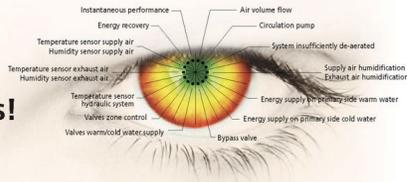


Keep an eye on your energy savings!

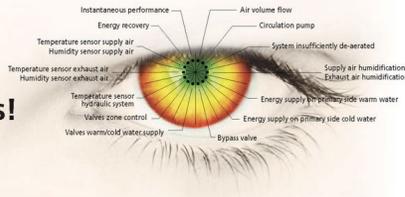


Energy Recovery & Integrated Heat Pumps: A path to Electrification and Proof of Concept after the first year of operation of a large Lab Building in Boston, MA

Tom McGee
Konvekta USA, Inc.



Keep an eye
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energy savings!

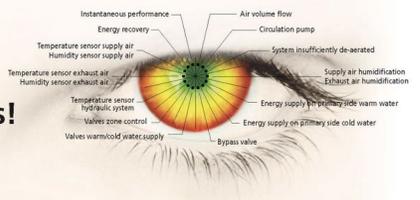


Learning Objectives

- Learn about the **actual operating performance** of an energy recovery system with an **integrated heat pump**
- Understand the **requirements** of a high performing Energy Recovery System to allow for a successful heat pump integration
- Analyze **options and scope** for integrated reversible heat pumps
- **Lessons learned** during the first year of operation



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Energy Recovery Coil Design

3-3-3+9 Cu

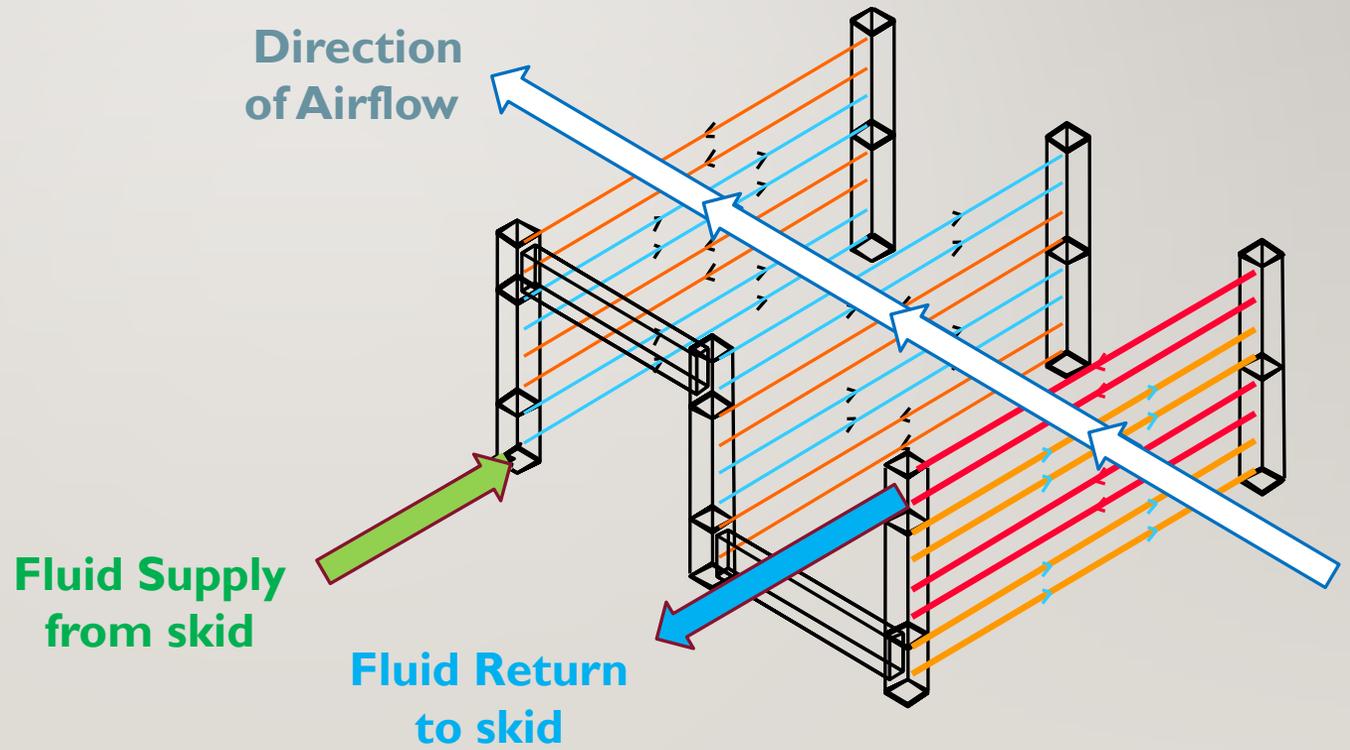
Supply

- Snow Melt
- Pre-heat/pre-cool
- Re-heat

Exhaust (frost-defrost design)

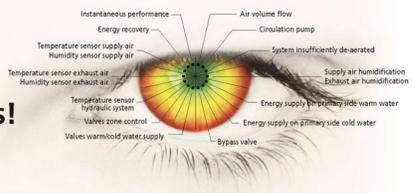
- **Direction of airflow is opposite to the direction of fluid flow**
- **Each coil row is multiple passes**
- **Design results in increased time to exchange energy**

Fin Tube Heat Exchanger with Headers at both Ends



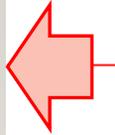
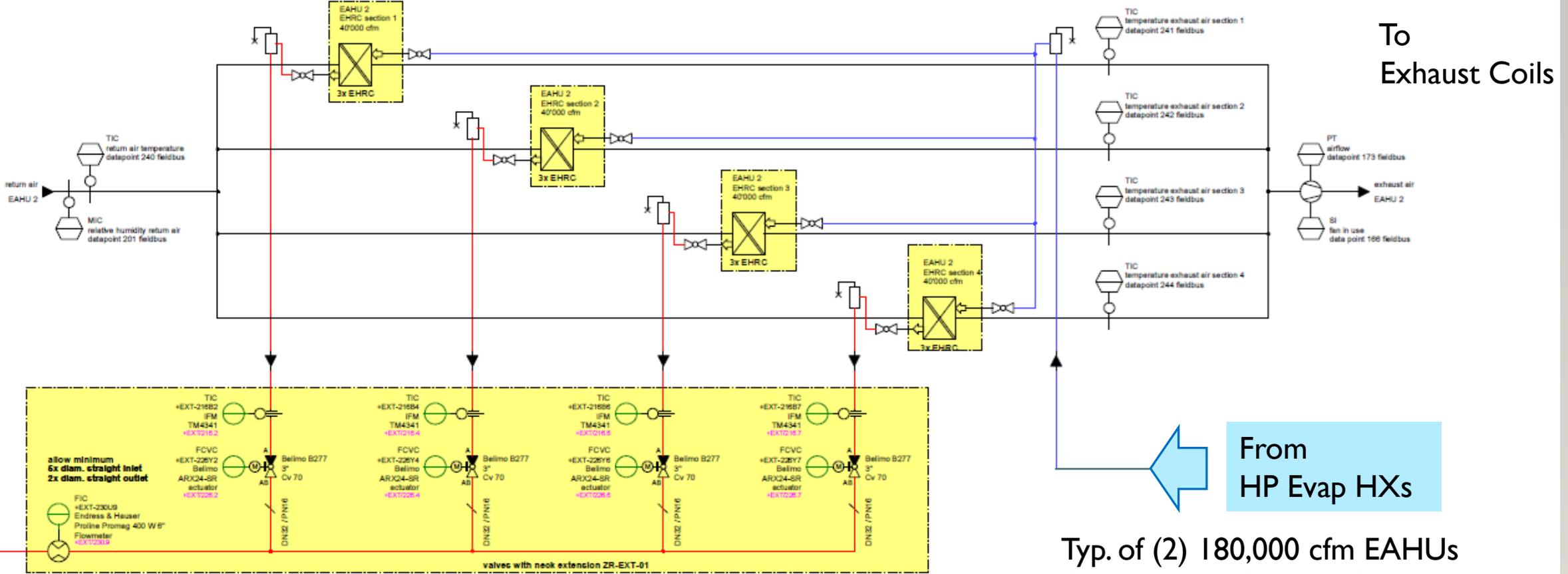
Enthalpy Transfer Efficiency: 65% +

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Exhaust Unit Piping & Instrumentation

Frost/Defrost OPTION Design



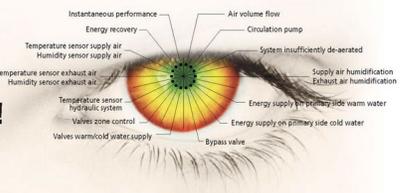
To HP Condenser HXs

From HP Evap HXs

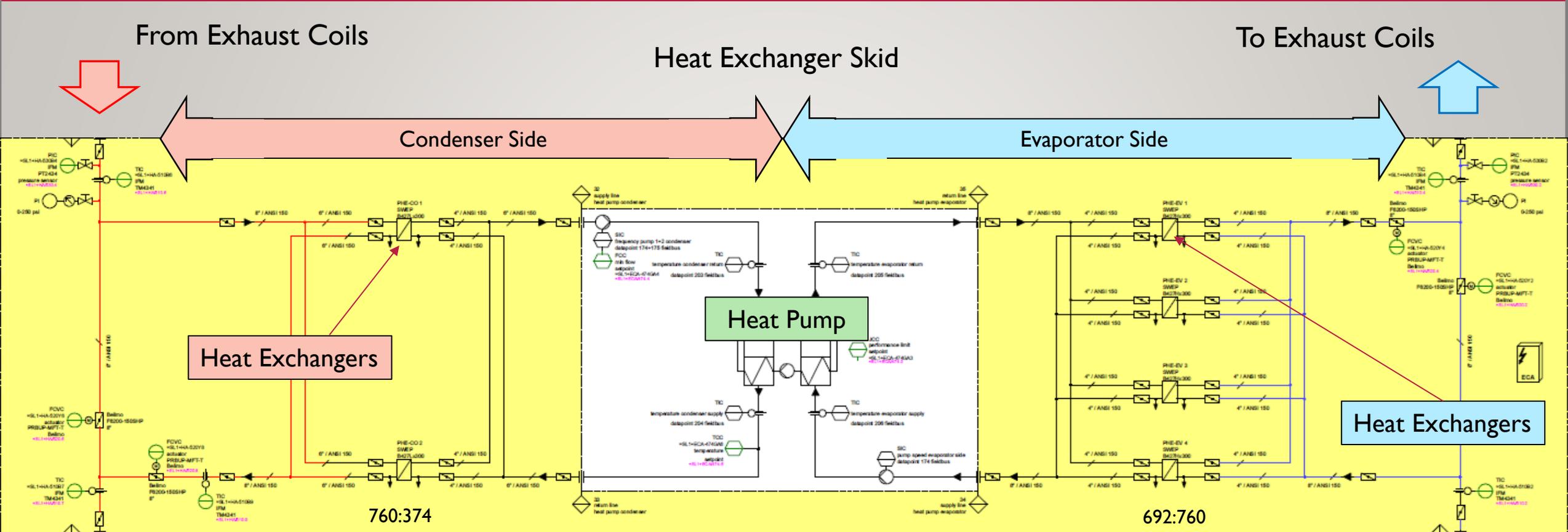
Typ. of (2) 180,000 cfm EAHUs
4 zones per EAHU or **8 zones total**

How is this design different from a typical high efficiency ERS?

Keep an eye on your energy savings!

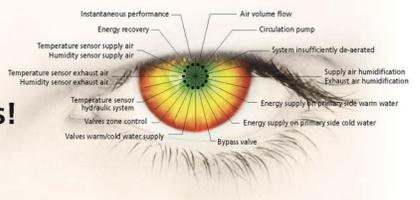


Integrated Heat Pump Piping & Instrumentation



Interface between heat pump & energy recovery system

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Exhaust Coil – Frost Considerations

Exhaust Coil – Design Considerations:

Accumulation of frost will occur at conditions near winter design.

- Coil fins must be designed and manufactured to withstand frost/defrost cycles

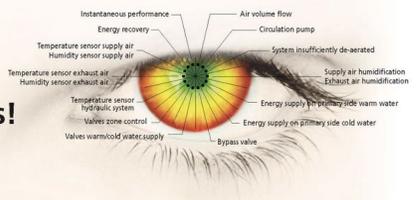
Important factors:

 - Spacing
 - Thickness

- Controls design and sequence of operation, must account for a defrost cycle
 - Valves
 - Control logic



Keep an eye on your energy savings!



Energy Recovery Design Basis

Boston, MA

100% Outside Air Req.
24/7 Operation

- 320,000 cfm Total Supply
- OA Conditions:
 - Winter: 0F
 - Summer: 91F/61.4WB
 - Winter DAT Setpoint = 60F
 - RA Conditions:
 - Winter: 70F/30%RH [37F DP]
 - Media: 30% Ethylene Glycol

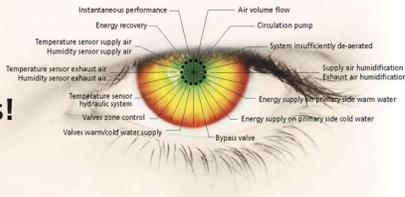
Humidified Buildings help to maximize the benefit of the exhaust coil frost-defrost option with integrated heat pump!!!

GOAL:
Integrated Heat Pump Design Proof of Concept



ERS Design Options

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on your
energy savings!



Boston, MA

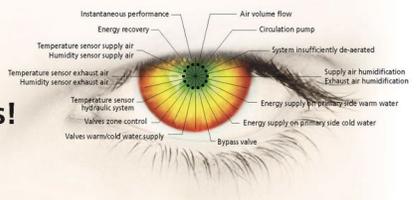
- Frost/defrost of Exh. coils
 - + Increased latent exh. air recovery
- WRAP design – includes supply air reheat coil
 - Use recovered energy for reheat req.
 - Enhanced pre-cooling results
 - Reduce loading of cooling coil
- Integrated Heat Pump
 - Further maximize latent recovery potential
 - Displace or reduce the need for natural gas with electricity

GOAL:

Integrated Heat Pump Design Proof of Concept



Keep an eye on your energy savings!



Frost Defrost Mode
No Heat Pump

Winter Design Performance

Winter Design: OAT = 20F

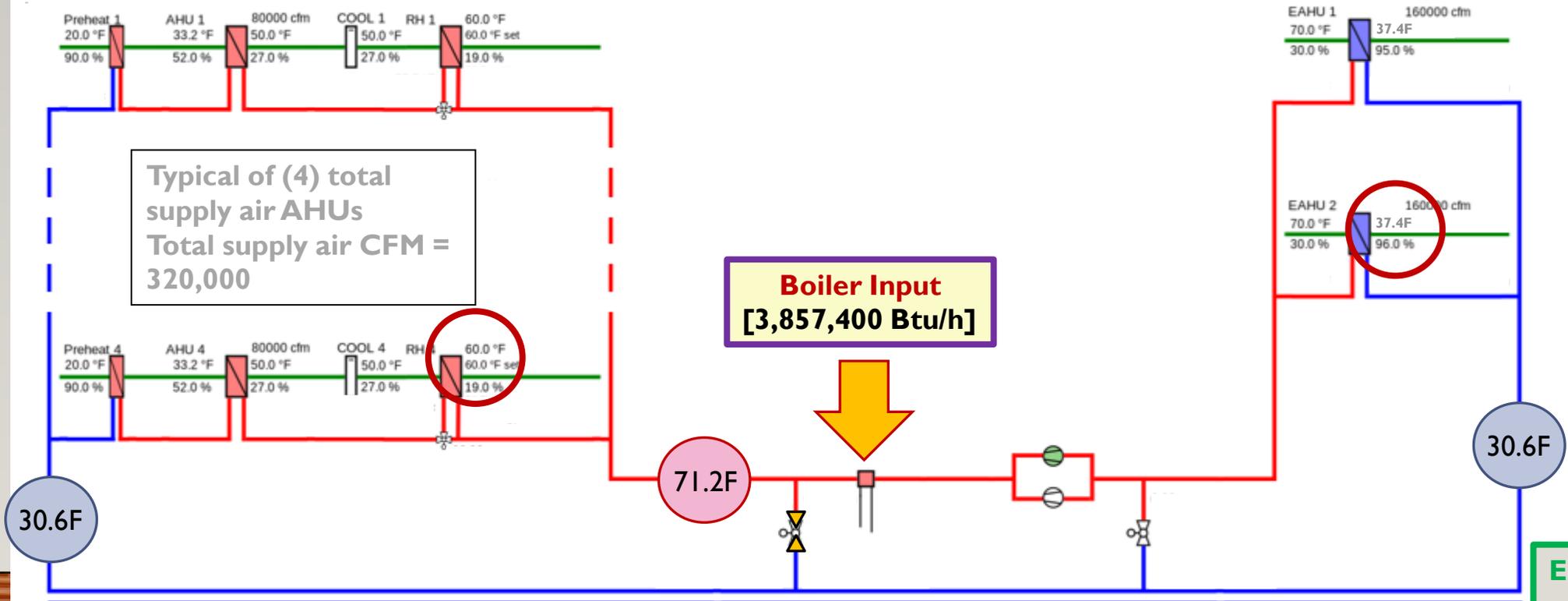
3-3-3+9 Cu

performance	requirement	ERS	external	reduction of peak performance for heating:
	(Btu/h)	(Btu/h // kW)		
heating	14314766	10457366	3857400	73%
cooling	0	0	0	

Btu/h Requirement
[14,314,766 Btu/h]

ERS COP
15.2

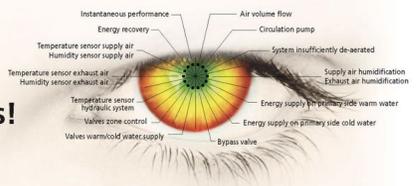
ERS Exh. Coil
[10,457,366 Btu/h]



Climate: Boston, MA

ERS + Boiler COP
3.15

Keep an eye on your energy savings!



Frost Defrost Mode with Heat Pump

Winter Design Performance

Winter Design: OAT = 20F

3-3-3+9 Cu

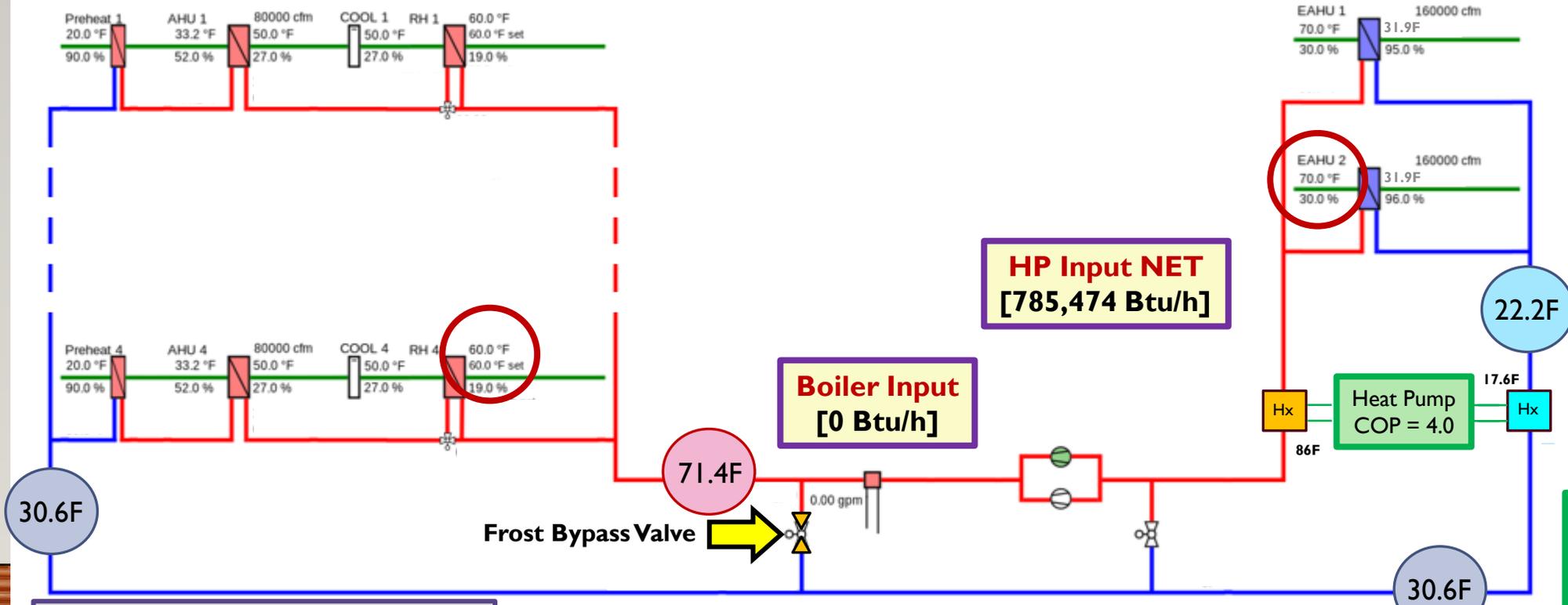
performance	requirement	ERS	HP	reduction of peak performance for heating:
	(Btu/h)	(Btu/h // kW)		
heating	14314766	13529292	785474	94.5%
cooling	0	0	0	

Btu/h Requirement
[14,314,766 Btu/h]

ERS COP
19.7

ERS Exh. Coil
[13,529,292 Btu/h]

+ 29.0% vs. Frost-defrost w/o HP



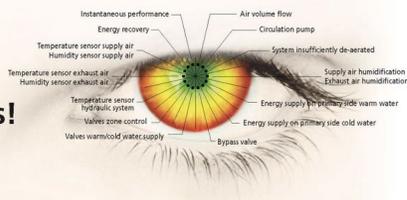
HP Input NET
[785,474 Btu/h]

Boiler Input
[0 Btu/h]

ERS + HP COP
7.6

Climate: Boston, MA

Keep an eye on your energy savings!



Annual Heating Hours

NEXT: Winter Design: OAT = 0F

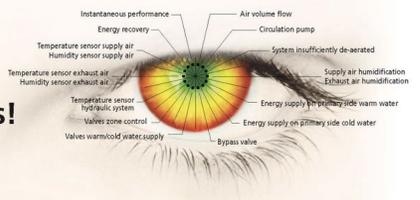
96.5% {

Outside Air Temp	Boston, MA	Atlanta, GA	Denver, CO	
< 17 F	192	0	335	ERS + HP + Ext
17 F ... 38 F	2,136	909	2,300	ERS + HP
38 F ... 60 F	3,239	2,880	3,060	ERS Coils Only
Total Operating Hours Heating	5,567	3,789	5,695	

= 3.5% of total annual heating hours



Keep an eye on your energy savings!



Frost Defrost Mode
No Heat Pump

Winter Design Performance

Winter Design: OAT = 0F

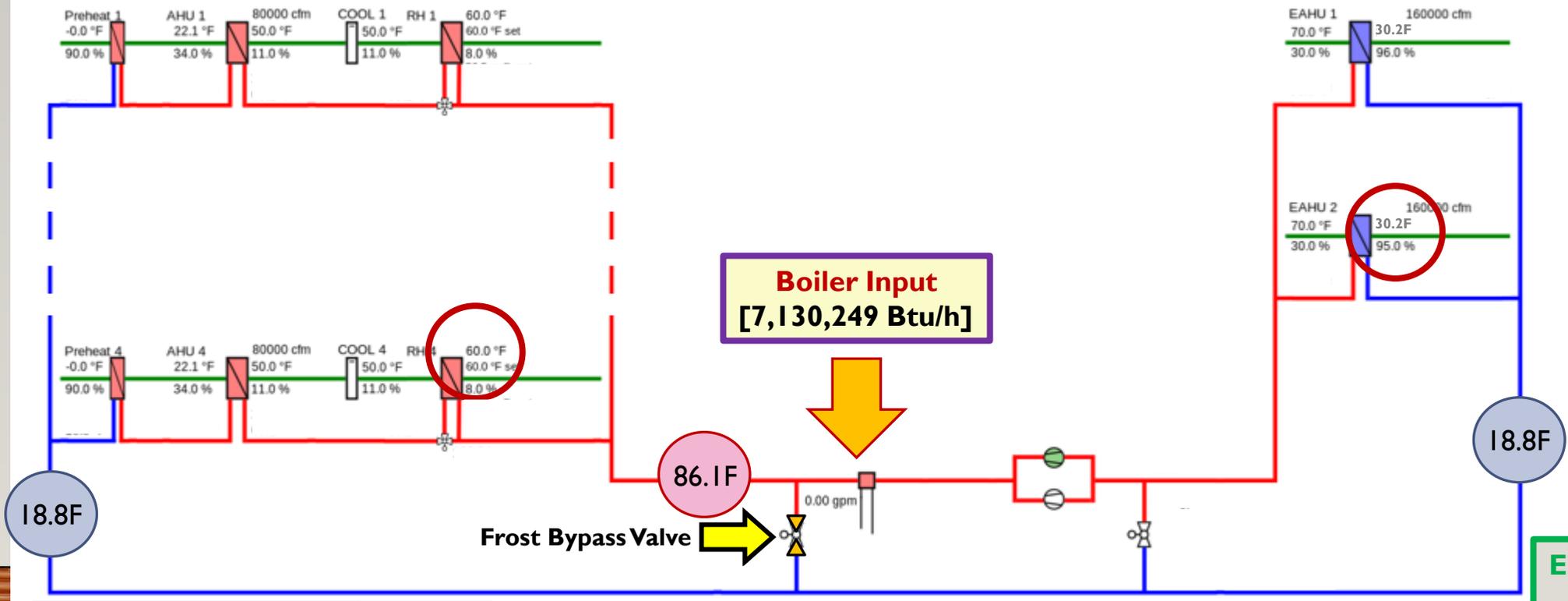
3-3-3+9 Cu

performance	requirement	ERS	external	reduction of peak performance for heating:
	(Btu/h)	(Btu/h // kW)		
heating	21422450	14291494	7130249	66%
cooling	0	0	0	

Btu/h Requirement
[21,422,450 Btu/h]

ERS COP
20.8

ERS Exh. Coil
[14,291,494 Btu/h]



Boiler Input
[7,130,249 Btu/h]

86.1F

Frost Bypass Valve

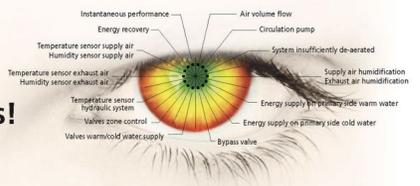
0.00 gpm

18.8F

ERS + Boiler COP
2.7

Climate: Boston, MA

Keep an eye on your energy savings!



Frost Defrost Mode with Heat Pump

Winter Design Performance

Winter Design: OAT = 0F

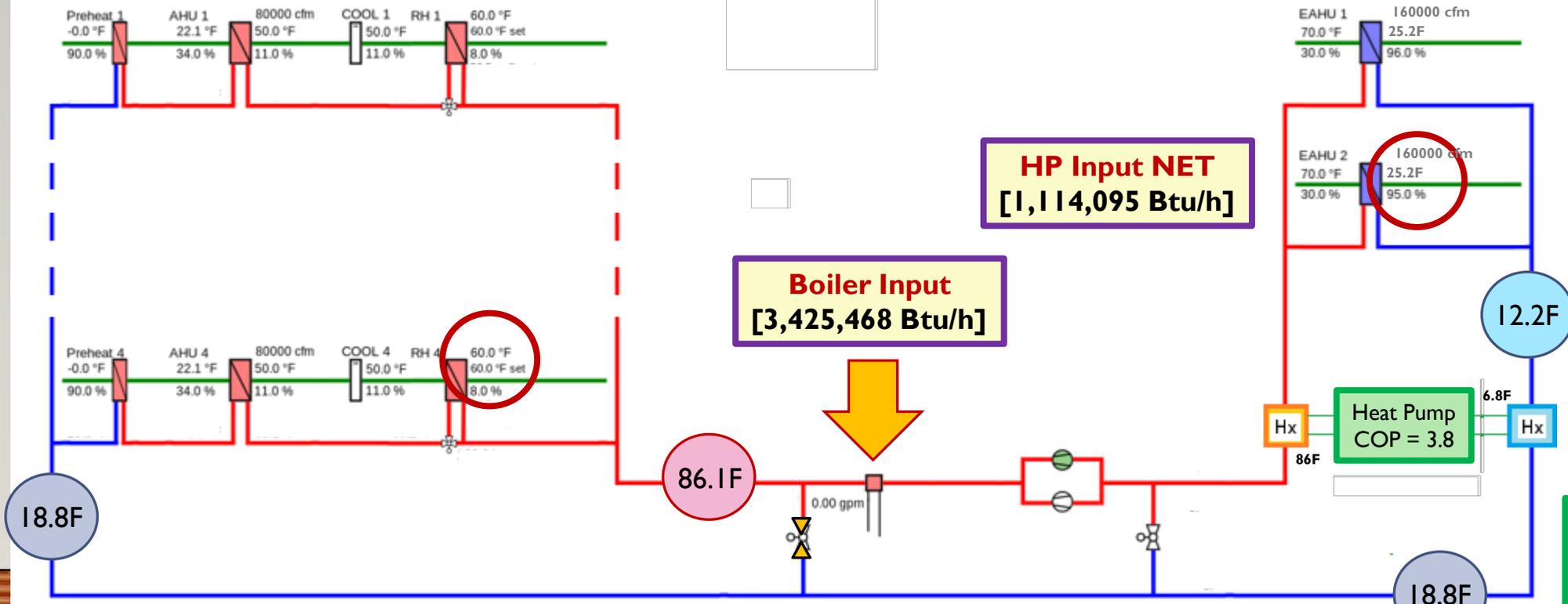
3-3-3+9 Cu

performance	requirement	ERS	HP + Boiler	reduction of peak performance for heating:
	(Btu/h)	(Btu/h // kW)		
heating	21422450	16882887	4539563	78.8%
cooling	0	0	0	

Btu/h Requirement
[21,422,450 Btu/h]

ERS COP
24.6

ERS Exh. Coil
[16,882,887 Btu/h] + 18.1%



HP Input NET
[1,114,095 Btu/h]

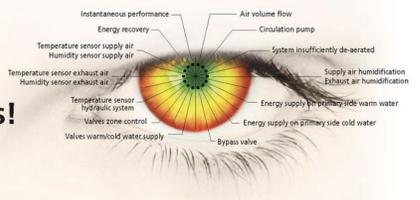
Boiler Input
[3,425,468 Btu/h]

ERS + HP + Boiler COP
4.3

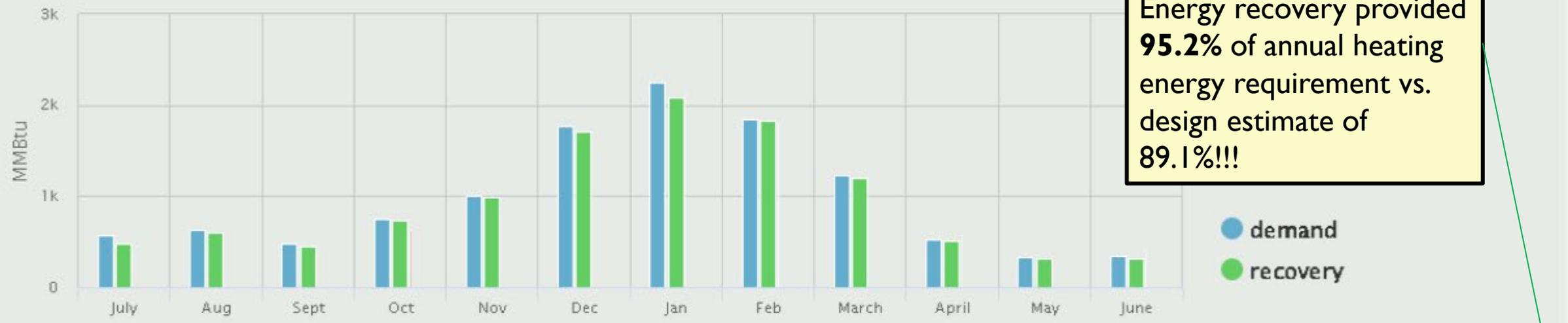
Climate: Boston, MA

Energy Results

Keep an eye on your energy savings!



heating energy (07/2024 – 06/2025)



Energy recovery provided **95.2%** of annual heating energy requirement vs. design estimate of **89.1%!!!**



heating energy (07/2024 – 06/2025) // (MMBtu)

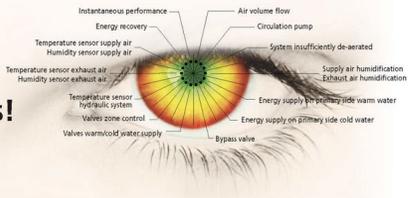
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	total
demand	564.88	628.54	473.1	751.84	1'006.87	1'771.53	2'257.45	1'852.02	1'231.23	523.56	323.11	338.96	11'723.12
recovery	479.3	603.12	450.58	728.24	994.92	1'708.5	2'077.67	1'824.61	1'201.81	512.42	314.26	320.07	11'215.48

GOAL:
Integrated Heat Pump Design Proof of Concept



Summary of Benefits

Keep an eye on your energy savings!



Heat Pump

- Shift gas heat generation to Electric
- Fuel Switching ability based on electric vs. gas rates
- Improve heating plant redundancy

Common

- Maximize exhaust air latent recovery
- Significantly reduce or eliminate Natural Gas consumption
- Reduce overall peak heating demand

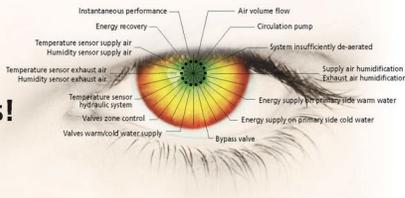
Energy Recovery

- Eliminate separate heating coil & associate piping
- Pre-fabricated pumping & HX skids
- Reduced BMS scope
- 21% reduction in annual cooling energy requirements
- Cooling Tower capacity reduction
- Reduced Cooling Tower water consumption
- Downsize Refrigerant Exhaust



Lessons Learned

Keep an eye
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energy savings!



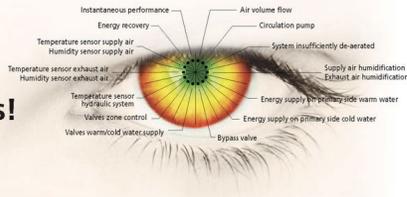
- Design & Implementation Considerations
 - + Coil design & fin spacing is critical
 - + **Return air humidity** levels directly correlate to potential benefit (latent recovery)
 - + Layout and design of exhaust units (6 to 8 zones typ.)
 - + Defrost zone bypass can result in **fogging** (mist eliminators)
 - + **Heat trace** exhaust coil condensate pans and drain piping is a requirement
 - + **Ongoing monitoring** & remote connectivity is essential

GOAL:

Integrated Heat Pump Design Proof of Concept



Keep an eye
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energy savings!

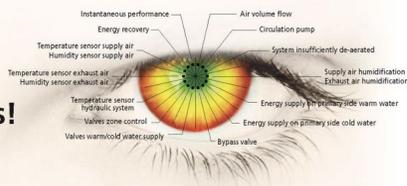


Conclusions:

Consideration of an Energy Recovery System with Integrated Heat Pump Design can provide REAL results on the path to a **NET ZERO** future, while delivering exceptional energy efficiency and utility cost savings.

“Preliminary design assessments are available at the price of a short amount of time”

Keep an eye on your energy savings!



Questions:
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