Operating Engineers Seminar 2017

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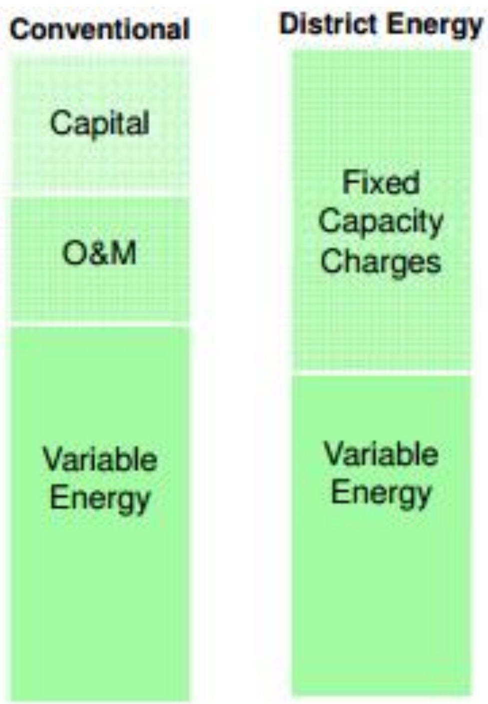
DISTRICT ENERGY ST. PAUL™

Overview

- Annual energy consumption to demand
- Heat recovery updated requirements
- Process cooling best practices

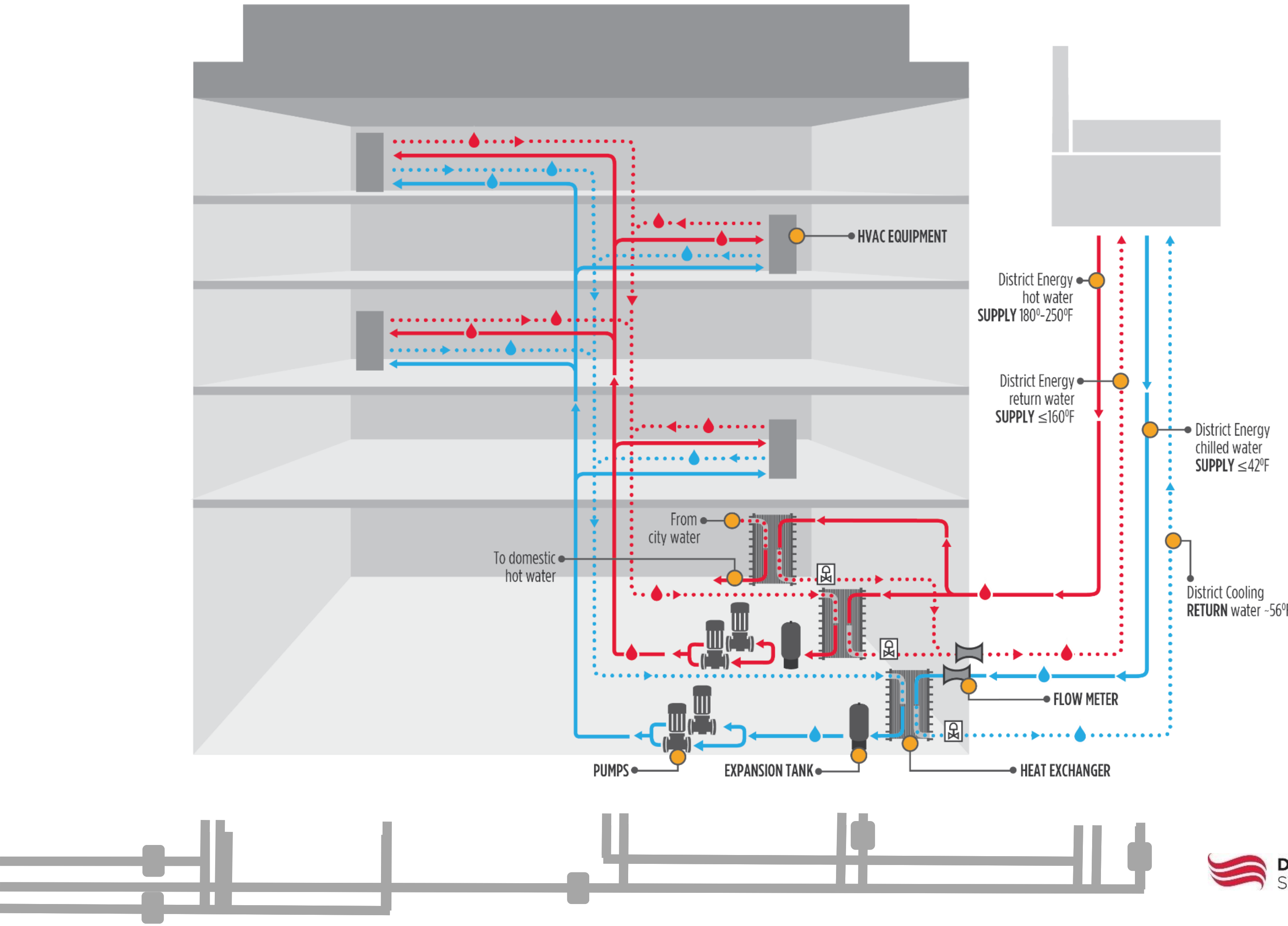
How does District Energy compare?



District Energy benefits

- Rate stability
- Reliability
- Requires less mechanical space
- Environmental performance
- Simplicity of operations
- Integration of renewables

District Energy Interface



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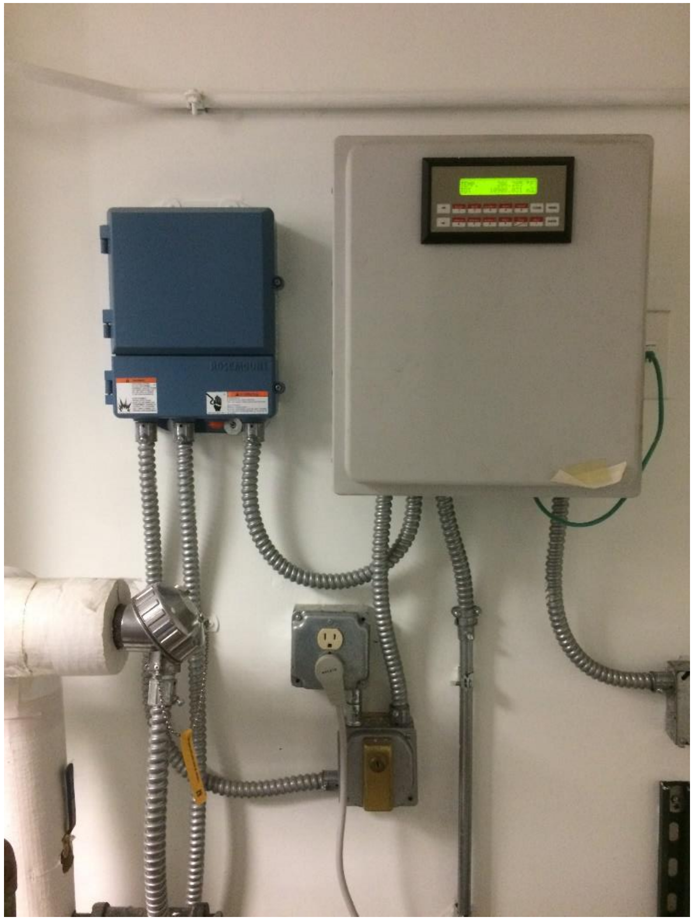
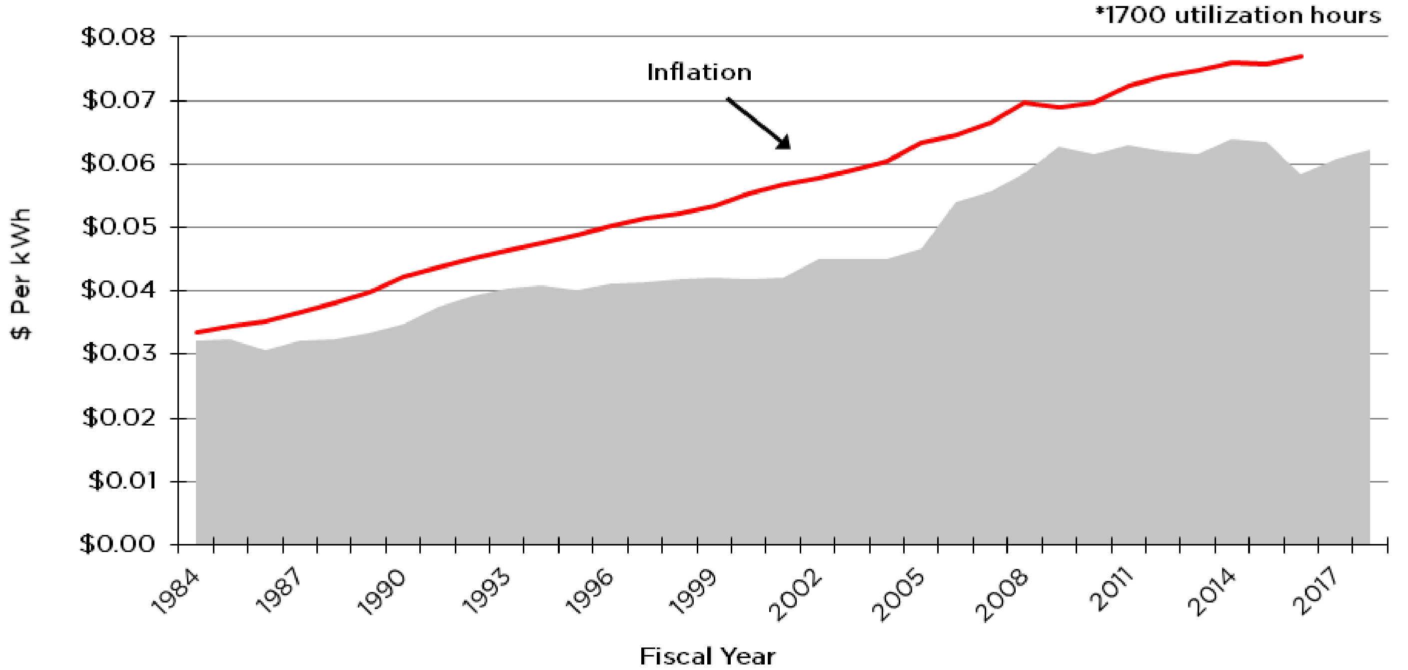
Metering



Combined Rate Summary Heating

District Energy customers are paying less for our services today than 35 years ago (adjusted for inflation)

Combined Rate Summary 1984-2018



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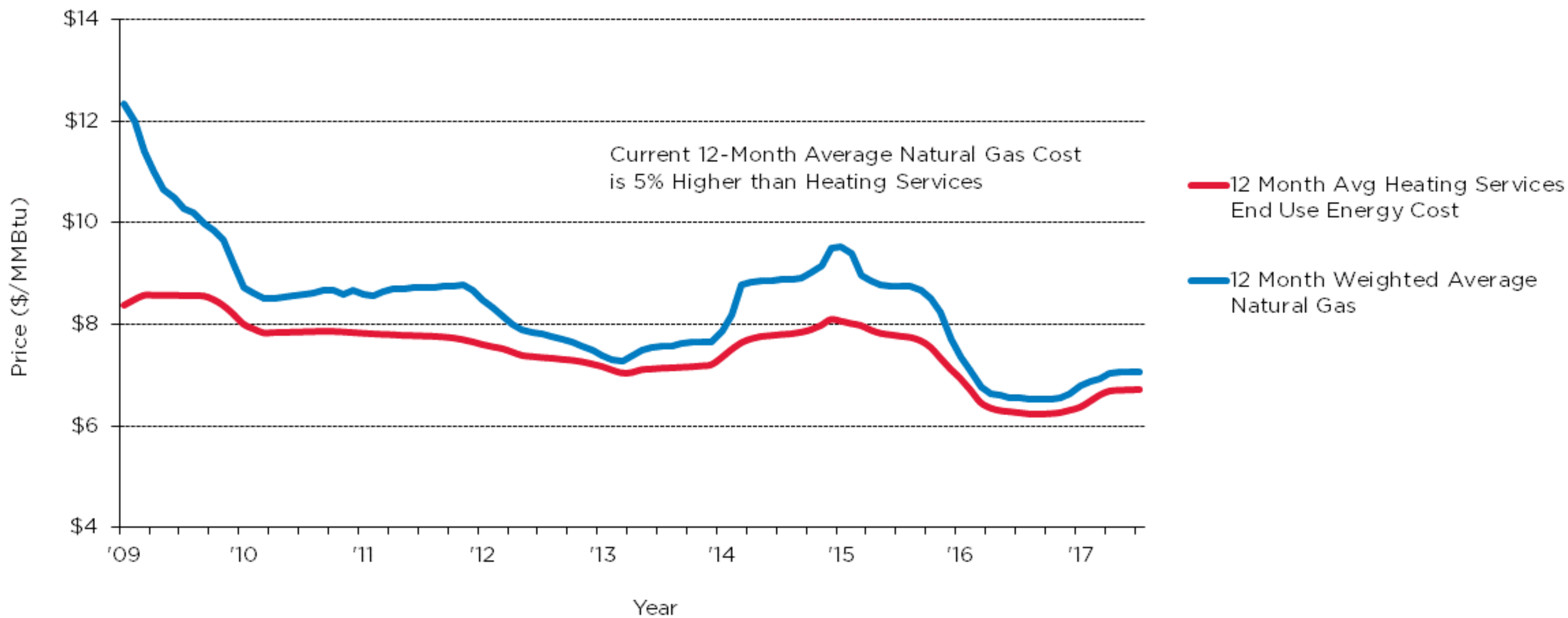
District Energy vs. On-Site



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Energy and District Rates

- Energy = (Flow)*(Supply Temp – Return Temp)*Conversion Factor
  - Hot water unit of energy is Megawatt Hours
  - Hot water demand is measured in Kilowatts
  - Chilled water unit of energy is Ton-hr
  - Chilled water demand is measured in Tons
- District Energy use a two part rate structure
  - Total Costs = Energy + Demand + Surcharges + City Fee + Sales Tax

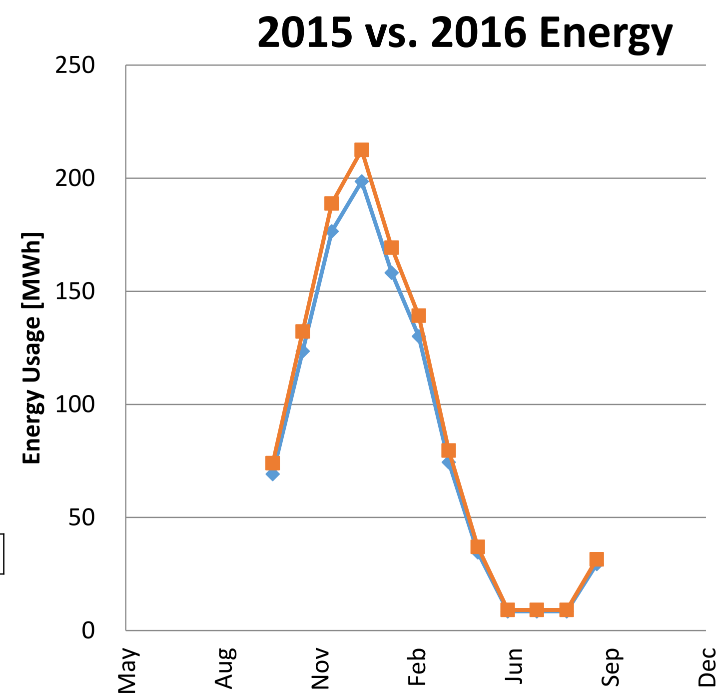
How much can improvements help?

Hot Water Energy Usage

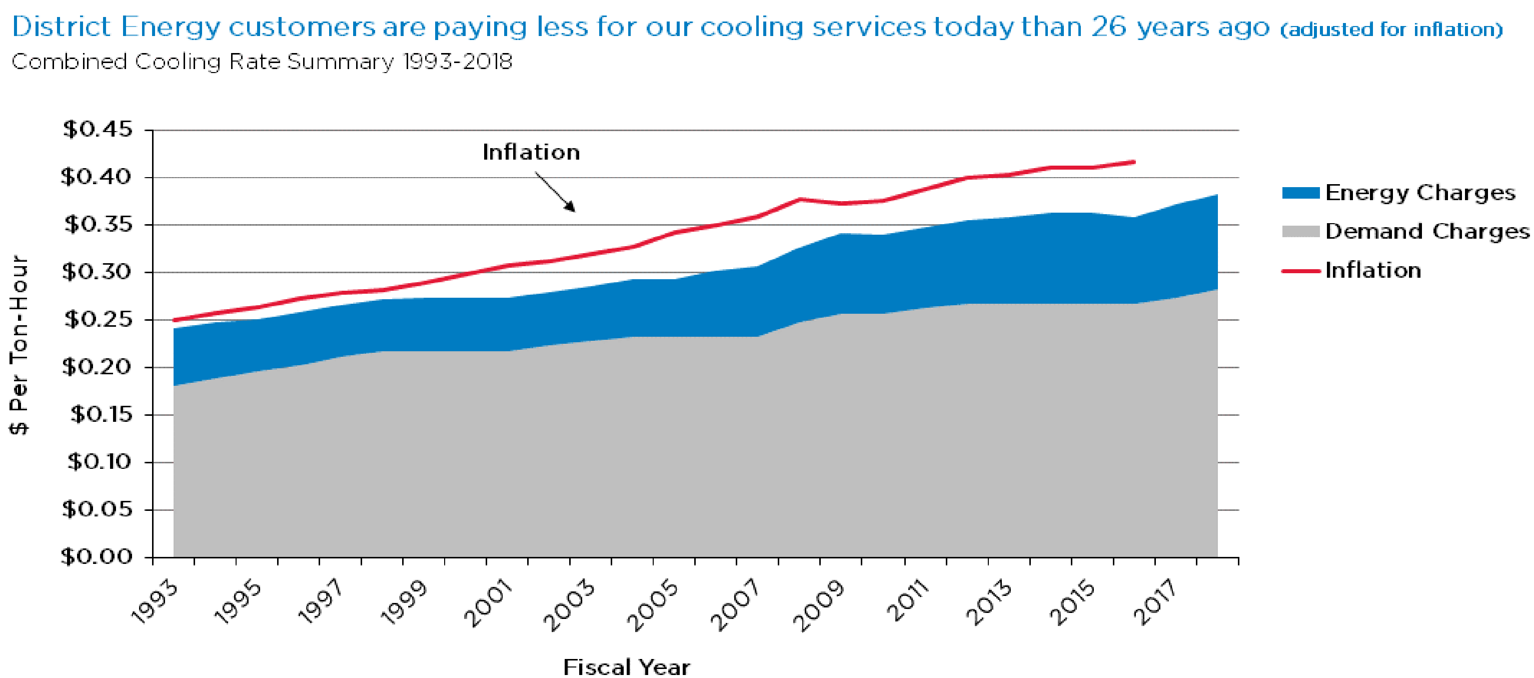
Month	2015 [MWh]	2016 [MWh]
October	74.0	69
November	132.2	124
December	188.8	177
January	212.5	199
February	169.3	158
March	139.2	130
April	79.6	74
May	37.0	35
June	9.1	9
July	9.1	9
August	9.1	9
September	31.5	29
	1,091	**1,020**

7% Change

Equivalent kWh (1000X)	1,091,400	1,020,000
Utilization Hours	1700	1700
Equivalent Demand (kW)	642	600



Combined Rate Summary Cooling



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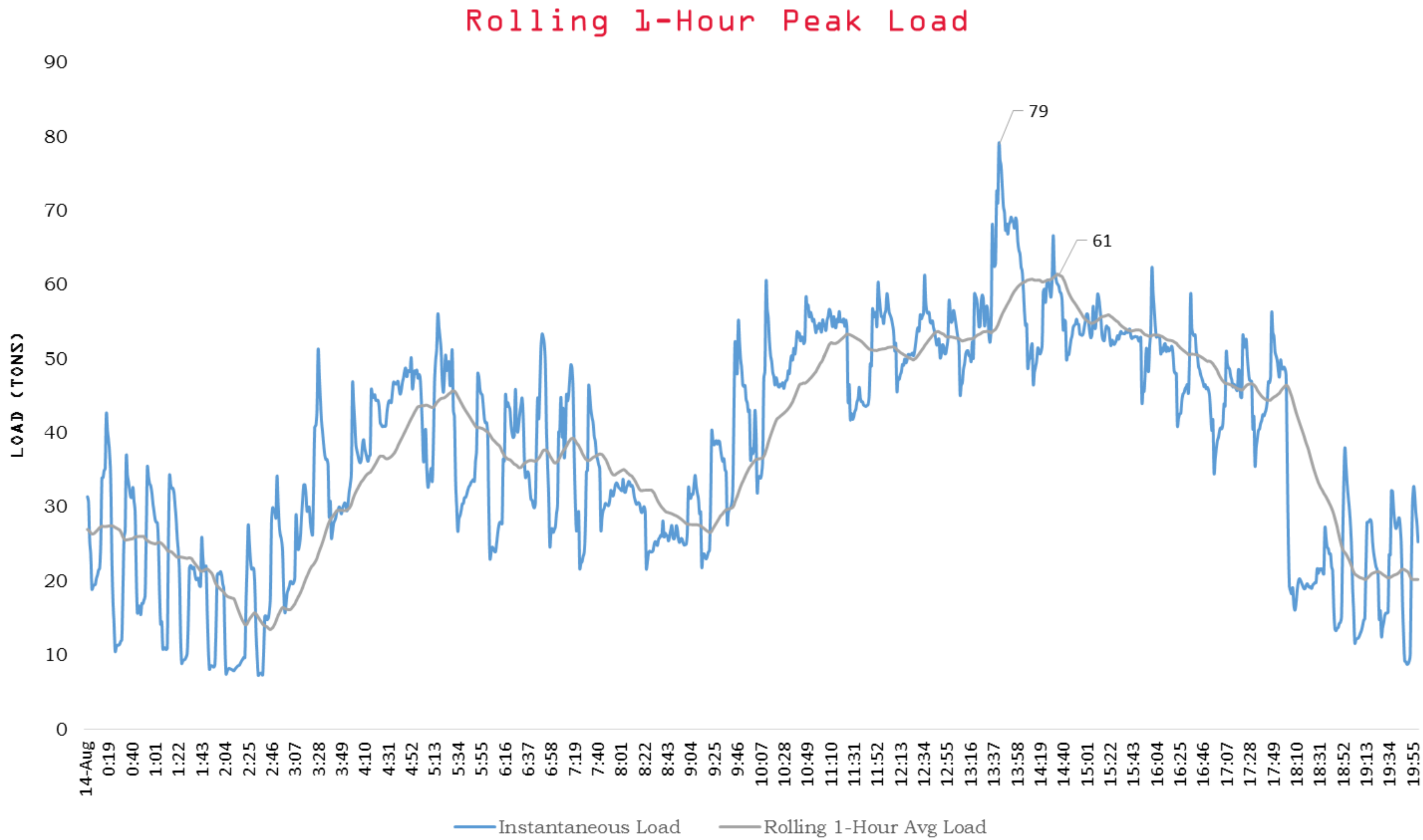
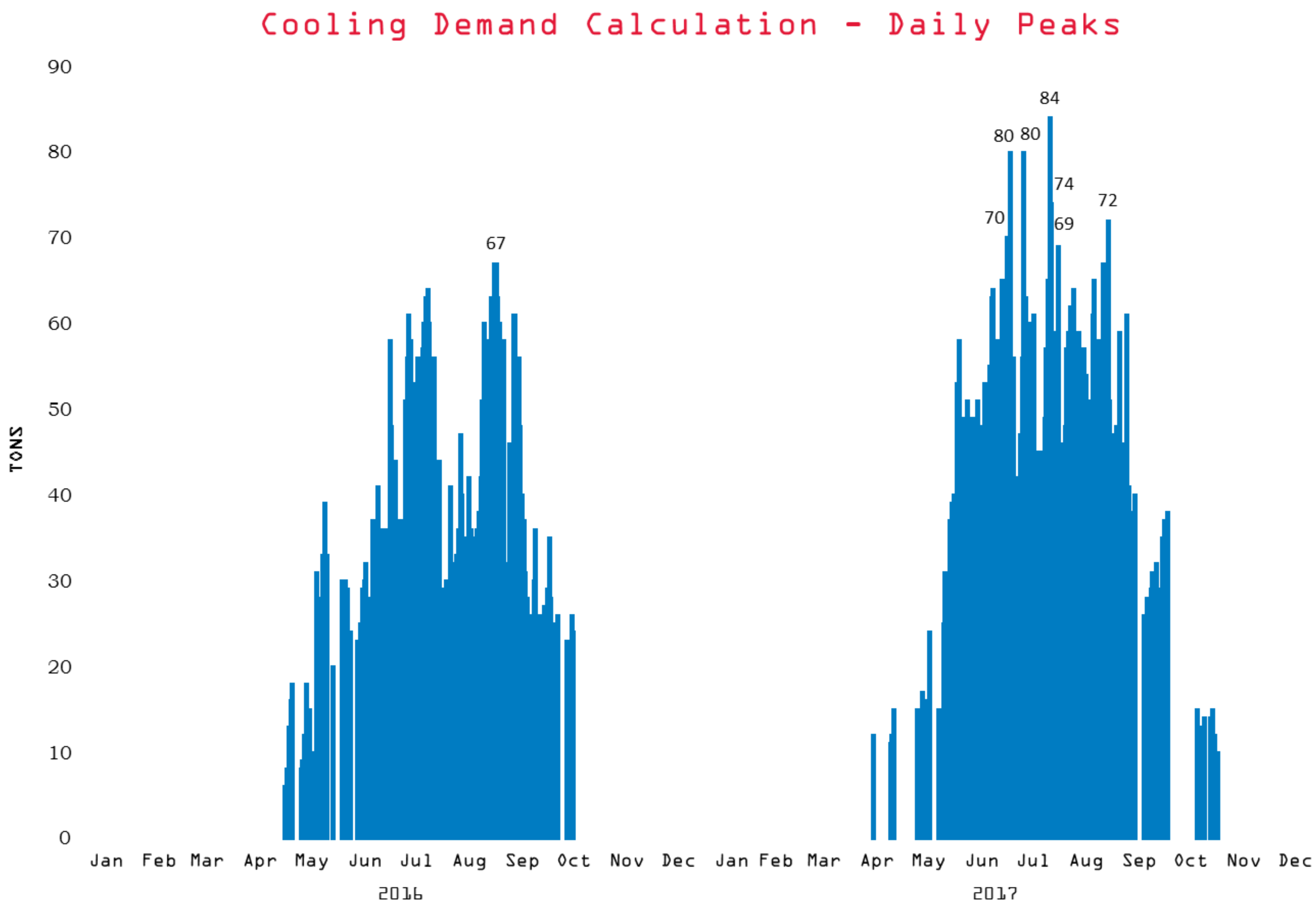

Rolling 1-Hour Peak Load
LOAD (TONS)
90
80
70
60
50
40
30
20
10
0
79
61
14-Aug
0:19
0:40
1:01
1:22
1:43
2:04
2:25
2:46
3:07
3:28
3:49
4:10
4:31
4:52
5:13
5:34
5:55
6:16
6:37
6:58
7:19
7:40
8:01
8:22
8:43
9:04
9:25
9:46
10:07
10:28
10:49
11:10
11:31
11:52
12:13
12:34
12:55
13:16
13:37
13:58
14:19
14:40
15:01
15:22
15:43
16:04
16:25
16:46
17:07
17:28
17:49
18:10
18:31
18:52
19:13
19:34
19:55
Instantaneous Load
Rolling 1-Hour Avg Load



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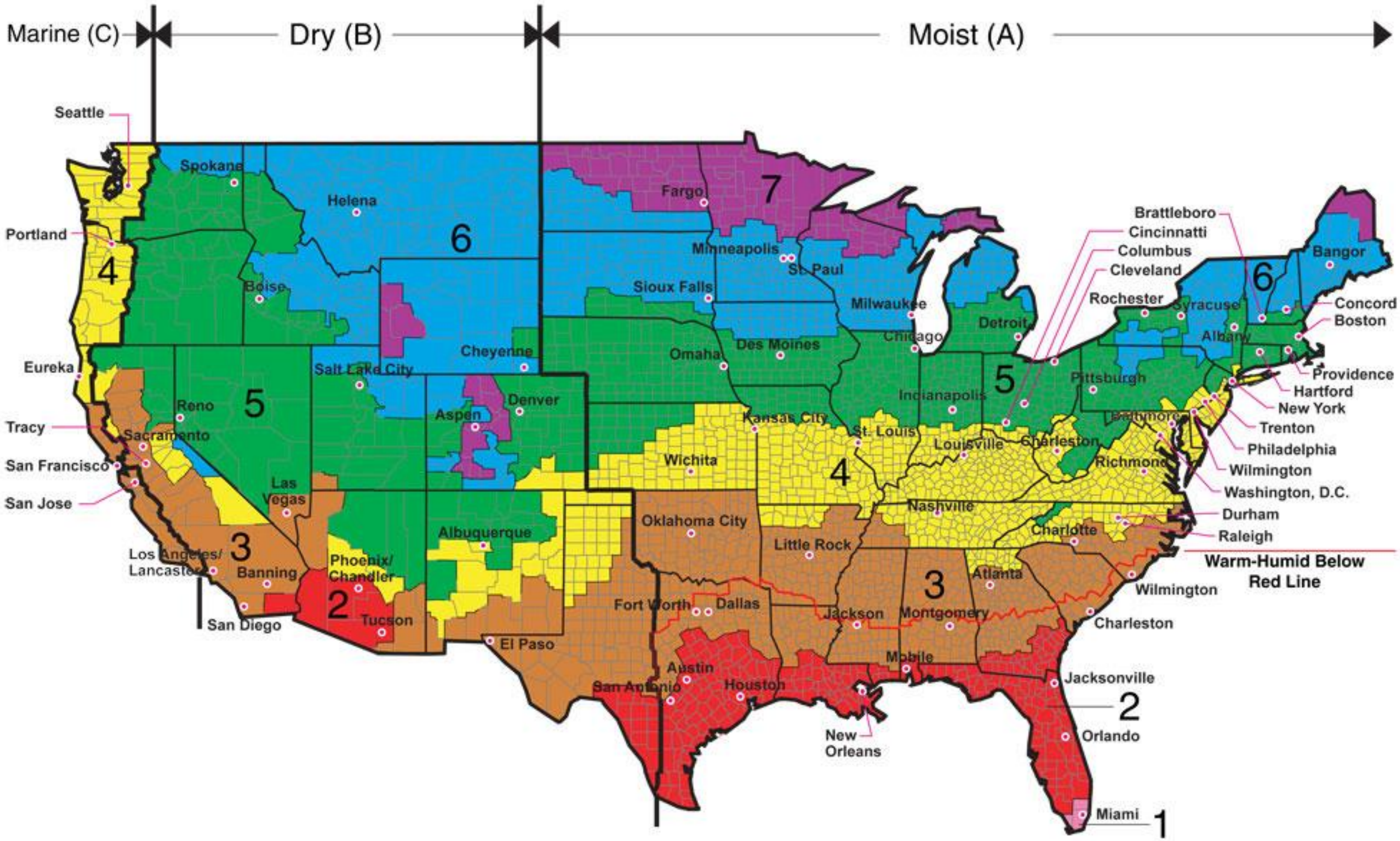
Heat Recovery Updated Requirements

- IECC Current Requirements for Heat Recovery on Dedicated Outside Air Systems (DOAS) and Mixed Air Systems
- Different types of heat recovery options
- Potential control sequence issues

ASHRAE Climate Zone Map



All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

IECC Current Heat Recovery Requirements

TABLE C403.2.7(1)
ENERGY RECOVERY REQUIREMENT (Ventilation systems operating less than 8,000 hours per year)

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
1B, 2B, 5C	NR	NR	NR	NR	≥ 26,000	≥ 12,000	≥ 5,000	≥ 4,000
6B	≥ 28,000	≥ 26,5000	≥ 11,000	≥ 5,500	≥ 4,500	≥ 3,500	≥ 2,500	≥ 1,500
1A, 2A, 3A, 4A, 5A, 6A	≥ 26,000	≥ 16,000	≥ 5,500	≥ 4,500	≥ 3,500	≥ 2,000	≥ 1,000	>0
7,8	≥ 4,500	≥ 4,000	≥ 2,500	≥ 1,000	>0	>0	>0	>0

For SI: 1 cfm = 0.4719 L/s.

NR = Not Required.

IECC Current Heat Recovery Requirements

TABLE C403.2.7(2)
ENERGY RECOVERY REQUIREMENT (Ventilation systems operating not less than 8,000 hours per year)

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	Design Supply Fan Airflow Rate (cfm)							
3C	NR	NR	NR	NR	NR	NR	NR	NR
1B, 2B, 3B, 4C, 5C	NR	≥ 19,500	≥ 9,000	≥ 5,000	≥ 4,000	≥ 3,000	≥ 1,500	> 0
1A, 2A, 3A, 4B, 5B	≥ 2,500	≥ 2,000	≥ 1,000	≥ 500	> 0	> 0	> 0	> 0
4A, 5A, 6A, 6B, 7, 8	> 0	> 0	> 0	> 0	> 0	> 0	> 0	> 0

For SI: 1 cfm = 0.4719 L/s.

NR = Not required

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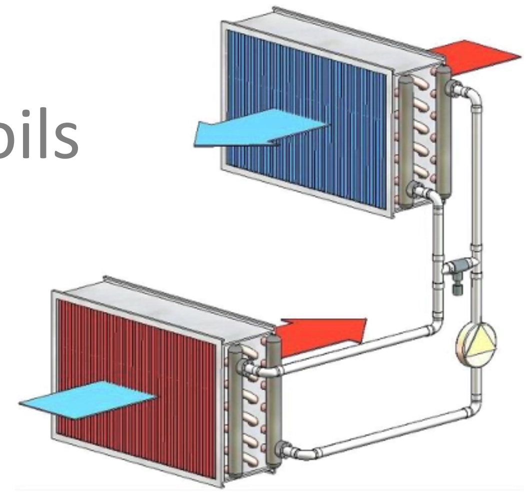
Proposed for 2018

- 70% efficiency at 0 Deg. F at full rated air flow
  - As air flows are less than design the efficiency should increase slightly

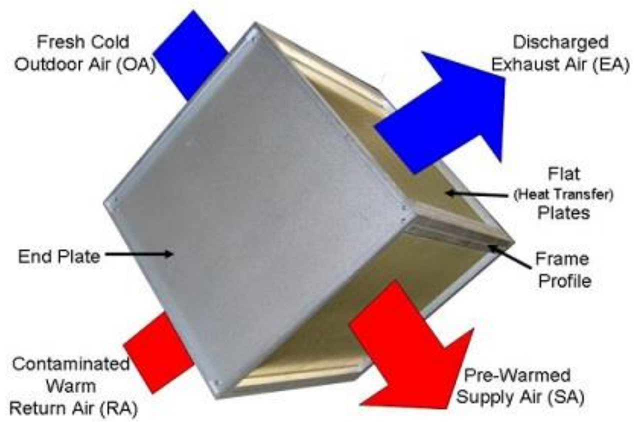
Types of Heat Recovery

- Run around pump and coils



The Renewable Energy Hub

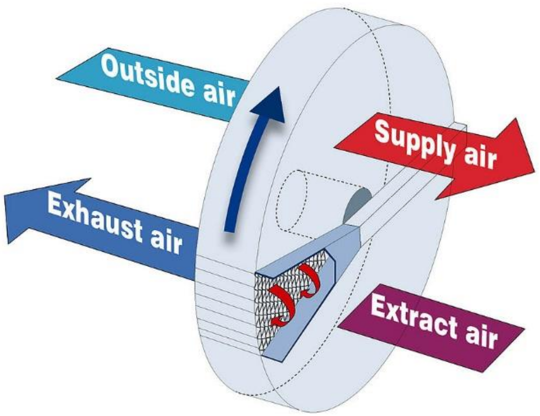
- Air to air



Workspace Technology Limited

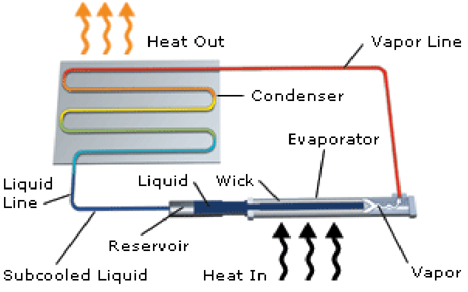
Types of Heat Recovery

- Heat wheel or enthalpy wheel



Klingenburg Energy Recovery

- Heat pipes



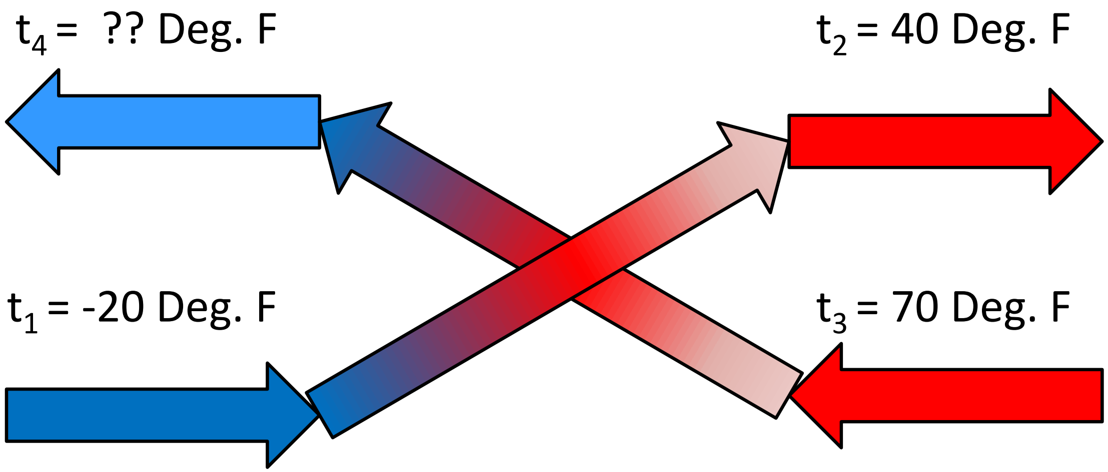
The Renewable Energy Hub

How to Calculate Heat Recovery Efficiency

- Thermal Efficiency

$$u_t = \frac{(t_2 - t_1)}{(t_3 - t_1)}$$

How to Calculate Heat Recovery Efficiency



$$u_t = \frac{(t_2 - t_1)}{(t_3 - t_1)} \qquad u_t = \frac{(40 - (-20))}{(70 - (-20))} \qquad u_t = .67 = 67\%$$

Don't need to know the final exhaust temperature to calculate the thermal efficiency.
Assuming equal airflows on both sides: Who knows what t4 would be?

How to Calculate Heat Recovery Efficiency

- For air to air heat exchangers and coil run around loops thermal efficiency is the same as total efficiency

- For enthalpy wheels the efficiency has to include the moisture transfer between the air flows as well

- Moisture Efficiency $$u_m = \frac{(x_2 - x_1)}{(x_3 - x_1)}$$

- Enthalpy Efficiency $$u_h = \frac{(h_2 - h_1)}{(h_3 - h_1)}$$

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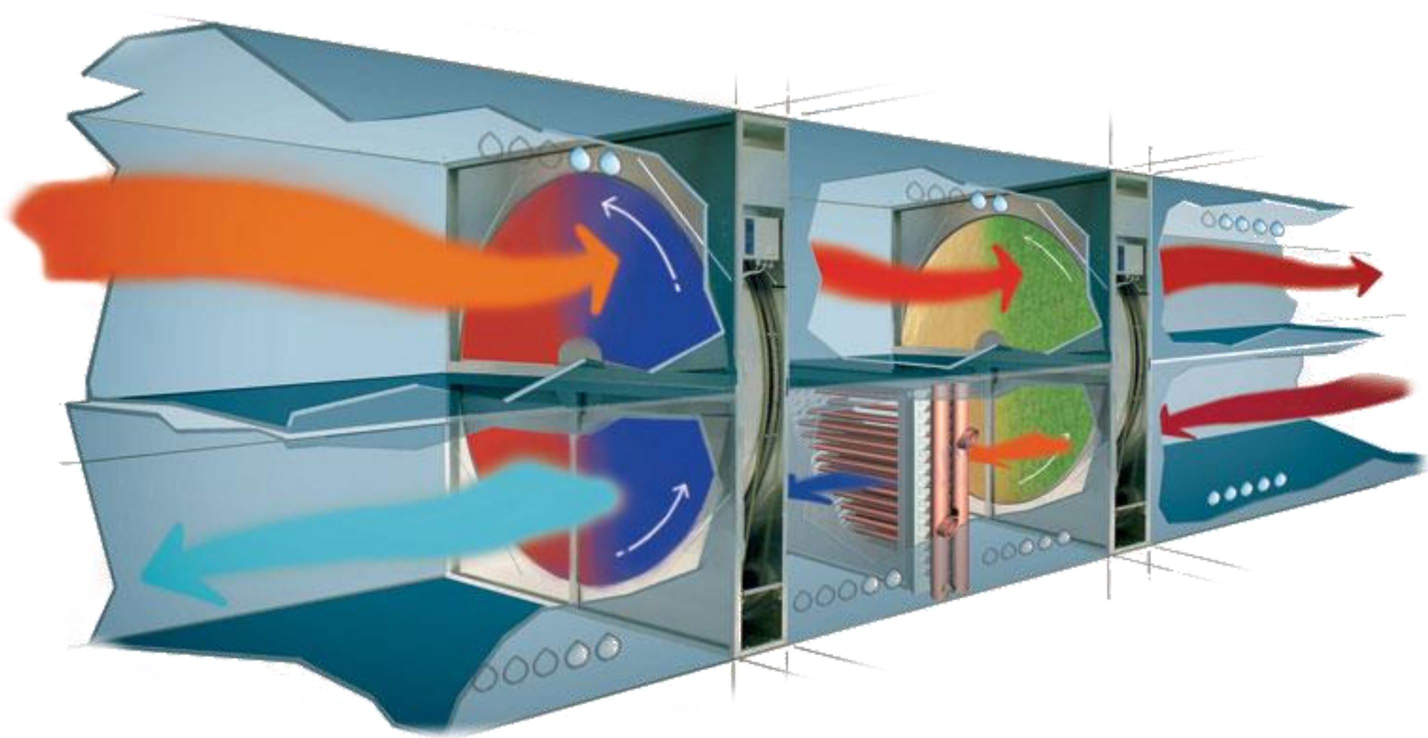
Potential Control Sequence Issues

- Heat or energy wheels
  - Slow down or stop for frost mode protection
  - Don’t have even heat throughout the air stream
  - Allows contaminates from the exhaust air stream into the fresh air stream

Temperature Varies as Wheel Spins



The Renewable Energy Hub

Frost Protection

- Many air to air exchangers have a bypass damper to keep moisture from freezing in the heat exchanger
  - Can not have freeze stat directly after bypass damper
  - May need to have a time delay freeze stat that gives the heating valve time to open
  - These units allow for completely separate airstreams

Process Cooling Best Practices

- District Energy provides cooling year round throughout the Saint Paul cooling loop
  - Summer operation
  - Winter operation
- Tricks to make the process cooling more resilient and more efficient
- Start planning ahead for cooling system maintenance
  - Equipment that needs 24/7 operation for critical programmatic needs should have an independent operational backup

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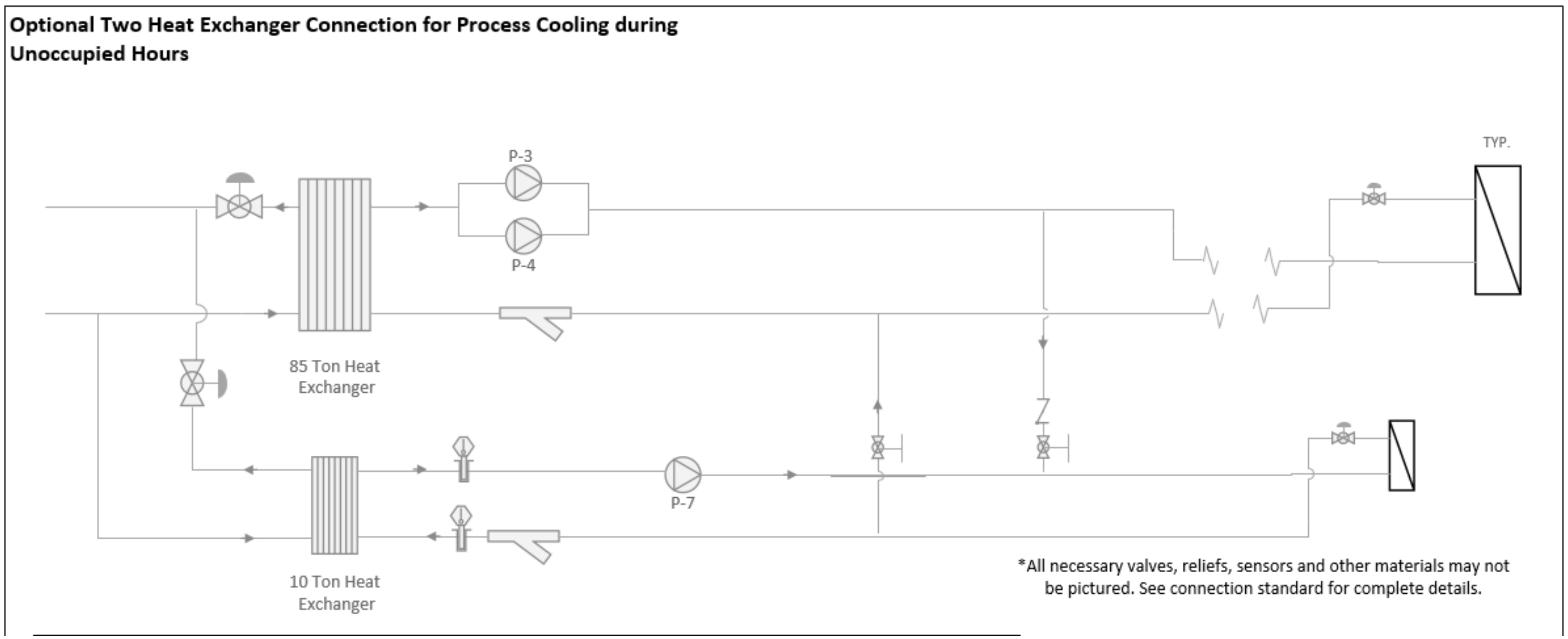
District Cooling Year Round Operation

- Summer
  - Provide chilled water June through September that is 42 Deg. F or colder.
- Winter operation
  - When there are no latent cooling requirements the supply temperature can, but is not always, reset to 50 Deg. F.
- The minimum differential pressure to the building remains the same year round.

Optimizing Process Cooling Efficiency

- Select equipment and associated heat exchangers to operate at chilled water supply temperature of 60 Deg. F or warmer.
- If process loads are less than 20% of building thermal comfort loads, plan to have a dedicated process cooling heat exchanger and associated pump and valves.

Proposed Piping and Instrumentation Diagram (P&ID)



What Happens if there is Maintenance?

- District Energy will work with you in advance of any planned shut down to coordinate the timing of the cooling outage.
- District Energy will help to identify options for hoses or auxiliary connections for once through cooling if the building loads can be met in this way.
- District Energy can help in the design and selection of backup equipment for critical process loads to be permanently installed at the building in the event of a future cooling planned or unplanned outage.