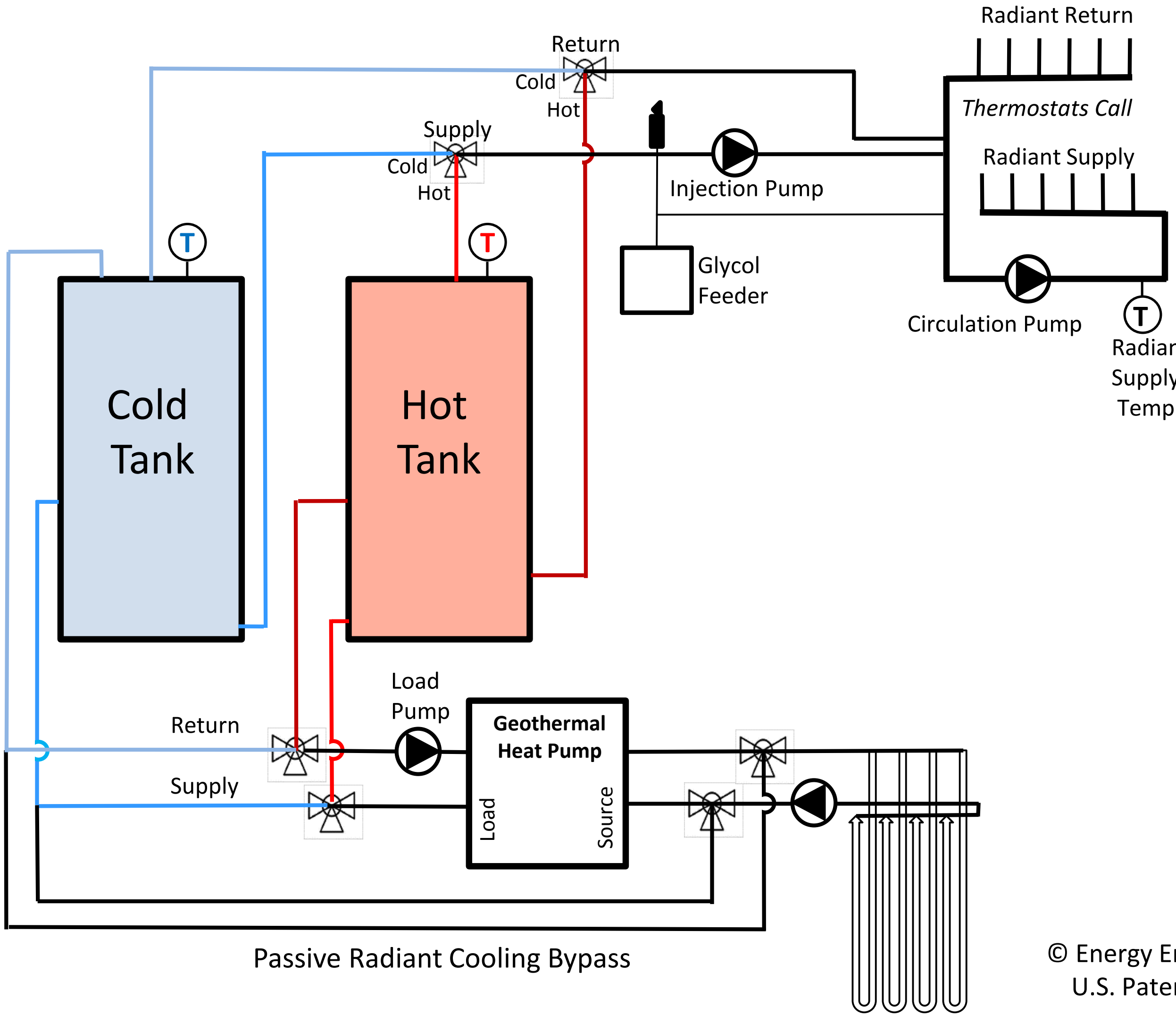
72,750 BTU/hr / 3,412 BTU/h/w = **21.3 kWh**

COP = Power Out/Power In

= 21.3 kWh / .4 kWh = 53

Passive RFC® ***"uses ground water as a thermal energy sink to cool a dwelling unit and exceeds Energy Star efficiency requirements"***

High Efficiency, High Comfort System Lacks Controls



Radiant Cooling used since 500 AD, Controls are the Challenge

Radiant Floor Cooling Systems

By **Bjarne Olesen, Ph.D.,** Member ASHRAE

In many countries, hydronic radiant floor systems are widely used for heating all types of buildings such as residential, churches, gymnasiums, hospitals, hangars, storage buildings, industrial buildings, and smaller offices. However, few systems are used for cooling.

People choose floor heating because it uses space wisely, temperature distribution is uniform and it is a low-temperature heating system. One advantage compared with air systems is that floor heating is a more efficient means of transporting energy. The demand for comfort, better building insulation, and greater internal loads from people and equipment have increased interest in installing a cooling system to keep indoor temperatures within the comfort range. This resulted in the introduction of floor systems for cooling.[1–3]

Because these systems operate at a water temperature close to room temperature, they increase the efficiency of heat pumps, ground heat exchangers and other systems using renewable energy sources.

More than half the thermal energy emitted from a floor heating system is in the form of radiant heat. The radiant heat exchange directly influences the heat exchange with occupants and surrounding surfaces such as walls and ceilings. In this way, a uniform thermal environment is established. Because of the high radiant heat output and the fact that occupants are close to the floor surface, it's an obvious choice to use the same floor system for cooling. However, the convective heat exchange coefficient for floor cooling is much lower than it is for floor heating. Several comfort factors such as acceptable floor temperature, vertical air temperature difference, radiant asymmetry and dew-point temperature may reduce the cooling capacity of a floor system. The floor construction (slab thickness,

About the Author

Bjarne Olesen, Ph.D., is director of the International Centre for Indoor Environment and Energy, and a professor at the Technical University of Denmark.

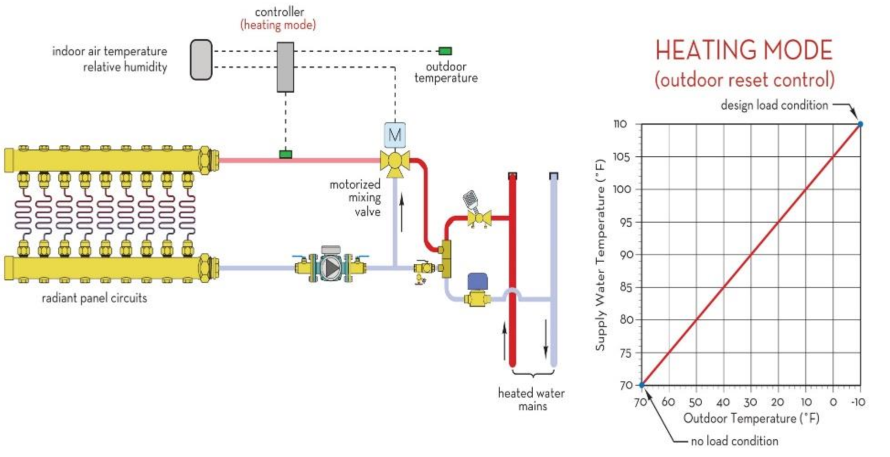
16 ASHRAE Journal ashrae.org September 2008

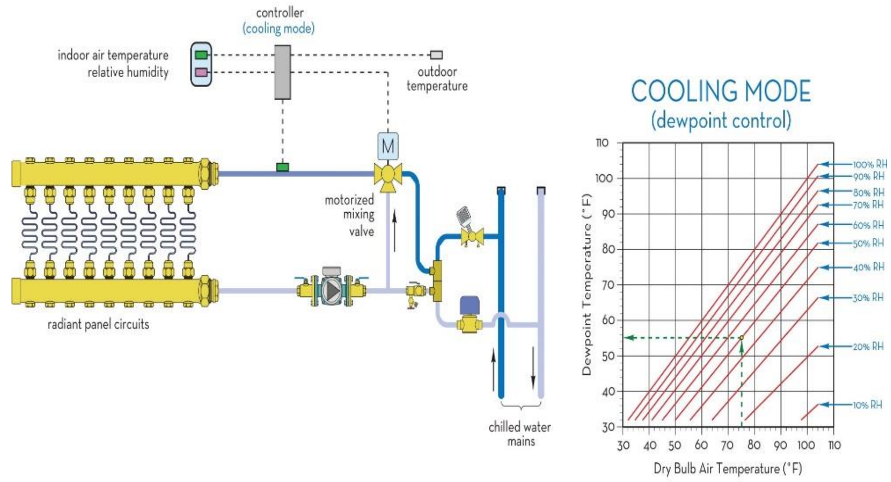
ASHRAE Journal
Sept 2008

November
2010

RFC® with GHP Requires Low Cost Dew Point Control

August 2015





Source: ACHRNEWS.com
March 2014 *John Siegenthaler, PE*

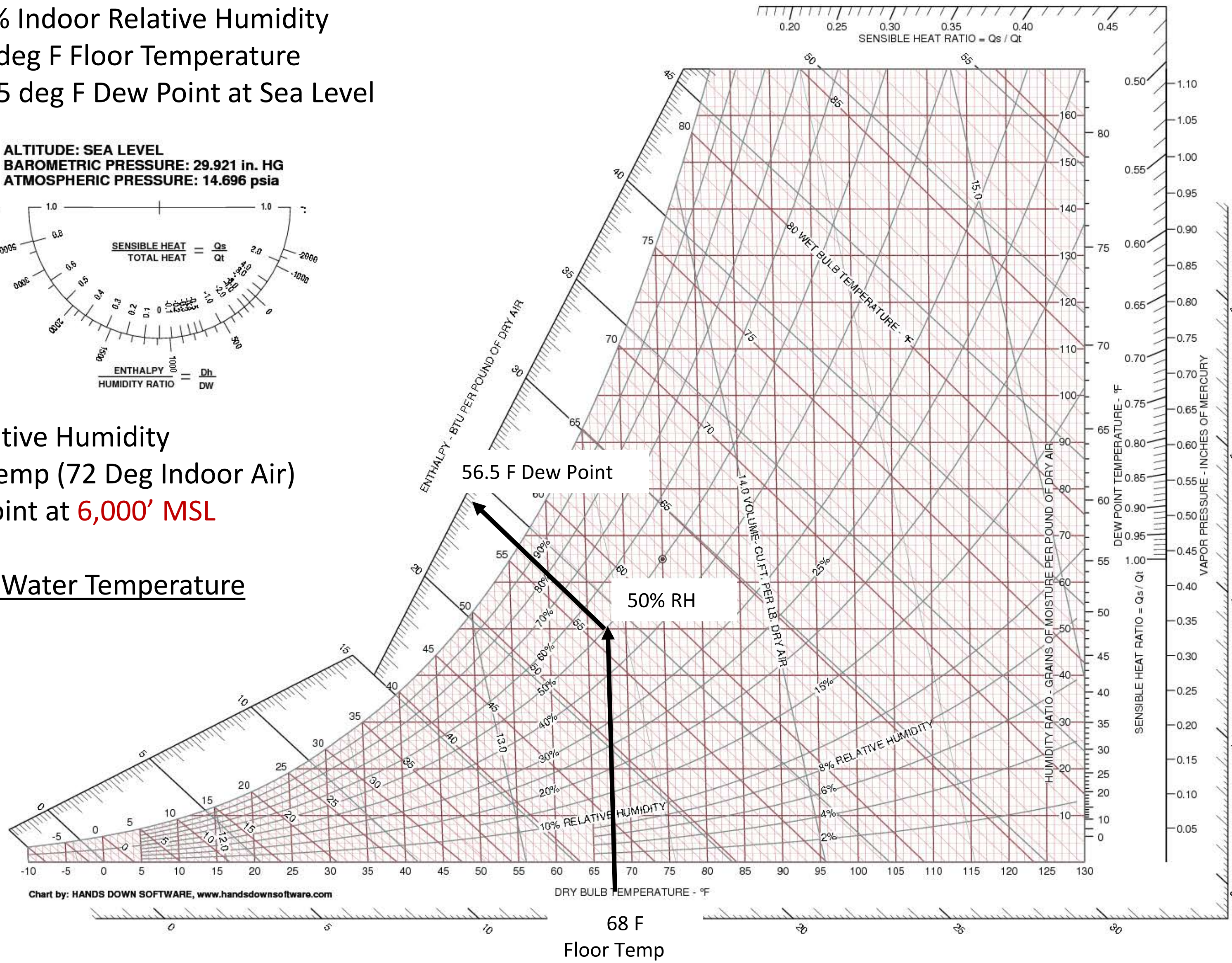
Psychrometric Chart Used to Calculate Dew Point

50% Indoor Relative Humidity
68 deg F Floor Temperature
56.5 deg F Dew Point at Sea Level

ALTITUDE: SEA LEVEL
BAROMETRIC PRESSURE: 29.921 in. HG
ATMOSPHERIC PRESSURE: 14.696 psia

50% Indoor Relative Humidity
68 deg F Floor Temp (72 Deg Indoor Air)
55 deg F Dew Point at 6,000' MSL

<u>58 deg F Supply Water Temperature</u>

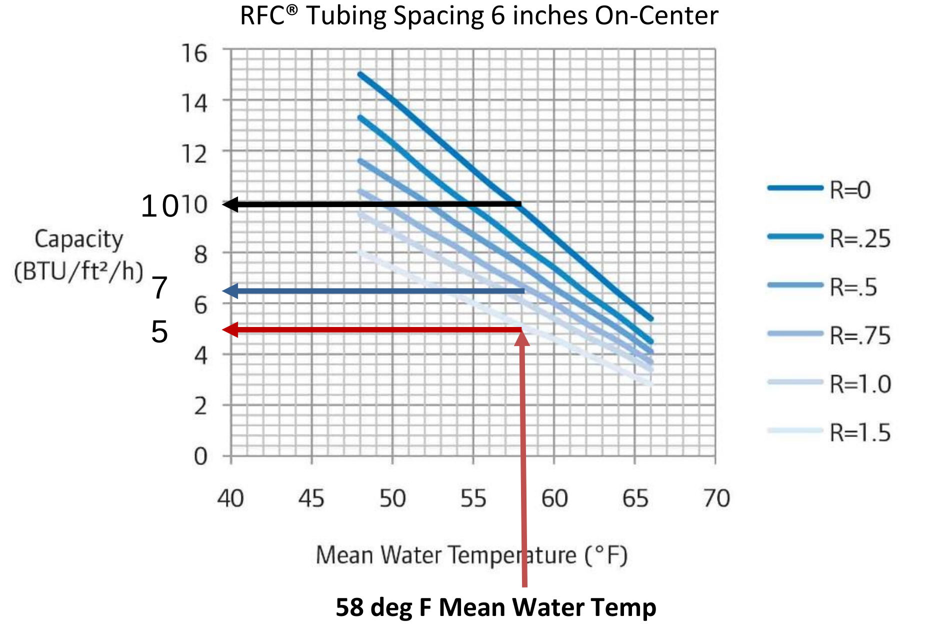


Radiant Floor Cooling – Residential Custom Home

Radiant Floor Cooling requires high mass floor, tubing at 6 inches on-center, and controls for 1) fan air flow, 2) RH, and 3) supply dew point.

Custom Home, Castle Rock, CO

Floor R-Value and Solar Exposure drive RFC® Efficiency

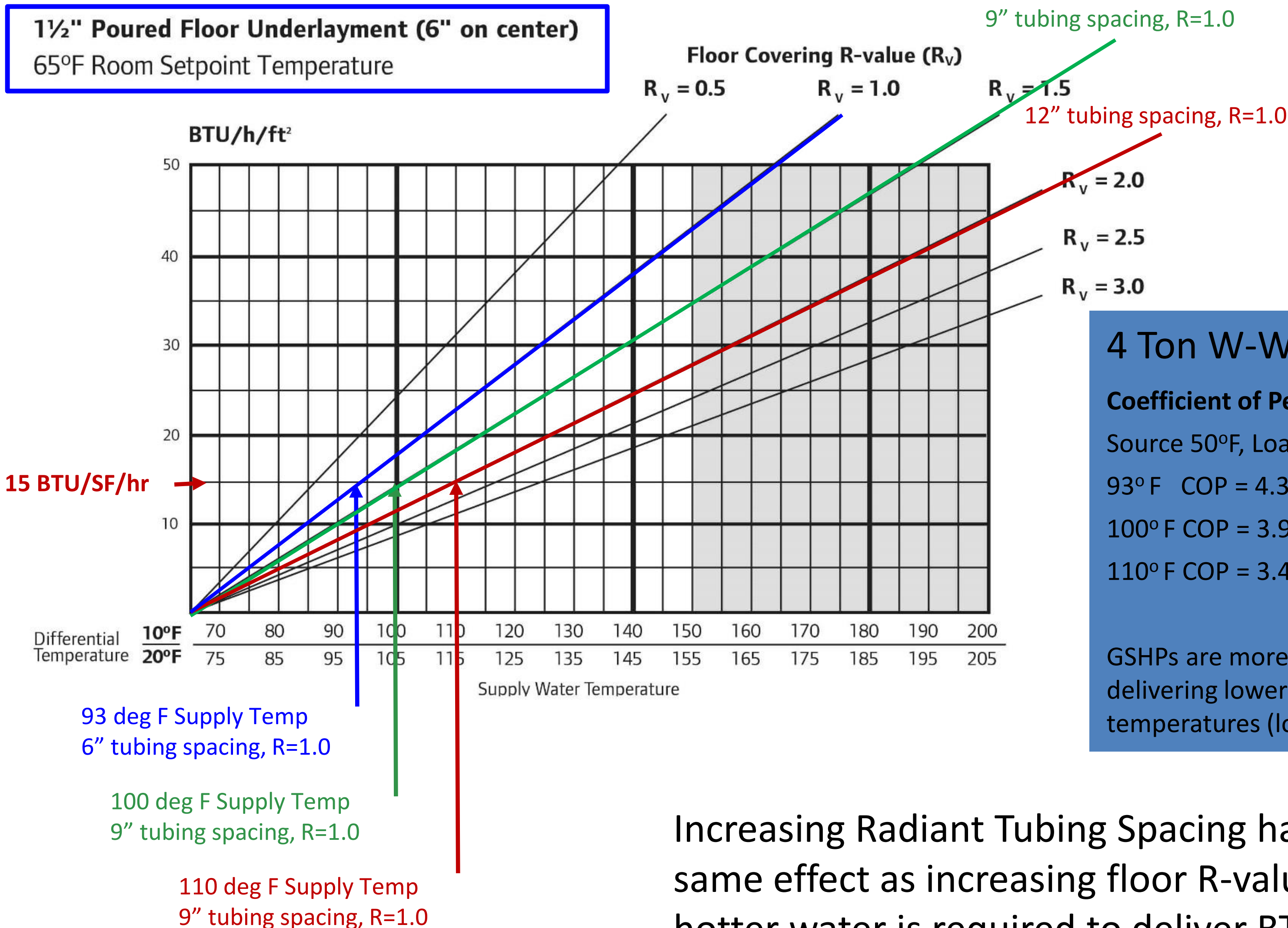


50% Indoor Relative Humidity
72 deg F Indoor Air Temp
55 deg F Dew Point

R= 0.0 Tile/Concrete, 10 BTU/SF/hr
R= 0.75 Hardwood Floors, 6.7 BTU/SF/hr
R= 1.5 Carpet & Pad, 5 BTU/SF/hr

Tubing Spacing 6 inches On-Center, Sea Level Conditions

RFC® PEX Spacing Increases GHP Efficiency up to 27%



4 Ton W-W GSHP

Coefficient of Performance

Source 50°F, Load Temp:

93° F COP = 4.35 +27%

100° F COP = 3.91 +11%

110° F COP = 3.49 Base

GSHPs are more efficient delivering lower supply water temperatures (load temp)

Increasing Radiant Tubing Spacing has same effect as increasing floor R-value: hotter water is required to deliver BTUs/SF

Radiant Floor Heating and Cooling Loads: 7,000 SF - Denver, CO

RADIANT FLOOR COOLING CAPACITY BY FLOOR COVER
5 BTU/h/SF Carpet @ R = 1.5
7 BTU/h/SF Hardwood @ R = .75
9 BTU/h/SF Tile @ R = 0
30 BTU/h/SF DIRECT SOLAR

			MANUAL J ZONE LOAD TOTAL		ZONE LOAD BY BTUS PER SQUARE FT		ZONE LOAD SQUARE FT AFTER RADIANT FLOOR COOLING	REQUIRED AIR COOLING TOTAL BTU BY AIR ZONE	Supply Size .08 Hd Duct 450 CFM/Ton RFC® vs. All Air
			Heat Total	COOL TOTAL	Heat Zone	COOL ZONE			
Zone #	Description	Net SF	BTU/hr	BTU/hr	BTU/SF	BTU/SF	BTU/SF	Total Cool	Duct Size (CFM)
1	Master Bedroom (Carpet)	714	15927	9685	22	14	9	6,115	8" x 8" (229)
2	Master Bath - Heat Only	238	4263	2414	18			12,099	10" x 10" (454)
3	North Study/Hall	240	6471	3657	* 27	15	8	6,887	8" x 8" (258)
4	South Study	174	3244	1945	19	11	4	15,246	10" x 12" (572)
5	Bedroom 2 (Carpet)	258	8438	4143	**33	16	11	*21% of 6 Ton GHP - All Air*	
6	Bedroom 3/East Hall	348	8925	3766	*26	11	4	*26% of 2 Ton with RFC*	
7	Baths 2 & 3 - Heat Only	134	2435	1735	18			47% Duct Size Reduction	
8	Main Hall, Powder, Closet	632	7529	2855	12	5	0	9,073	8" x 10" (340)
9	Kitchen	330	5437	2429	16	7	0	25,584	12" x 16" (964)
10	Dining Room	336	3891	4396	12	13	6	*36% of 6 Ton GHP - All Air*	
11	Den/Media	350	9546	5484	27	16	9	*35% of 2 Ton GHP with RFC®*	
12	Mud, Laundry, Powder (Tile)	364	10526	3450	* 29	9	0		
13	Great Room	442	11283	6970	* 26	16	9	60% Duct Size Reduction	
14	Rec Room	580	15617	7204	* 27	12	5	4,231	8" x 6" (159)
15	Exercise Room	288	2440	1971	8	7	0	13,561	10" x 12" (509)
16	Hall Lower Level	340	4360	270	13	1	0	*19% of 6 Ton GHP - All Air*	
17	Bedroom 4 (Carpet)	260	6432	2387	25	9	4	*16% of 2 Ton GHP with RFC®*	
18	Bedroom 5 (Carpet)	292	6023	1565	21	5	0	60% Duct Size Reduction	
19	Baths Lower Level - Heat Only	132	1479	164	11				
		6,452 SF	134,266 13 Tons	66,490 6 Tons			0 = RFC® Meets Cooling Load	26,306 BTU/hr – 2 Tons AIR COOLING WITH RFC®	

** Near Hardwood Peak Floor Temp*

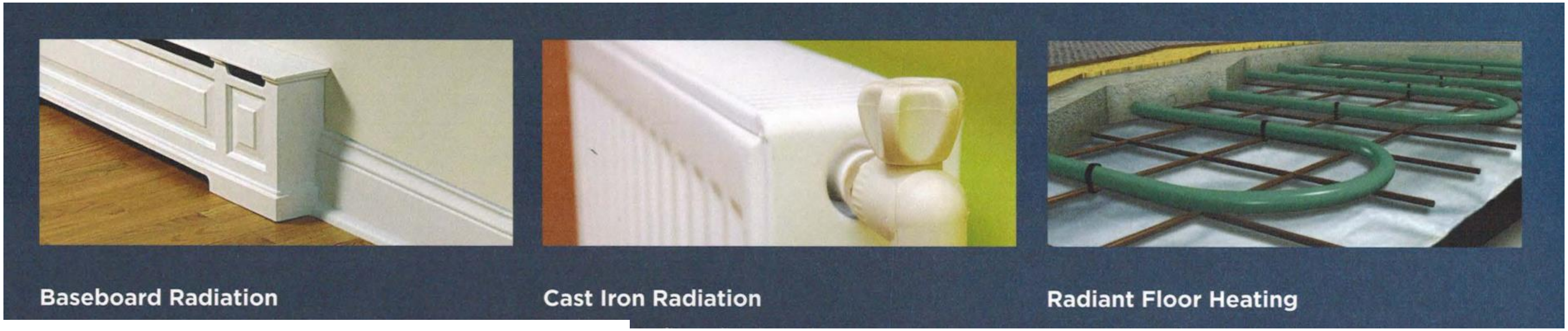
*** Over 125 F Max Supply Temperature*

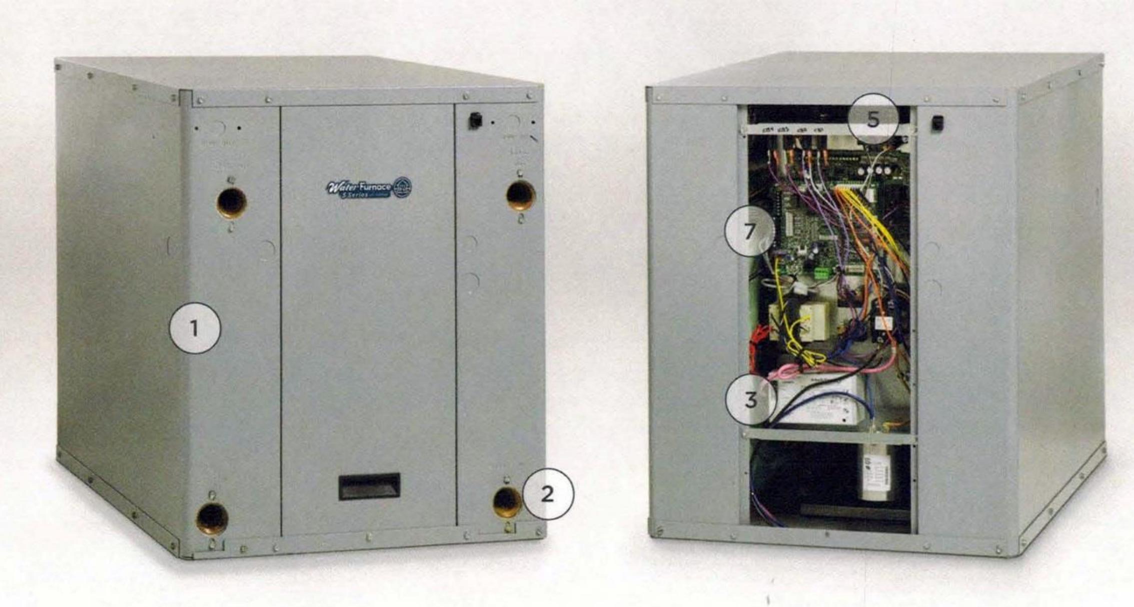
Variable Speed Compressor Heat Pump

Variable Speed Compressors can scale back to **<u>20% of rated capacity</u>**.
Two Stage Compressors can scale back to 66% of rated capacity.

Waterfurnace 7 Series Variable Speed Heat Pumps provide on-board sensors to report humidity, built-in relays for humidity, and <u>humidity set point control</u>.

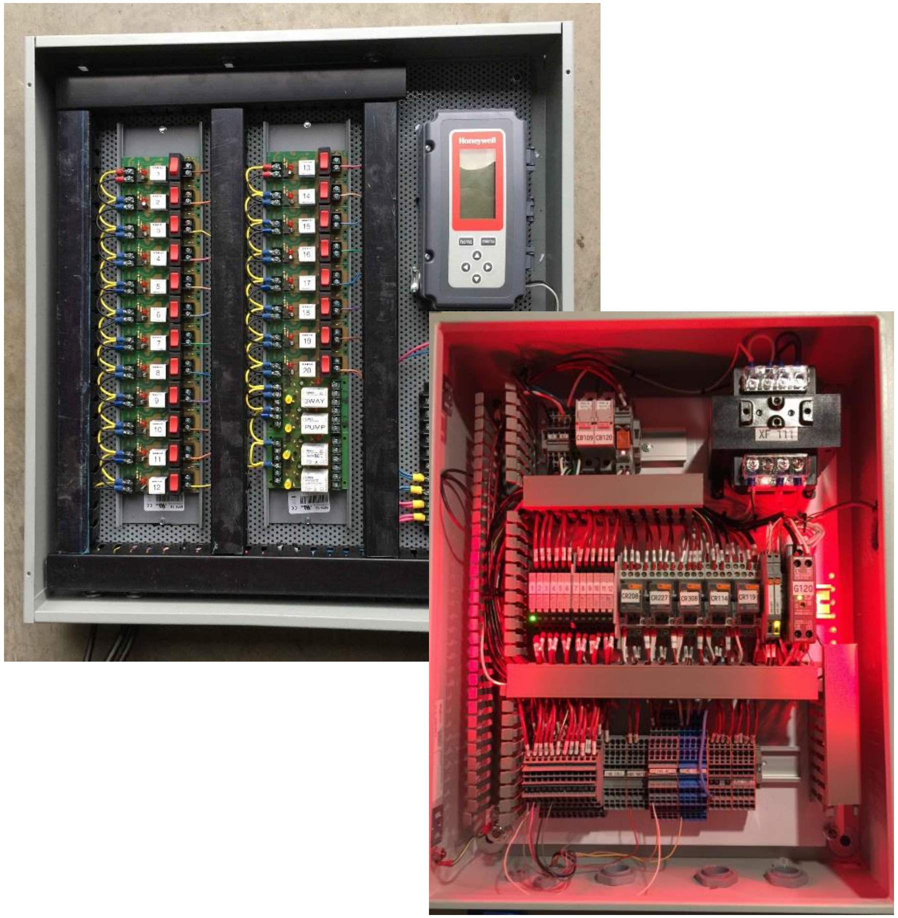
High Temp Vapor Injection Heat Pump





Waterfurnace Optiheat High Temperature Vapor Injection Heat Pumps deliver water temperatures up to 150 degrees for snow melt or baseboard applications.

Low Cost Residential Hydronic Control – Advanced GHEX



US 20140048244A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2014/0048244 A1**
Wallace (43) **Pub. Date: Feb. 20, 2014**

(54) **HYDRONIC BUILDING SYSTEMS CONTROL**

(71) Applicant: **Albert Reid Wallace**, Centennial, CO (US)

(72) Inventor: **Albert Reid Wallace**, Centennial, CO (US)

(21) Appl. No.: **13/969,316**

(22) Filed: **Aug. 16, 2013**

Related U.S. Application Data

(60) Provisional application No. 61/684,564, filed on Aug. 17, 2012.

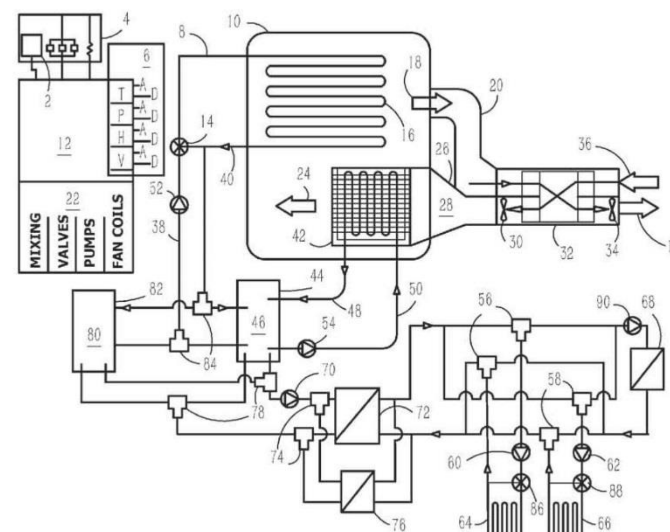
Publication Classification

(51) **Int. Cl.**
F28F 27/00 (2006.01)

(52) **U.S. Cl.**
CPC *F28F 27/00* (2013.01)
USPC **165/253**

(57) **ABSTRACT**

Controlling heating and cooling in a conditioned space utilizes a fluid circulating in a thermally conductive structure in fluid connection with a hydronic-to-air heat exchanger and a ground heat exchanger. Air is moved past the hydronic-to-air heat exchanger, the air having fresh air supply and stale air exhaust. Sensors located throughout the conditioned space send data to a controller. User input to the controller sets the desired set point temperature and humidity. Based upon the set point temperature and humidity and sensor data, the controller sends signals to various devices to manipulate the flow of the fluid and the air in order to achieve the desired set point temperature and humidity in the conditioned space. The temperature of the fluid is kept less than the dew point at the hydronic-to-air heat exchanger and the temperature of the fluid is kept greater than the dew point at the thermally conductive structure.



Last Slide

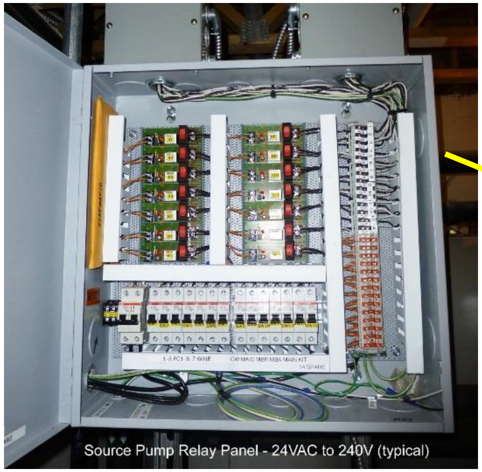
Integrated Control use simple wiring and mechanical controls. Our goal - *"Plumber with #12 screwdriver"* can install

Alternative Designs for GHEX for Superior Energy Efficiency

- **Solar Paver Heat Recovery with Virtual Horizontal Ground Loop**
  - Snow melt patio with PEX tubing at surface
  - Reverse flow for GHEX operation in Spring, Summer, Fall
    - "Virtual Horizontal Ground Loop"
  - Controls select optimum GHEX source water temperature (EWT)
- **Direct Use (DU) and Deep Direct Use (DDU) of Ground Fluids**
  - Department of Energy FOA issued in December 2016
  - Similar to EEC's Passive RFC® Architecture for heating and cooling
- **Recycled Materials for Improving Efficiency of Horizontal GHEX**
  - Research Project for Colorado Dept Public Health and Environment
  - Details to be provided at IGSHPA National Conference in Denver

Patent – www.energyhomes.org

Commercial Hydronic Systems & GHPs



Fairways Villas Clubhouse, Oakwood Homes, Green Valley Ranch

GHP Forced Air
GHP Hydronics
Pool/Spa Heating
GHP Natatorium
Snow Melt
No DDC Controls

6 Residential GHPs from WaterFurnace at 38 tons capacity

QUESTIONS?

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