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· August 15-18, 2010 · Dallas, Texas ·
· Dallas Convention Center ·

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Chevron Energy Solutions
Heat Recovery
Humidification
R O Water
Study &
Systems Design

John C. Brady, P.E.

Laboratory Efficiency Lessons Learned US Environmental Protection Agency RTP Consolidated Facilities

US Environmental Protection Agency
Research Triangle Park, NC

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US Environmental Protection Agency Research Triangle Park, NC

Building Area

Total gross Area	1,160,000 Square Feet
Net Program Area	625,000
• Laboratory Space	270,000
• Office Space	220,000
• Computer Center	70,000
• Building Common	50,000
• Child Care Center	15,000

EPA RTP Design Criteria

Summer Design Conditions

Extreme Dry-bulb:	93°F DB/76°F WB
Extreme Dewpoint:	88°F DB/78°F WB, 75°F Dewpoint
Extreme Humidity Ratio:	134 grains/lb
Indoor Design:	70°F DB +/- 1°F, 50% RH +/- 5% RH

Winter Design Conditions

Extreme Dry-bulb:	16°F DB
Indoor Design:	70°F DB +/- 1°F, 50% RH +/- 5% RH

Occupancy

Occupants generally present 6 AM to 6 PM Monday through Friday, Ventilation systems run continuously to support the Laboratories.

EPA RTP Design Criteria

The program of ventilation rates, air exchange rates, duct air velocities, inter-zonal air transfer, and pressure relationships between the different spaces within the facility remain unchanged, as originally designed, and were not considered by this design.

METHOD OF ANALYSIS

Analysis of energy and psychrometrics:

8760 hour weather model employing TMY2 weather data generated with the Binmaker Plus® Software Program.

Outside air quantities and loads:

Based on the original design documents prepared by Vanderweil Engineers in 1996.

Total supply air volume = 228,000 CFM

Supplied from six of seven air handling units located in the Penthouse Mechanical Equipment Room of Building A.

Total exhaust air volume = 212,000

(Excluding bio and fume hood exhaust) Provided by four of five units located in the Penthouse Mechanical Equipment Room of Building A.

Existing Humidification System

- The Original Building Design Called for a

"Compressed air atomizing system for humidification …[which] Also serves as an evaporative cooling medium."

AirFog

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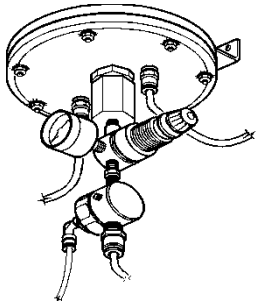
Existing Humidification System

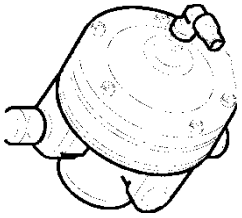
AFE Systems

Nozzle

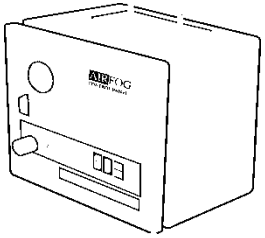
Vacuum Valve



Pilot Air Regulator



Control Panel



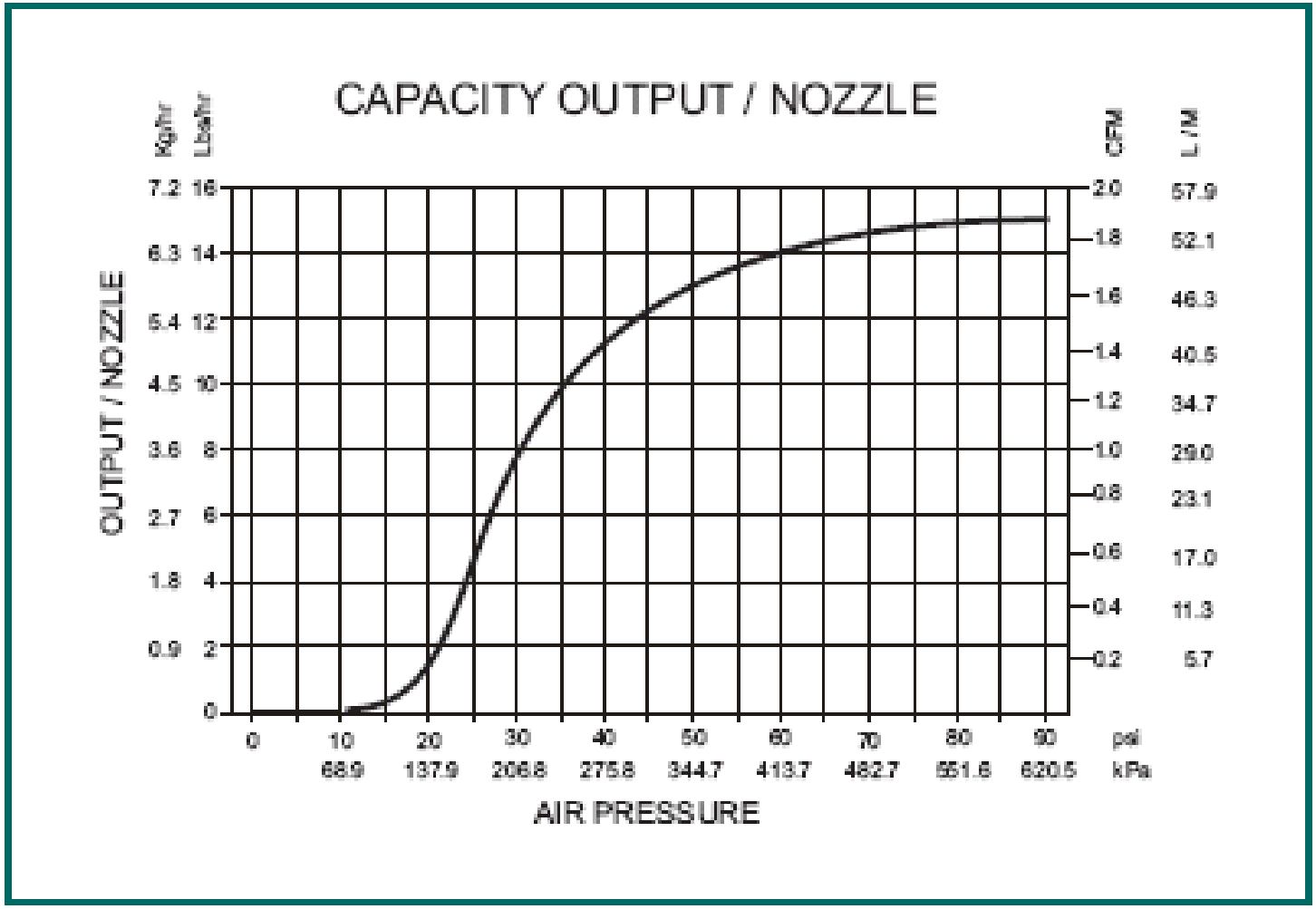
Existing Humidification Problems

- Compressed Air Atomizing Humidifier

  Required Absorption Distance Unavailable

Existing Humidification Problems

Figure #2
AFE Nozzle Performance



Existing Humidification Problems

FORMULA: Temperature Drop

$$\Delta T = \frac{\text{BTU}}{\text{CFM x 1.10 (Constant)}}$$

$$\Delta T = \frac{\text{107,500 BTU}}{\text{20,000 CFM x 1.10}}$$

$$\Delta T = 4.8°F$$

Existing Humidification Problems

The absorption distance can be calculated by determining the Z ratio. The Z ratio calculation is as follows:

$$Z = \frac{(Wah-Wbh)}{(Wsah-Wbh)}$$

Wah = Humidity ratio after manifold
Wbh = Humidity ratio before manifold
Wsah = Humidity ratio at saturation after manifold

The maximum value of Z is (1), any value above 0.60 is often unacceptable. The example used would have a Z value of 0.125. From the Psychrometric chart the Wbh = .005, Wah = .0065 and the Wsah = .0017

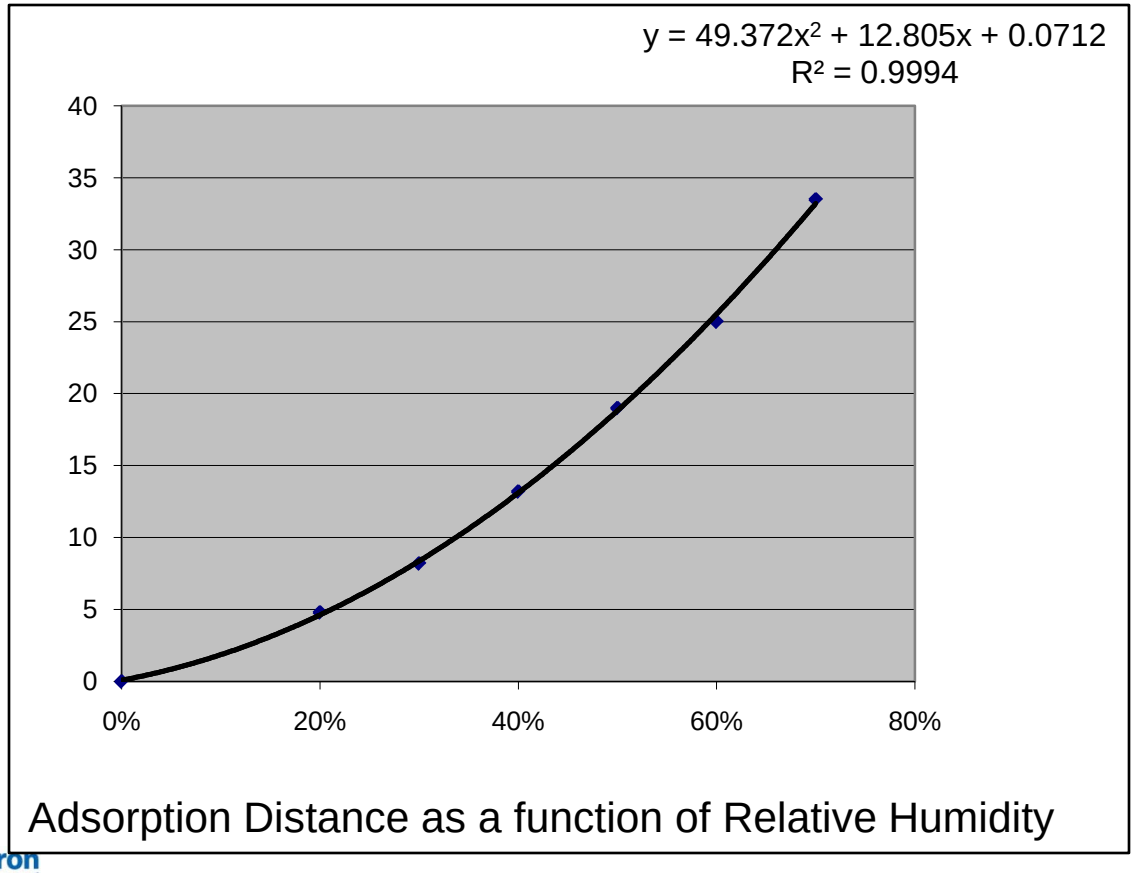
1

Existing Humidification Problems

wbh	wah	wsah	Zratio	Velocity	Absorption Distance
93.3	111.4	128.5	51%	309	20
93.3	114.3	129.9	57%	309	24
93.3	123.0	135.8	70%	309	33
93.3	123.7	136.3	71%	309	34
93.3	128.0	140.6	73%	309	36
93.3	128.4	141.1	74%	309	36

Existing Humidification Problems

Regression Analysis Yields Absorption Distance in excess of 20 feet when only 42” is available



Adsorption Distance as a function of Relative Humidity

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Existing Humidification

Initial Sample of measurement at Penthouse Air Handling Units Taken at time ending 2:36 p.m. 3/1/2004	Flow Volume (Oz)	Humber of Nozzles	Total Flow (Gallons)	Time Interval (Seconds)	Flow Rate (Gal/hr)	Flow Rate (lbs/hr)
Atomizing Air Nozzle Flow Rate from Nozzles	7.00	60.00	3.28	120.00	98.44	819.98
Condensate Drainage Flow Rate Unit 6-3	32.00	1.00	0.25	20.00	45.00	374.85
Condensate Drainage Flow Rate Unit 6-1	60.00	1.00	0.47	30.00	56.25	468.56
Condensate Drainage Flow Rate Unit 6-6	30.00	1.00	0.23	10.00	84.38	702.84
Condensate Drainage Flow Rate Unit 6-5	42.00	1.00	0.33	20.00	59.06	491.99
Average Condensate Flow Rate of 4 Units						509.56
Percent of Humidification Discharging Down The Drain						62%

Note: Of the three remaining units, two had inaccessible condensate drains and the other unit was not running.

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VENTILATION SYSTEM MODIFICATIONS

Supply Air Heat Recovery Coils

Installed in seven existing built-up air handling units in the space allocated by the original design documents

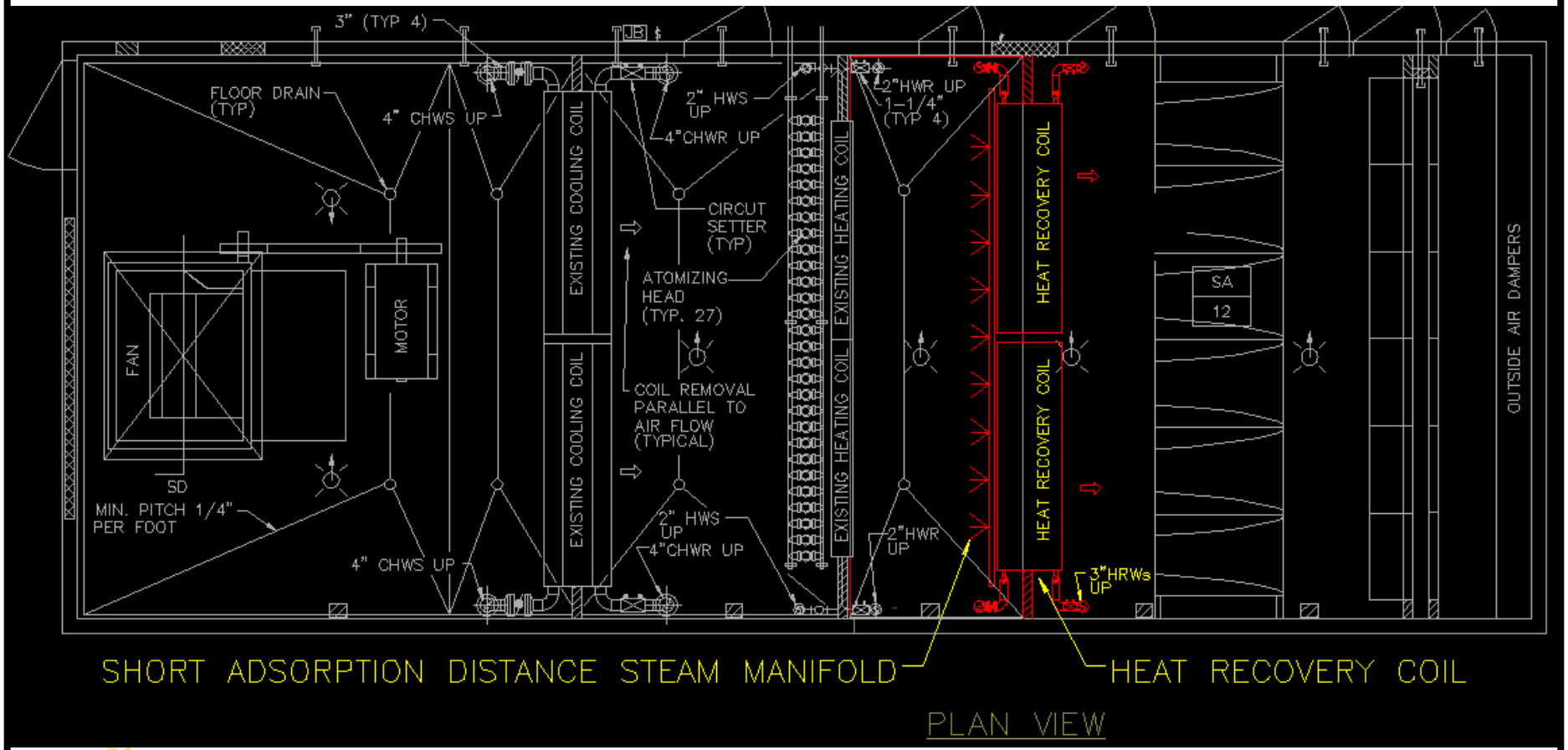
Exhaust Air Heat Recovery Coils

Installed in the existing built-up exhaust units in the space allocated by the original design documents utilized to construct the building.

Low Absorption Distance Steam Manifold Humidifiers

Installed in seven existing air handling units downstream of the new heat recovery coils. Supplied with clean steam generated by new clean steam generators installed under this contract.

RETROFIT AIR HANDLERS WITH HUMIDIFICATION & HEAT RECOVERY COILS



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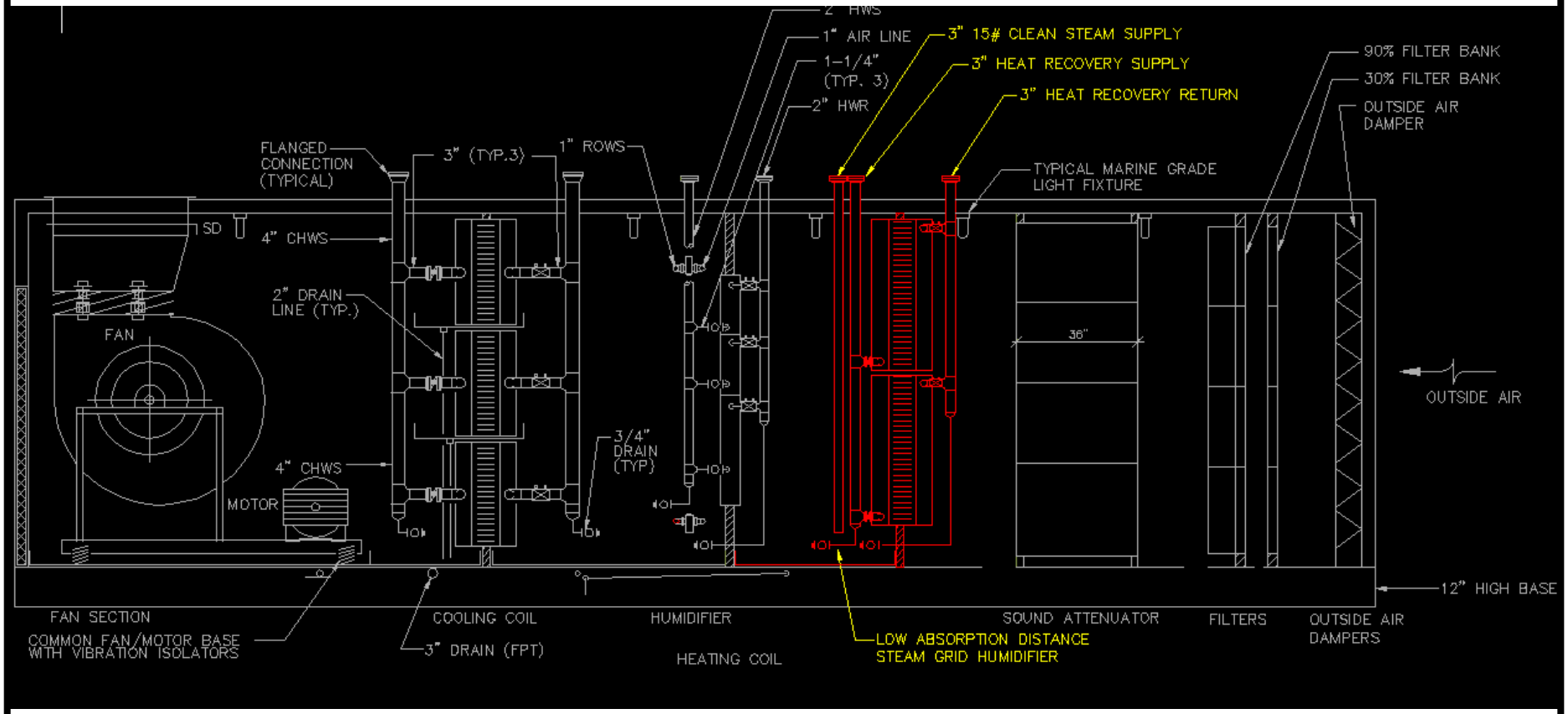
RETROFIT AIR HANDLERS WITH HUMIDIFICATION & HEAT RECOVERY COILS



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Humidification Retrofit With SAM-e Short Absorption Distance Manifolds

- ✓ Short absorption distances required
- ✓ Lower cost than multiple distributors
- ✓ Removes engineers concerns of wetting duct
- ✓ Easier to install than multiple LiveSteam and atmospheric distributors

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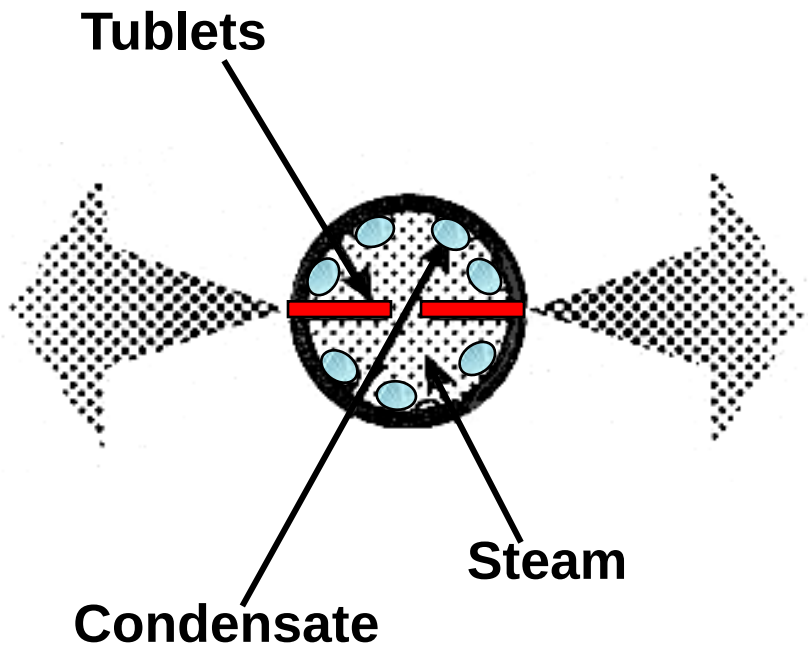
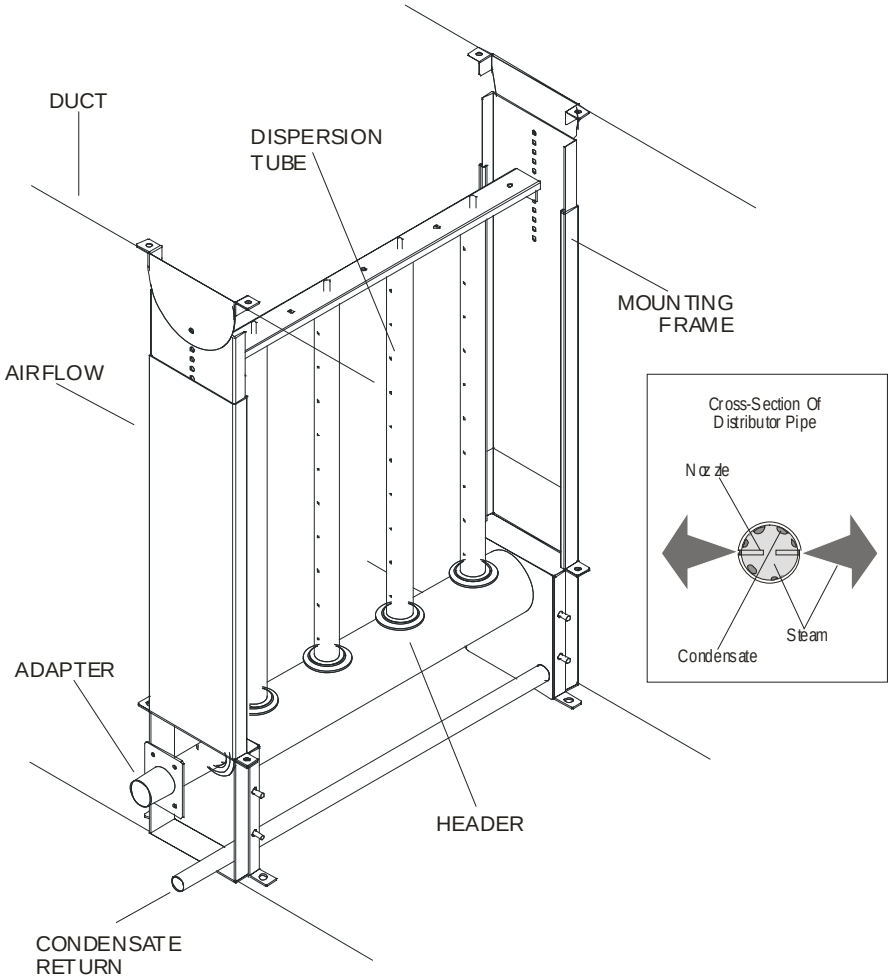
Humidification Retrofit With SAM-e Distributor Pipe Cross Section



- Steam Tapped from Center of Distributor Pipe
- No Jacketed Distributor Pipe

Humidification Retrofit With "SAM-e" Short Absorption Distance Manifolds

- More Tubes
- More Nozzles
- Offset Nozzle Spacing



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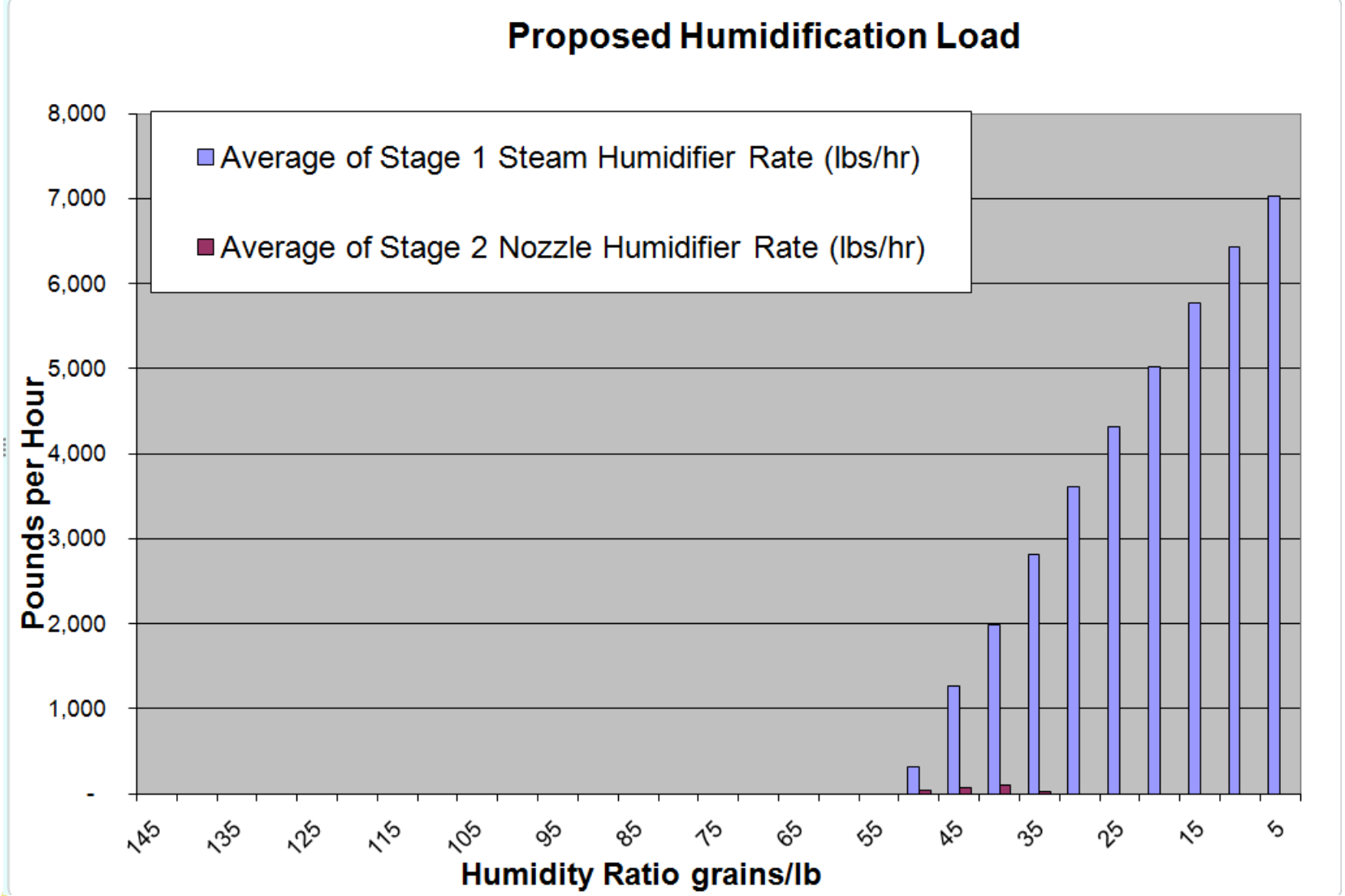
HUMIDIFICATION



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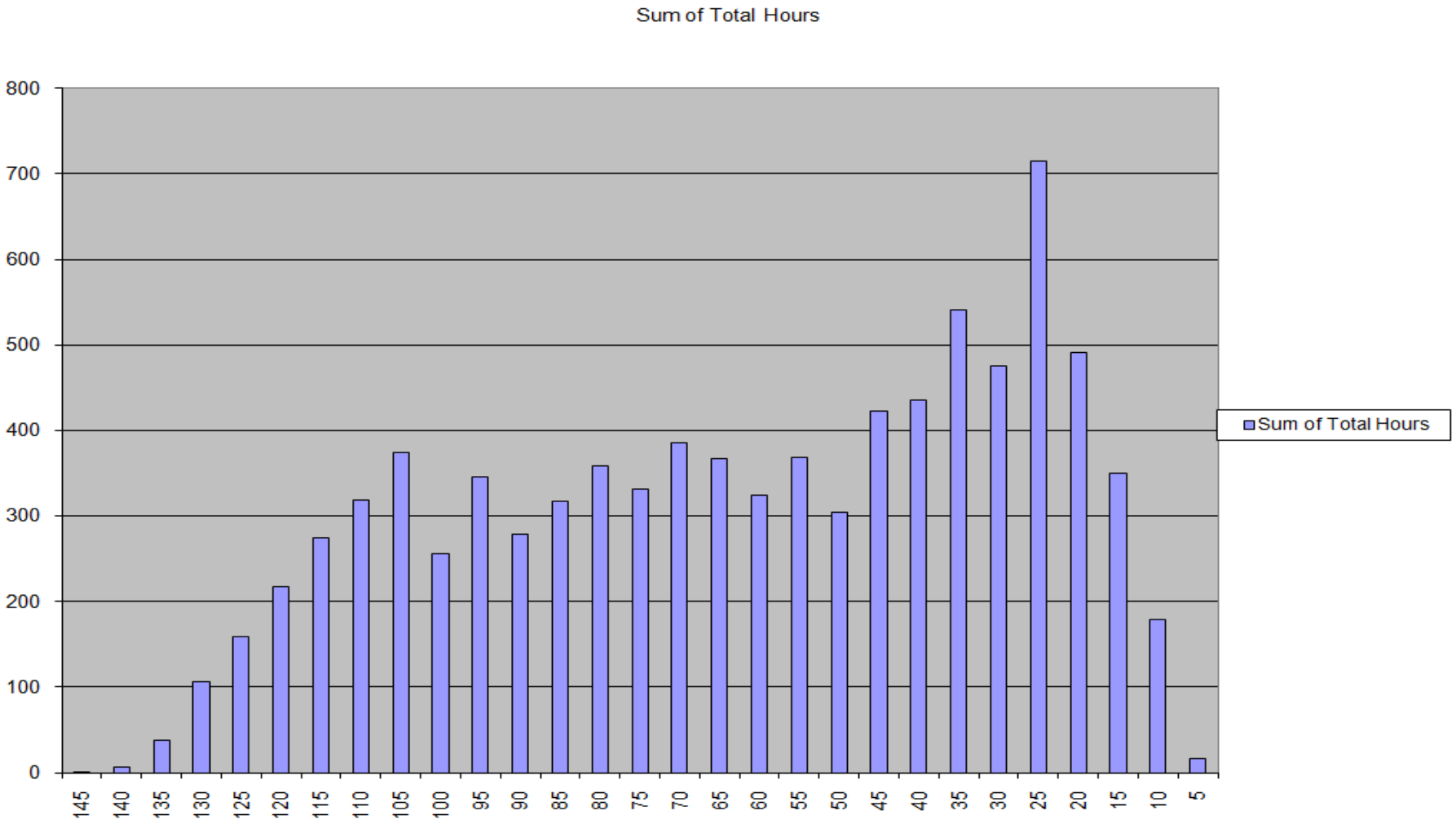
HUMIDIFICATION



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Existing Perception of Heat Recovery

Heat Recovery for Laboratory Exhaust

Heat exchangers operate in a number of different ways depending on the medium that is being used, and the proximity of the intake and exhaust streams. Their function is to use waste heat and waste cooling to accomplish preheating and precooling. The potential for energy savings can be quite high, particularly for building types like laboratories that require large volumes of conditioned air to be exhausted.

A value engineering study prepared during concept design for the EPA facility evaluated the cost-effectiveness of installing a glycol runaround system in the laboratory air handling equipment. The glycol system was proposed because it avoids possible contamination between air streams, and won't freeze in the outside air stream. In the winter, warm exhaust air transfers heat to a glycol solution, which is then pumped to the coil in the air handling unit to preheat outdoor air. Incoming air is warmed as it passes over the glycol loop before passing through the heating coil, thus reducing the energy required to heat the outdoor air. This is also true in the cooling season where cooler exhaust air cools the glycol solution, which then precools the outdoor air.

Much to everyone's surprise, the study indicated that the glycol heat recovery system would cost $915,000 to install and approximately $8,900 more per year to run than the system without the runaround cycle. This cost differential was attributed to the extremely low electric rates of the local electric power provider and the absence of profound, long-duration extremes in North Carolina weather. The glycol system had increased fan static pressure caused by the heat recovery coils, and additional energy

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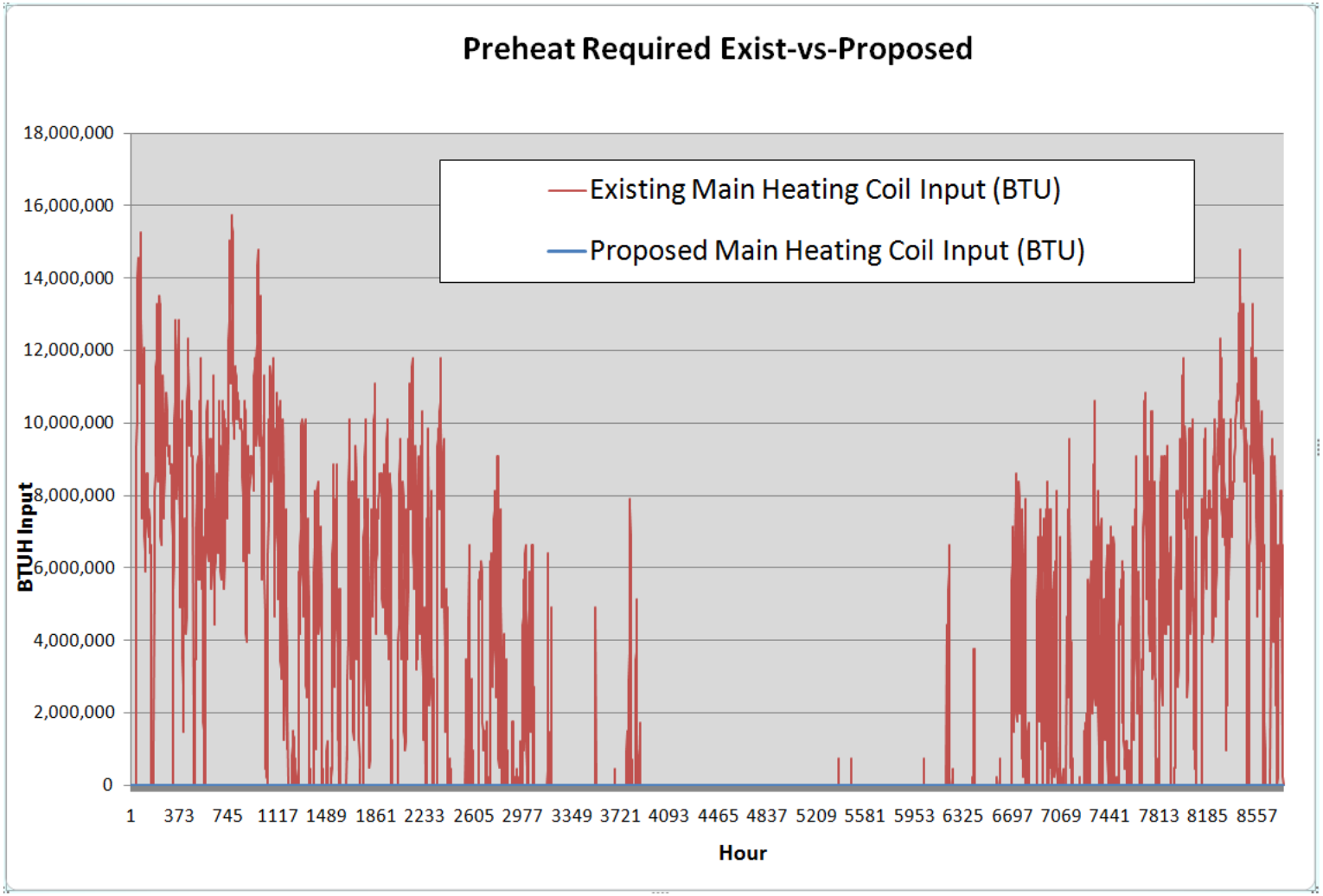
Heat Recovery

requirements for the glycol loop pumps. The energy to run the reheat system was enough of an additional load to actually make heat recovery a more expensive system to operate. As a result, EPA did not install a heat recovery system, but provided space in the mechanical penthouse to allow installation of a system should technology and economics make heat recovery a prudent choice in the future.

Heat Recovery



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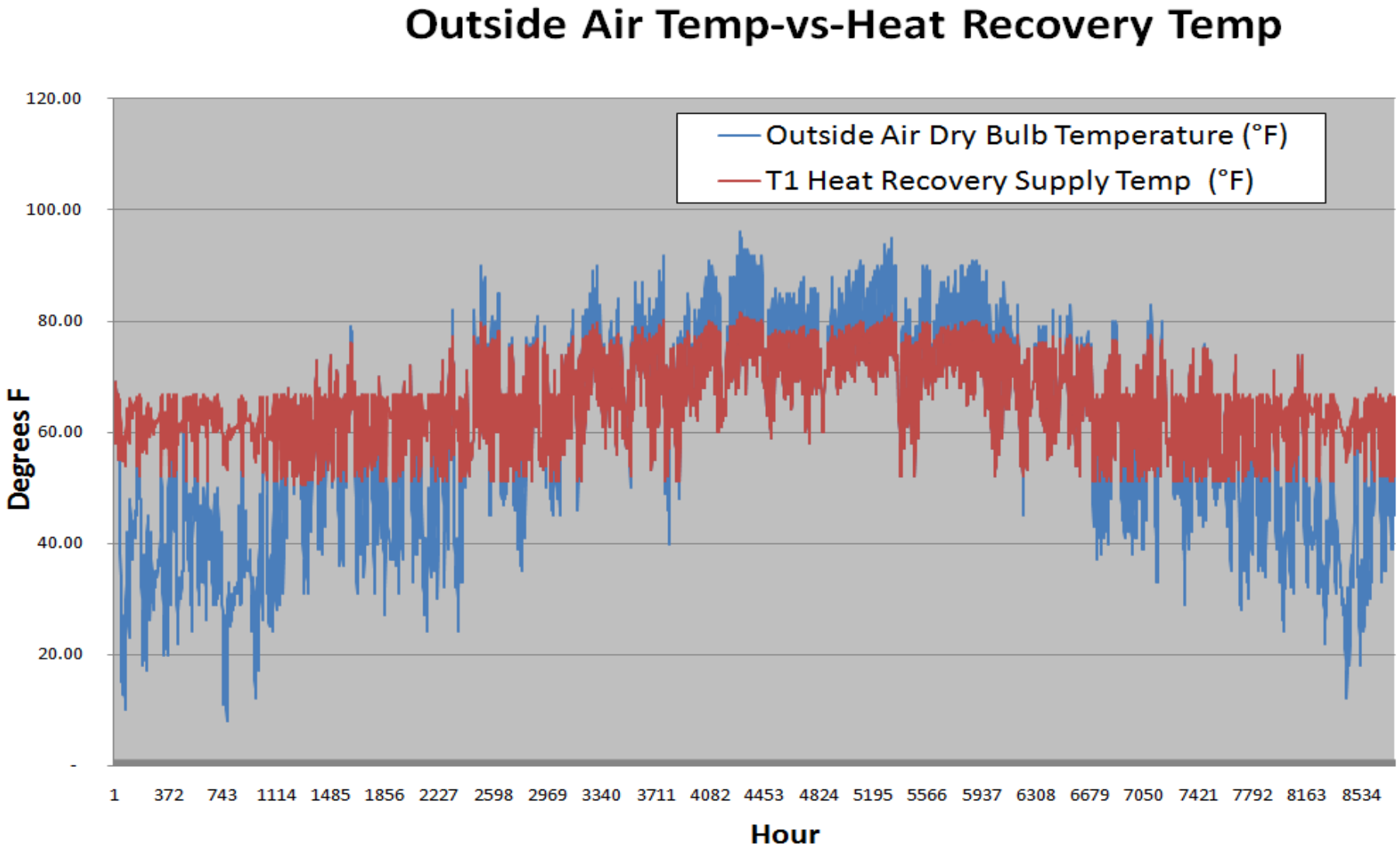
Heat Recovery



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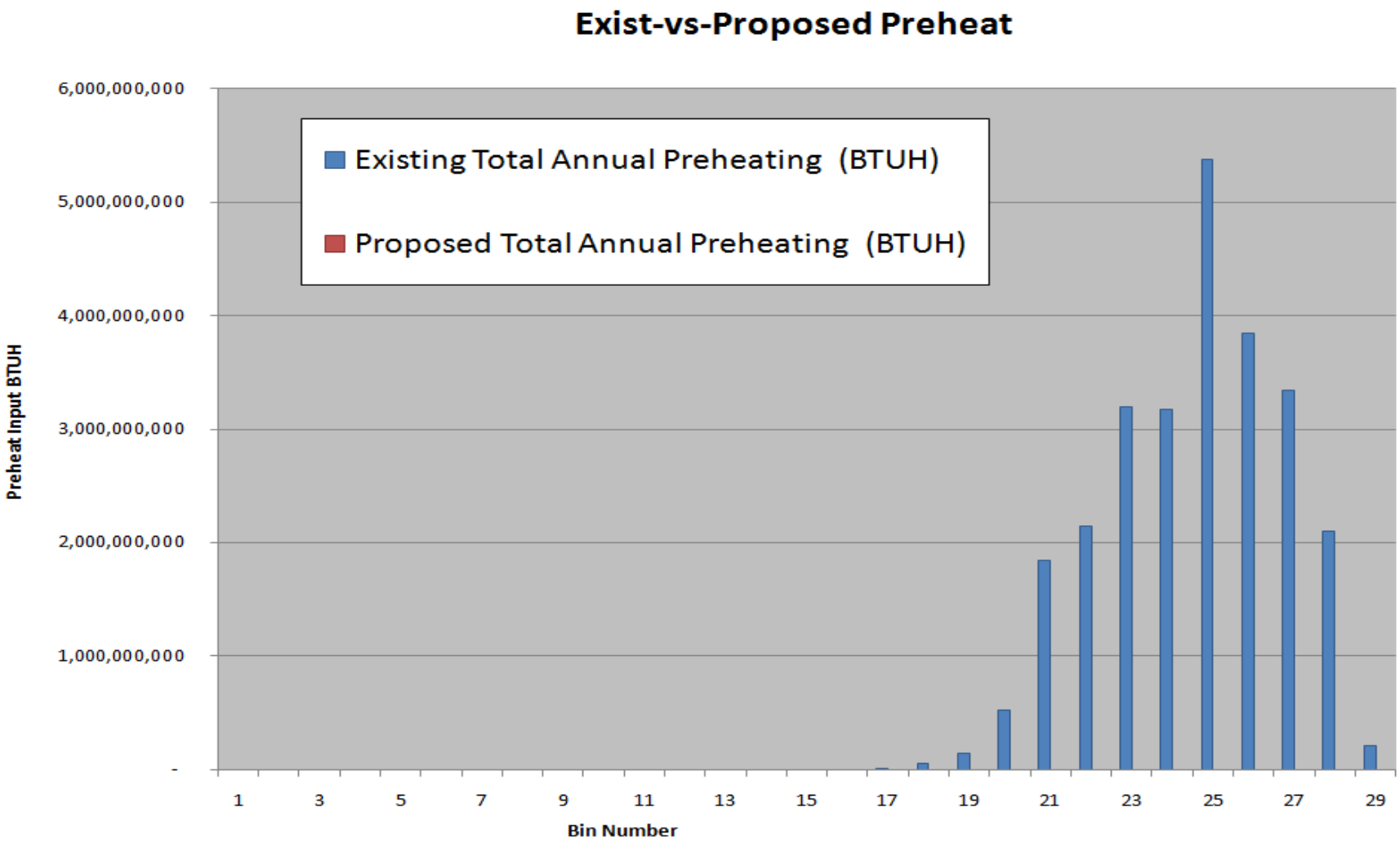
Heat Recovery



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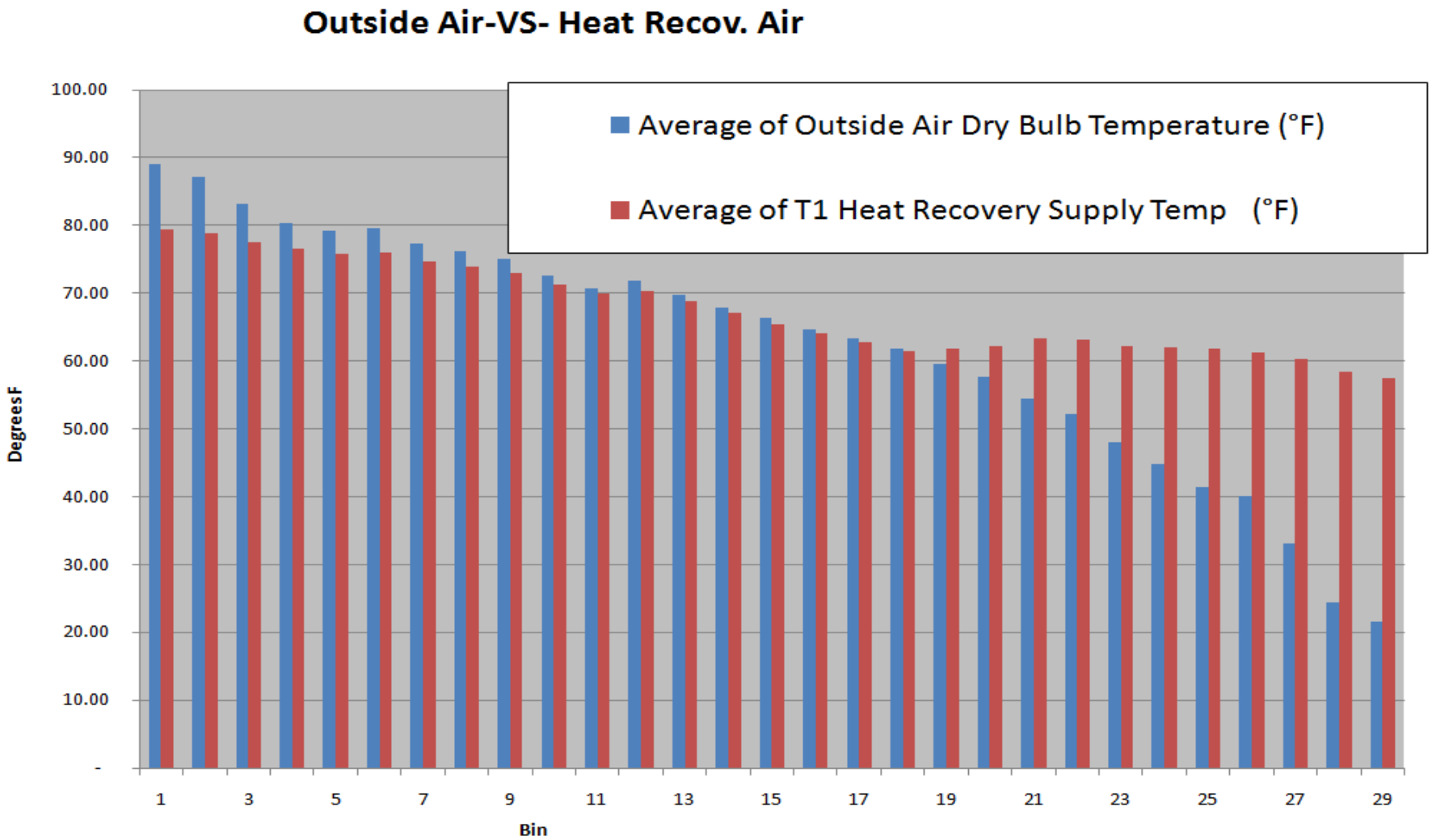
Heat Recovery



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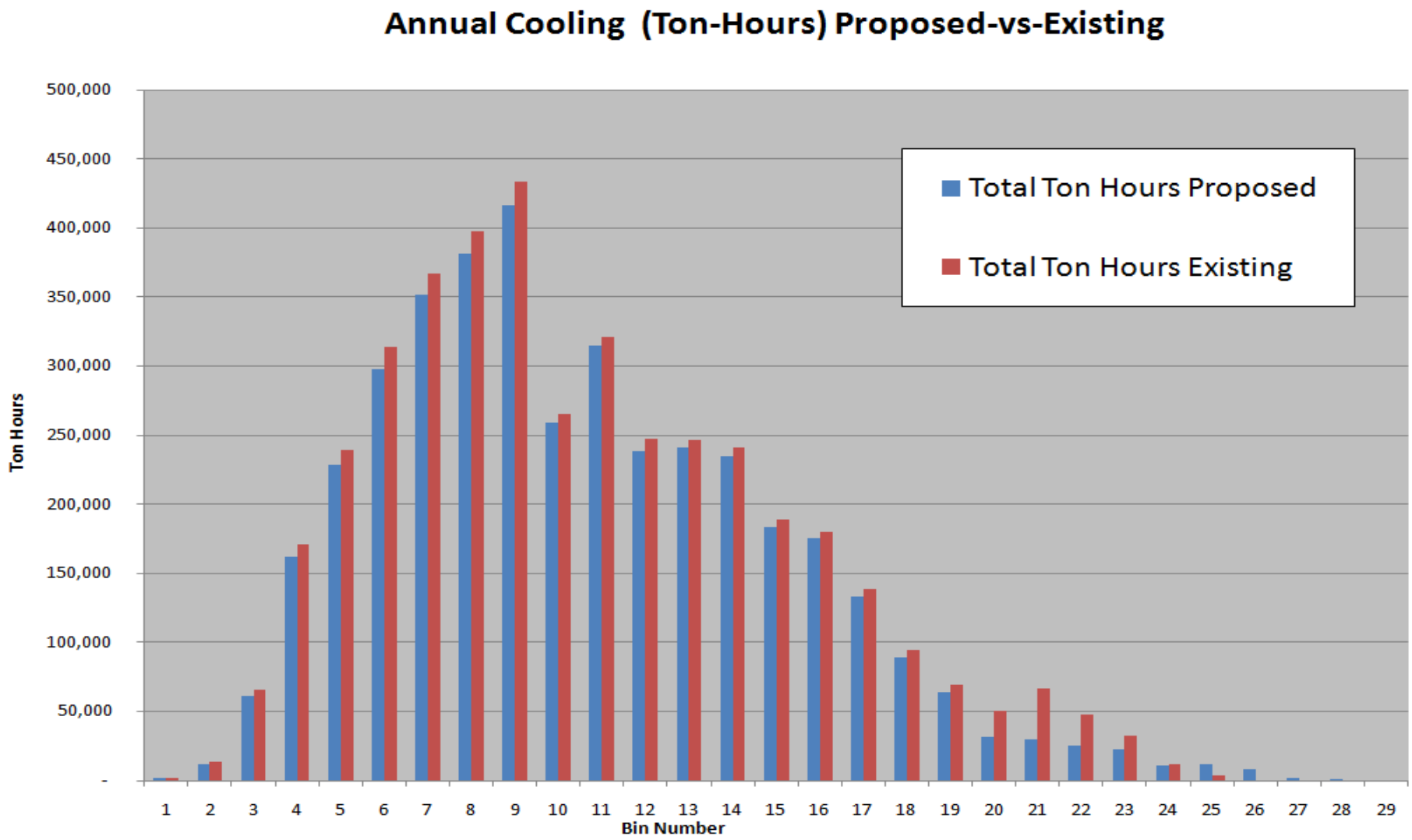
Heat Recovery



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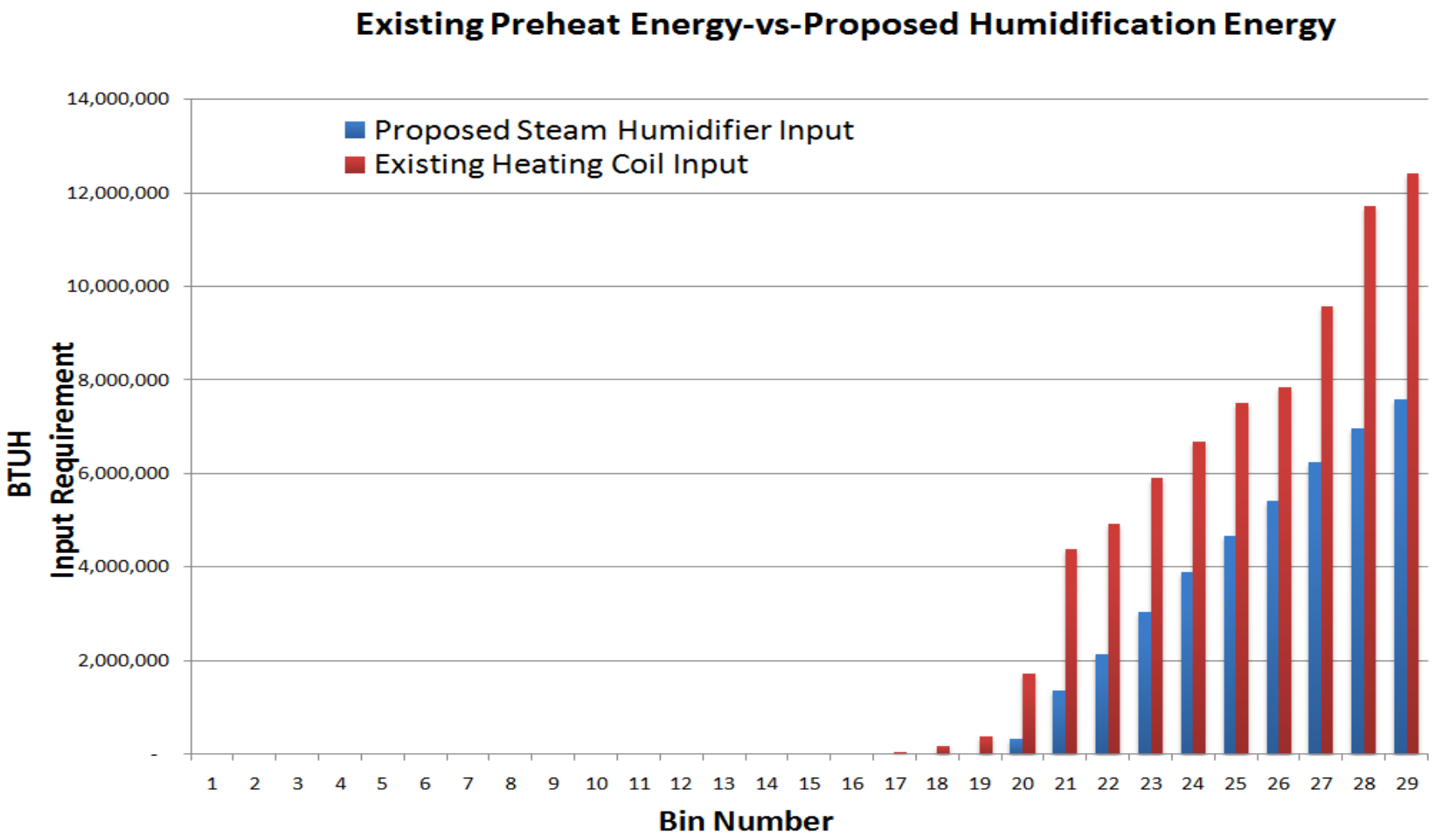
Preheat Energy –Vs – Humidification Energy



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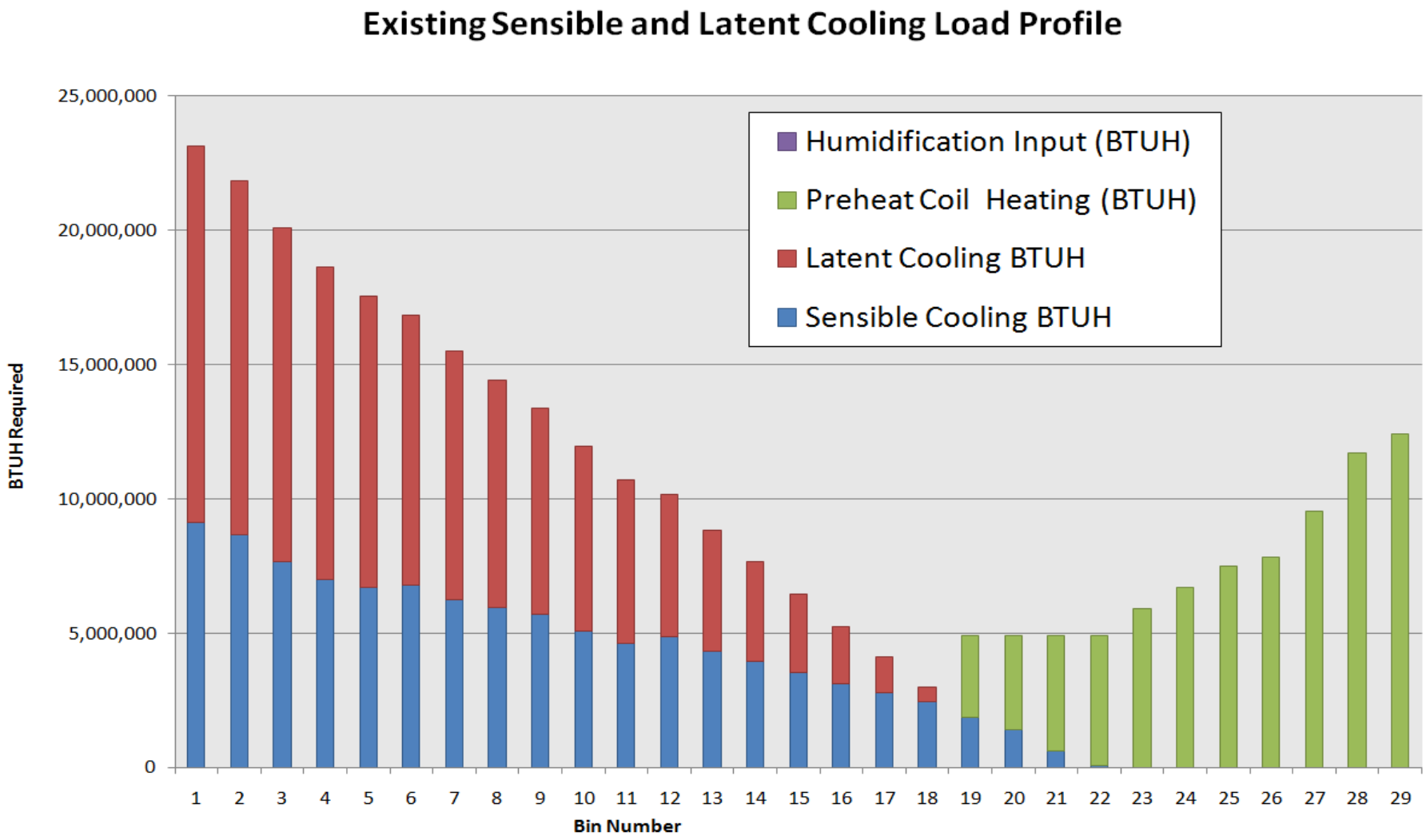
Existing Energy Consumption



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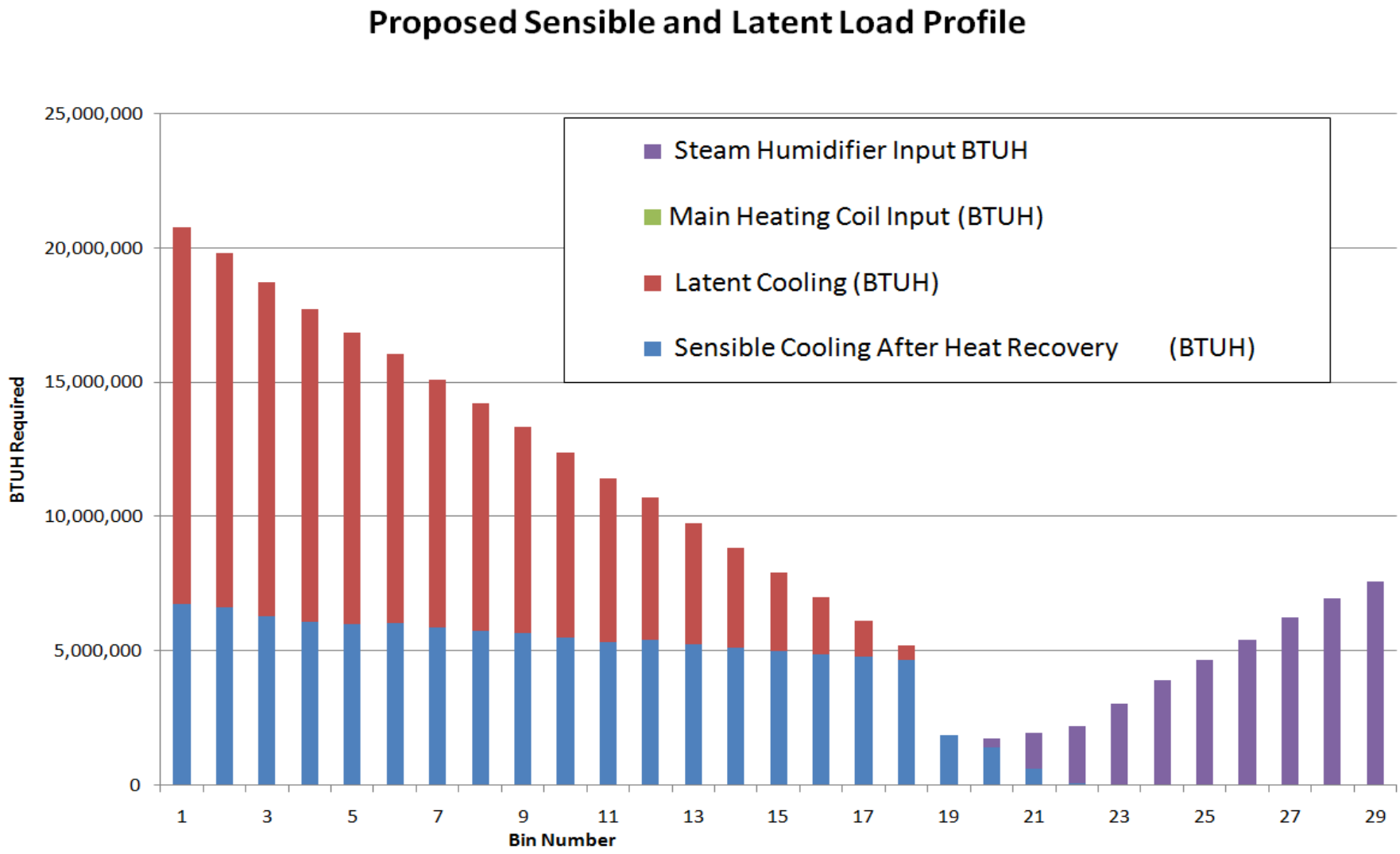
Proposed Energy Consumption



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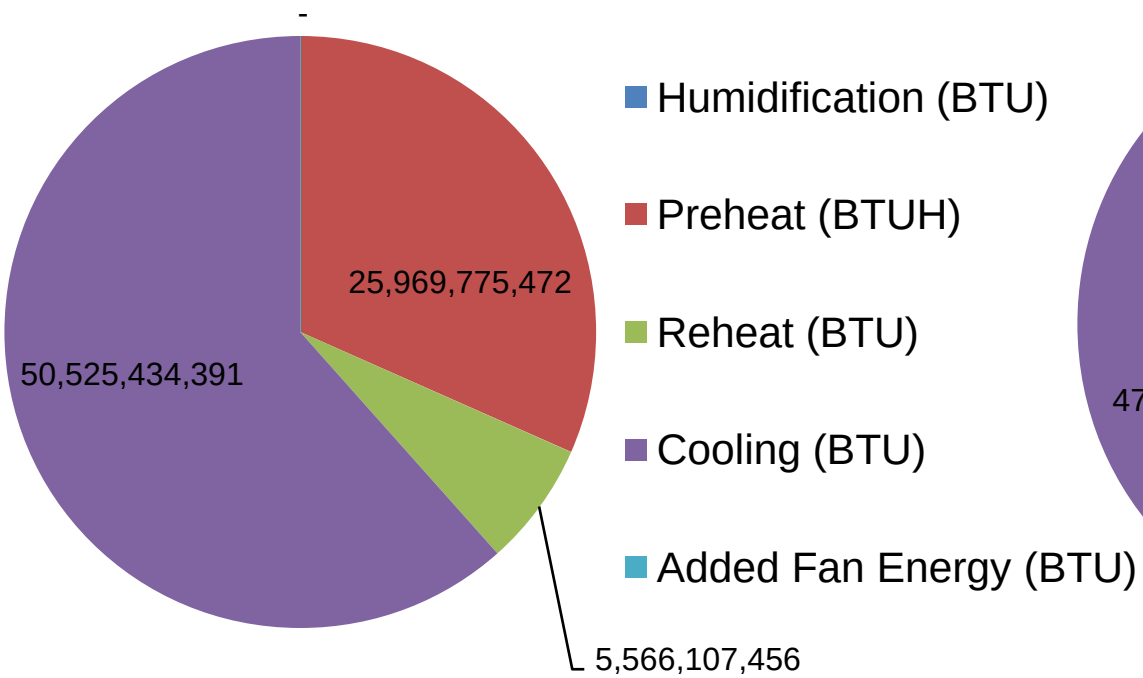
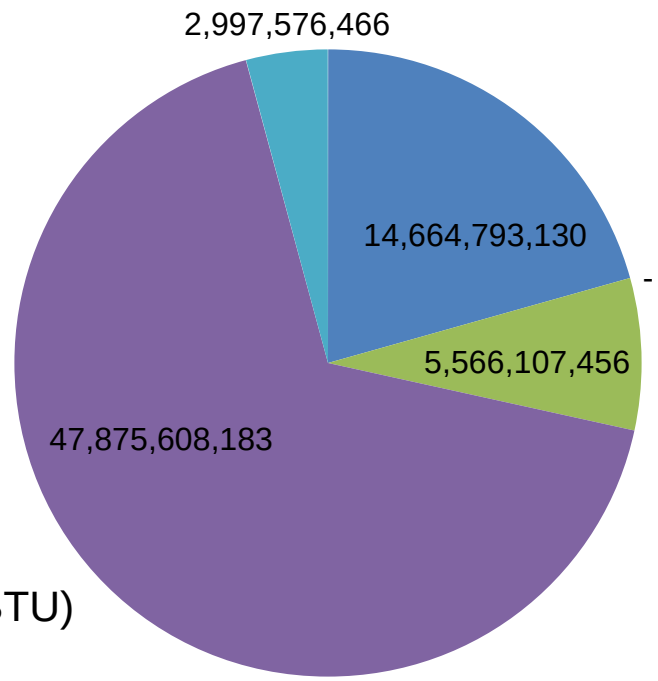
Total Annual Energy Consumption





Total Existing

Energy Consumption

82,061,317,319 BTUH

Total Proposed

Energy Consumption

71,104,085,236 BTUH

10,957,232,083 BTUH SAVED

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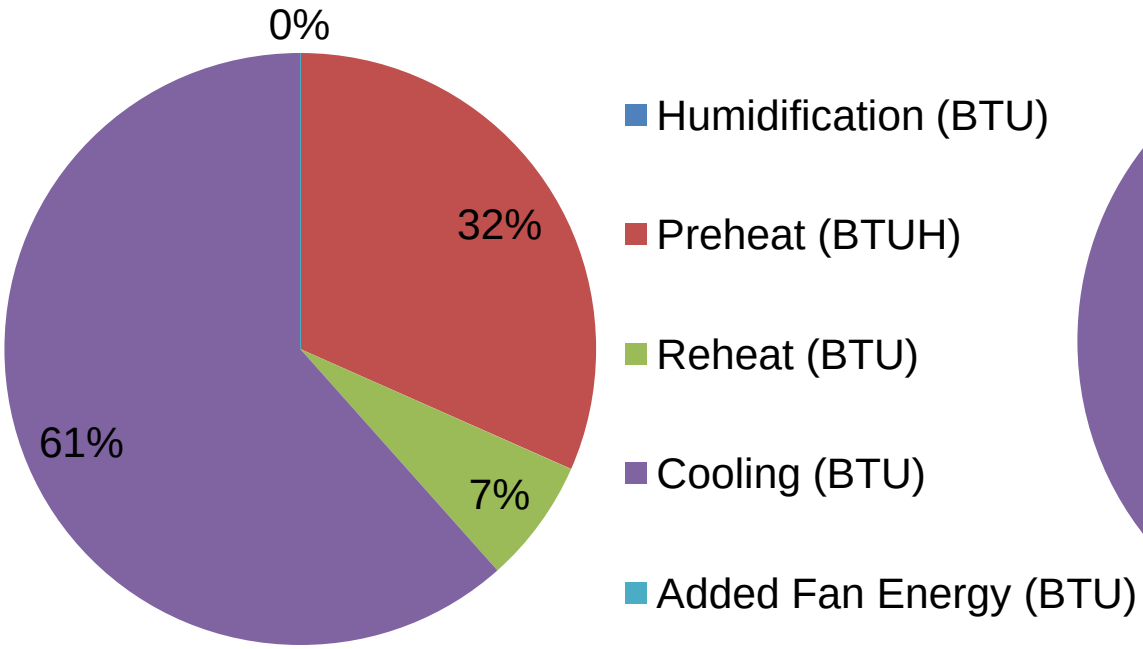
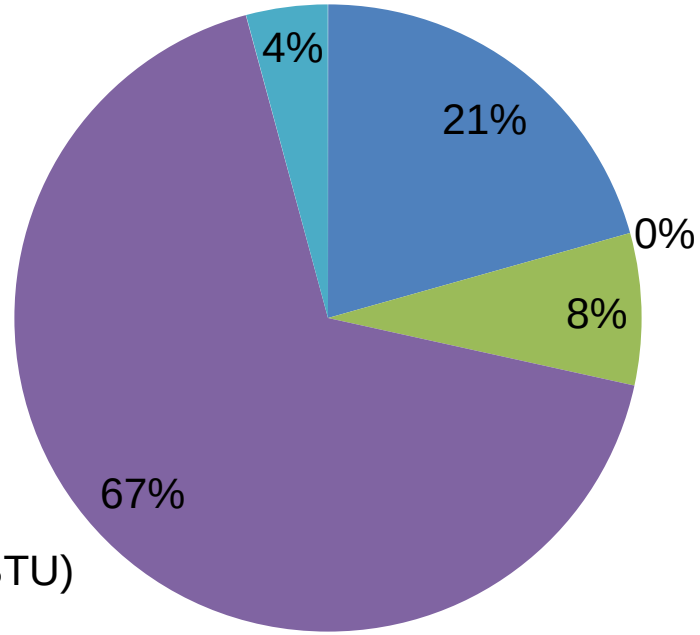
Percent Annual Energy Consumption





Total Existing

Energy Consumption

82,061,317,319 BTUH

Total Proposed

Energy Consumption

71,104,085,236 BTUH

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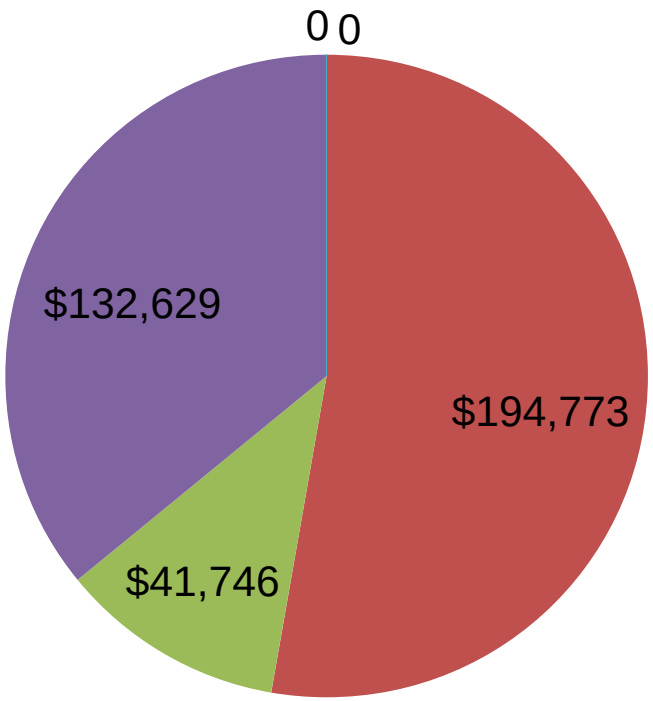
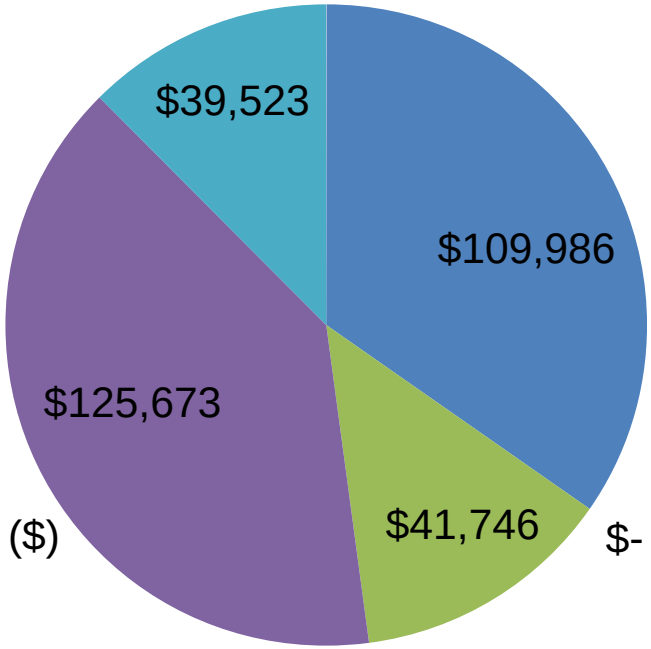
Total Annual Energy Cost



Humidification ($)
Preheat ($)
Reheat ($)
Cooling ($)
Added Fan Energy ($)



Total Existing Energy Cost

$369,148

Total Proposed Energy Cost

$316,928

$ 52,220 Saved

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