HIGH TEMPERATURE HEAT PUMPS FOR SPACE HEATING

Moderator: Aaron Schauger | *LaBella Associates*

Speakers: Sean Jarvie | *Flow Environmental Systems*

Chris Devins | *Trane*

Javier Aleman | *Energy Machines*

Decarbonizing Heating and Cooling

Flow

Environmental Systems Inc

Flow

Environmental Systems Inc

Who We Are

US company bringing commercially viable and environmentally responsible HVAC&R technologies to market.

Our Purpose

1. Decarbonize and Detoxify
2. Eliminate the need for fossil fuels
3. Serve harder to electrify end-use cases

Our Mission

To leave the planet in a better state than we found it.

The Problems

The EXISTING Built Environment contributes to ~40% of all greenhouse gas (GHG) emissions.

How do we retrofit existing systems?

The global building stock is expected to double by 2060.

How do I build a better building?

We need to reduce building emissions.

- Voluntarily
- Regulatory

Biggest Levers

- Electrification of Heat
- Heat Pumps
- Refrigerants

Refrigerants for Heat Pumps

		Natural			Synthetic High Pressure			Synthetic Low Pressure				
	Regulation Targets	**R-744 CO2**	R-290 Propane	R-717 Ammonia	R-410a	R-32	R-454B	R-134a	R-513A	R-1234yf	R-1234ze	R-1233zd
Composition		**Pure**	Pure	Pure	Blend 50% R-32 50% R-125	Pure	Blend 68.9% R-32 31.1% R-1234yf	Pure	Blend 44% R-134a 56% R-1234yf	Pure	Pure	Pure
Type		**CO2**	HC	NH3	HFC	HFC	HFO	HFC	HFC / HFO	HFO	HFO	HCFO
GWP_{100}	<750 <150	**1**	3	0	2256	677 771	467 531	1530	571	1	1	4
ODP	0	**0**	0	0	0	0	0	0	0	0	0	0.00034
Safety Class	A1	**A1**	A3	B2L	A1	A2L	A2L	A1	A1	A2L	A2L	A1
PFAS	No	**No**	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

1.) GWP's based on IPCC AR5. Items in yellow are changes coming in IPCC AR6

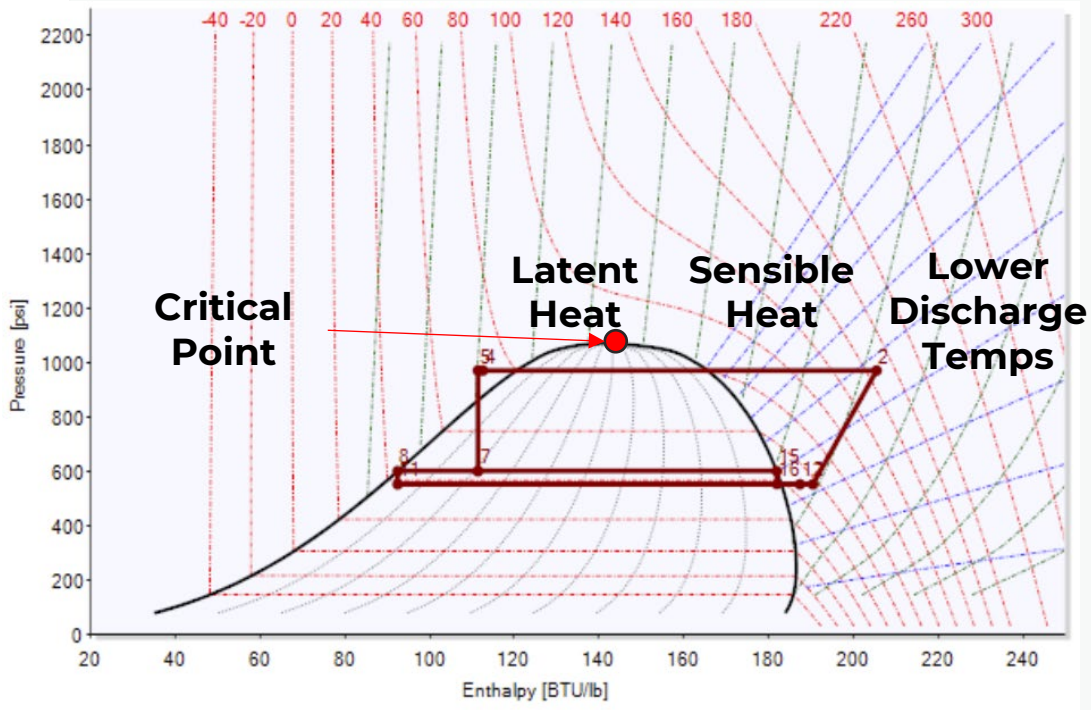
High Temp for Space Heating												
Max Temp (°F)	>180	**315+**	187	250	140	152	151	194	183	183	208	311

	Transcritical	**Subcritical**

What is different with a CO2 Heat Pump?

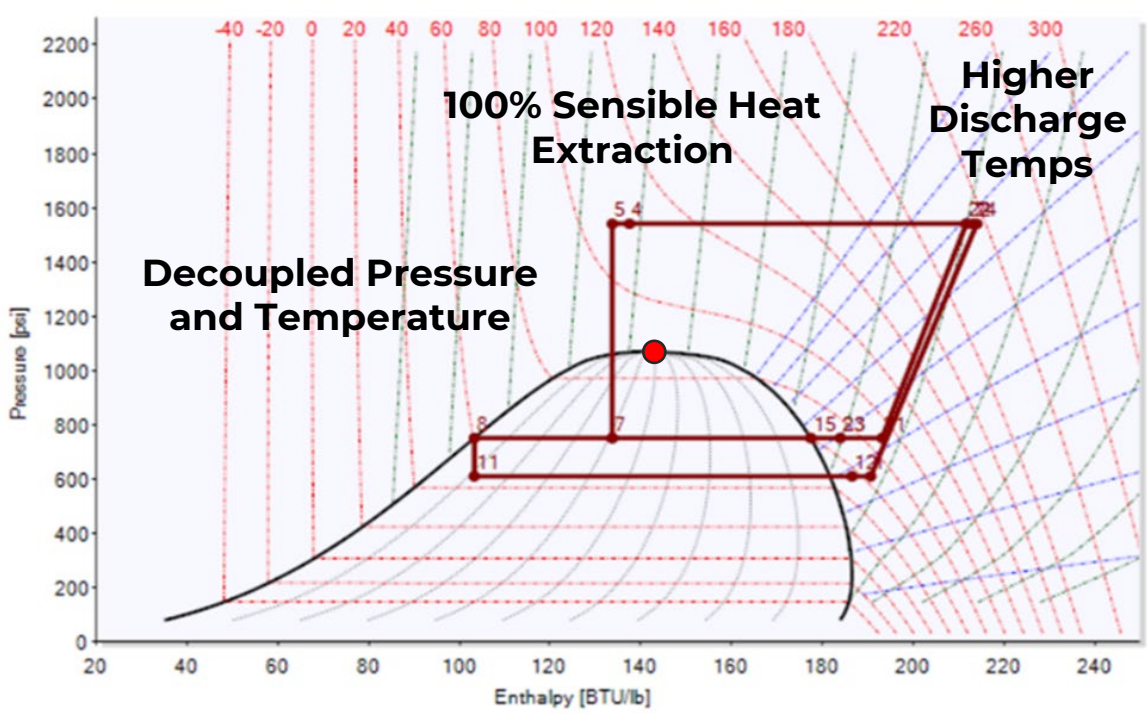
Subcritical

Refrigerant condenses in the condenser



Transcritical

Refrigerant does NOT condense in the gas cooler



ANSWER

CO_2 Heat Pump

Air-to-Water and Water-to-Water

HVAC Heating and Cooling

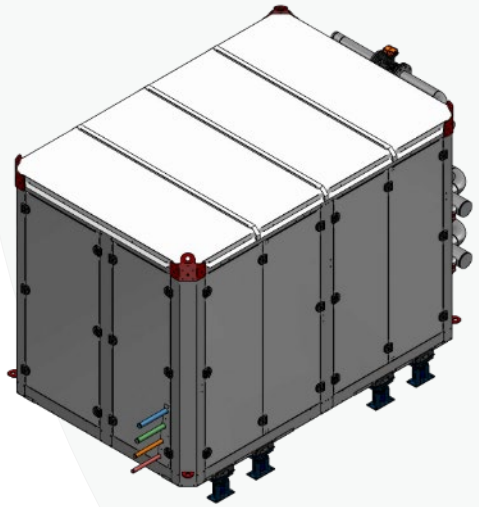
Simultaneous Heating and Cooling

Domestic Hot Water Production

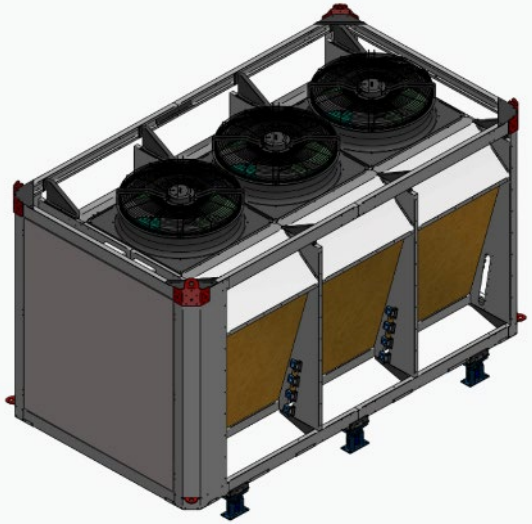
Hot Water Boilers

Split System

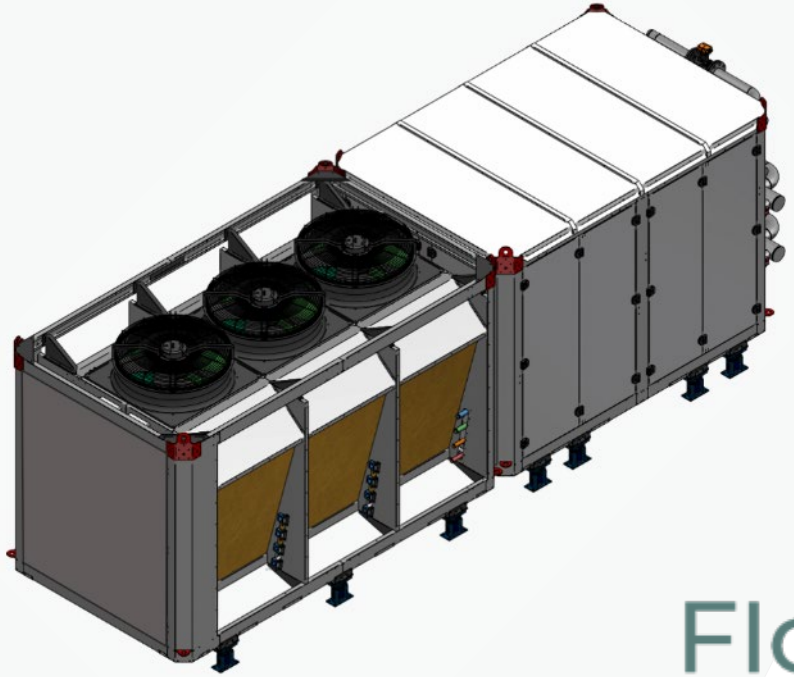
Heat Pump



Gas Cooler



Packaged

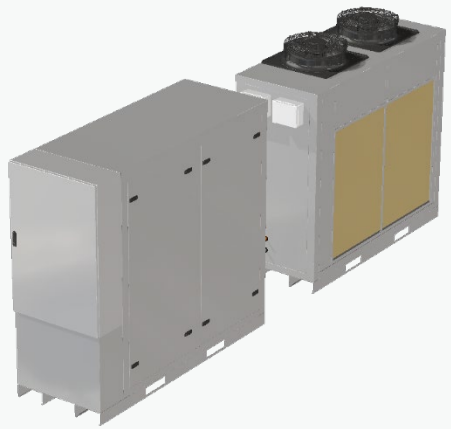


Flow

ANSWER Heat Pumps Are Configurable

Nominal Sizes: 20, 60, 90, 120 Tons

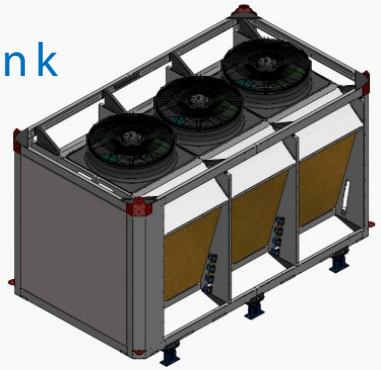
20TR Model
(fits through door and elevator)



Heat Pump(s)

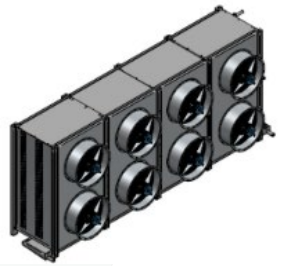
Gas Cooler(s)

V-Bank



Horizontal

Vertical



Modules are designed for parallel installation

Flow

Multiple Modes of Operation

Cooling Only

Heating Only

Simultaneous Heating and Cooling *

- Geothermal, Heat Recovery, WW Booster
- True simultaneous heating and cooling
- No reversing valves

Operational Range

- -15°F to 120°F ambient outside air temps*
  - -40°F option available
- No defrost derate *

Heat Pump

- AHRI Standard 550/590
- Cooling Supply: 38°F to 75°F
  - (colder with antifreeze)
- Heating Supply: 90°F to 180°F
  - High RWT WWHP 140°F and AWHP 170°F
- Variable refrigerant flow for stability *

Domestic Hot Water

- Up to 180°F Supply Hot Water *
- Large ΔT, as high as 140°F *

Boiler

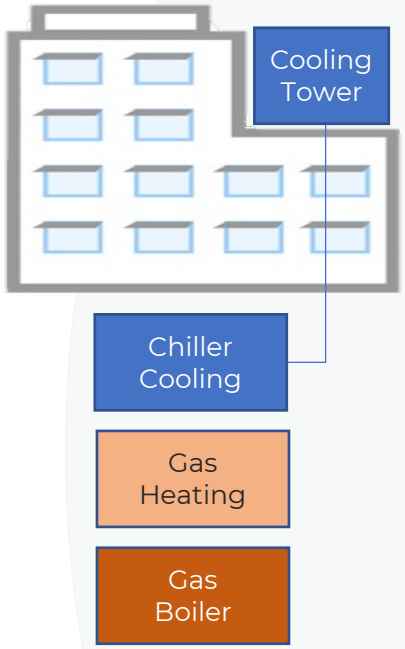
- Up to 180°F Supply Hot Water *
- Tight ΔT, as low as 20°F *

** Patent Pending*

Flow

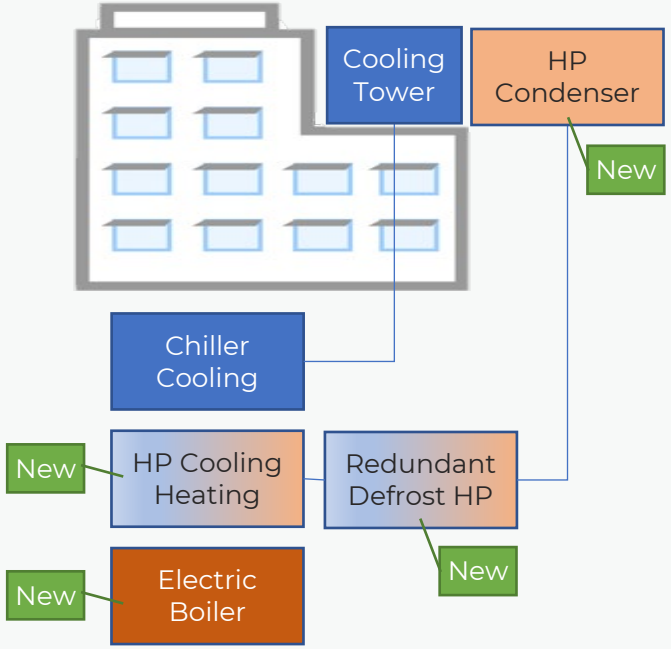
Streamlined and Efficient

Legacy Systems



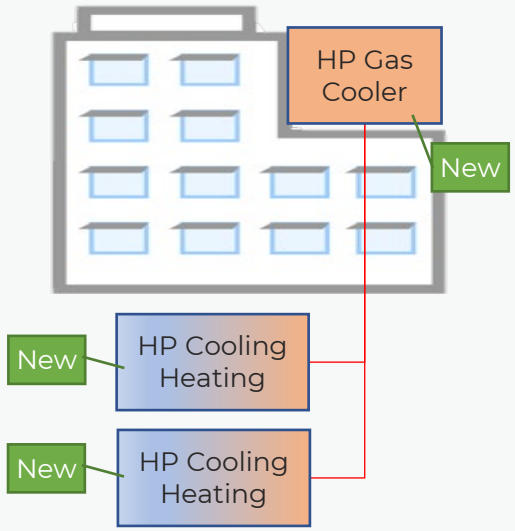
- Many separate systems
- Cooling: Central Chiller with high GWP refrigerant
- Heating: 100% combustible fossil fuel

Synthetic Heat Pumps



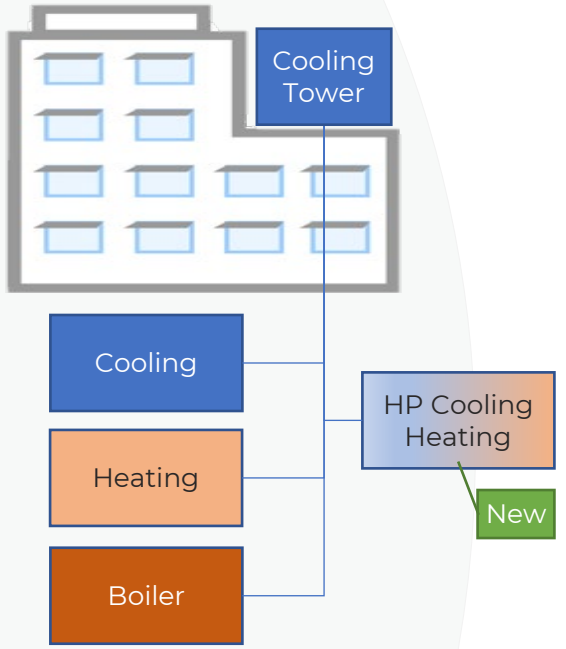
- More equipment
- Cooling: 100% electric central system with high GWP refrigerant
- Heating: HFC/HFO equipment with high GWP's
- Heating Supply Temps >135°F: Electric boiler or booster heat pump

Answr Heat Pump New Construction



- **Eliminate Redundant Defrost**
- **Eliminate Electric Boiler**
- **Efficient:** 1 power feed, multiple outputs
- **Save Space, less equipment**
- Parallel for **large installations**

Answr Heat Pump Retrofit



- **No new power feed**
- **Electrify heating, replace chiller**
- **Do not need to change building systems** (pipes, coils, AHU's, etc...)
- **Stage installation**
- **Wide operational range to match load at all OAT**

HIGH TEMP HOT WATER HEAT PUMPS

The Empire Technology Prize is focused on groundbreaking solutions to tackle the greatest single source of GHG emissions from New York's tall buildings — **heating**.

THE CLEAN FIGHT NEW YORK

RMI

EMPIRE TECHNOLOGY PRIZE

NEW YORK STATE | NYSERDA Supported

WELLS FARGO

GIL-BAR

Flow

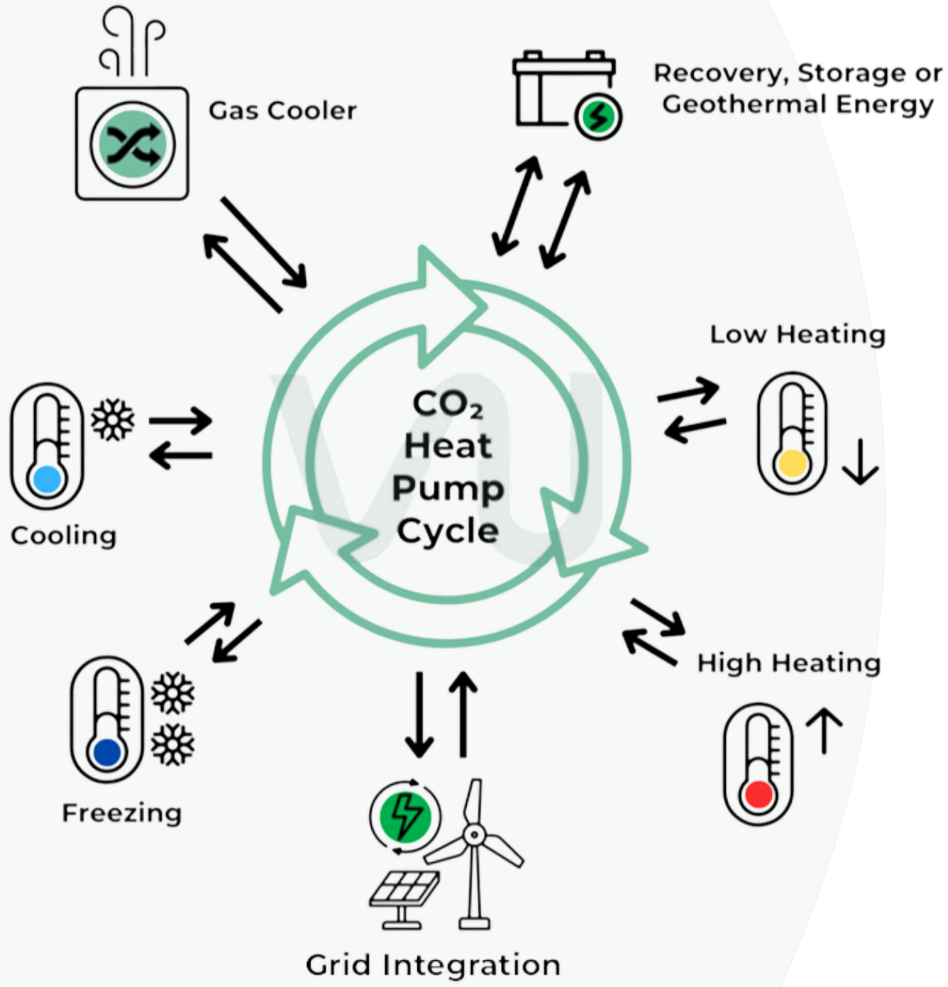
ANSWER

CO_2 Heat Pump

Key Benefits

- Environmentally friendly natural refrigerant (CO2/R744)
- Simplified system design and installs
- High delivery temperatures (up to 180°F)
- Cold climate performance (down to -40°F)
- Efficient (High COP, no defrost, no derates, etc...)
- Seamless transition between heat, cool, and simultaneous heating and cooling
- Robust supply chain
- Low carbon emissions
- Low total cost of ownership
- Minimal infrastructure changes
- Future proof (Regulations)

Energy Optimization



Flow

Environmental Systems Inc

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See Flow website for others

High Temp Solutions

All Electric. All Weather Comfort.

Chris Devins, Strategic Sales Leader

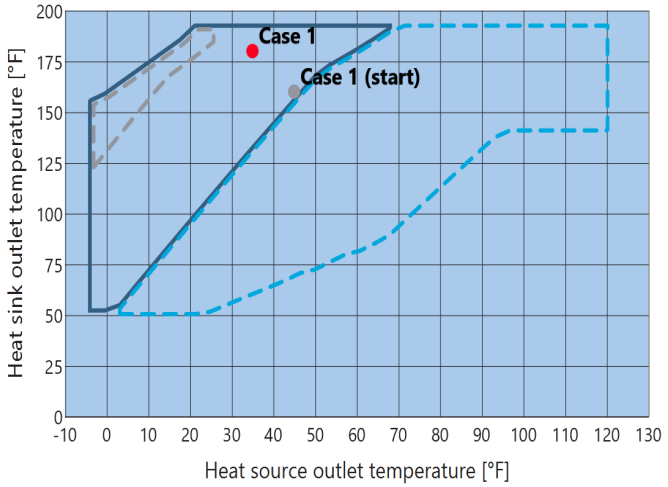
Oilon ChillHeat Industrial Heat Pumps

Type	P-series
Capacity	.15 - 2 MMBtu
Compressor	Piston w/VFDs

Refrigerant	Safety	GWP value*	Max. Outlet T
R513A	A1	573	176 °F
R515B	A1	293	212 °F
R450A	A1	547	194 °F
R1234ze	A2L	<1	212 °F
R1233zd	A1	1	248 °F

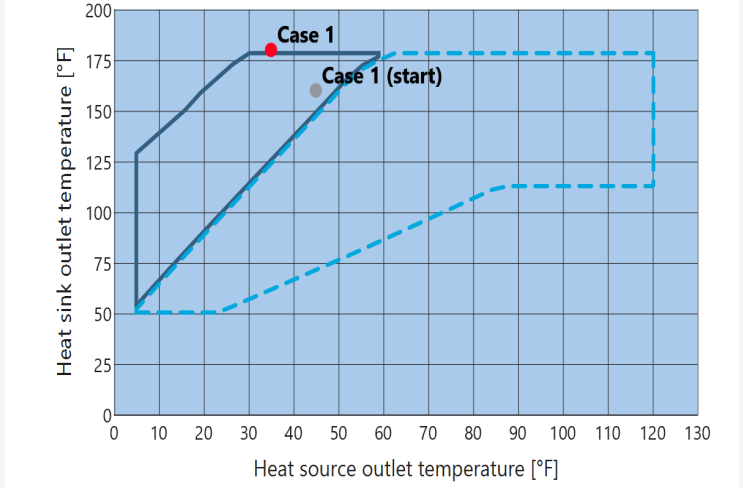
Application of temperature range

R450



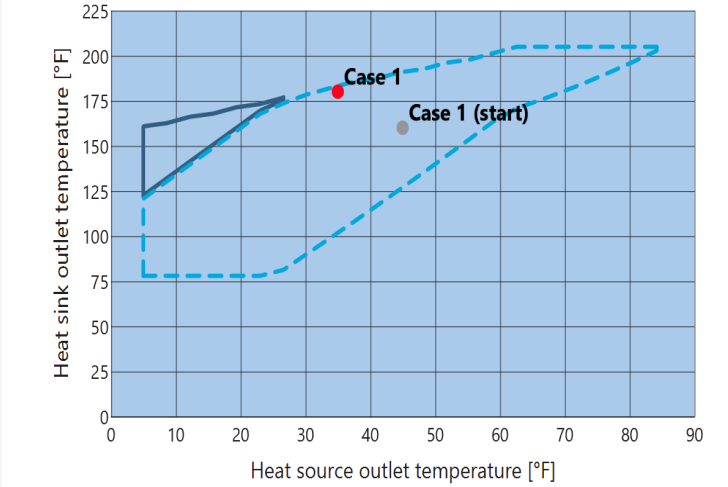
Lift: 175°F
Max: 195°F
Highest COP

R513A



Lift: 140°F
Max: 176°F
Highest Cap.

R515B



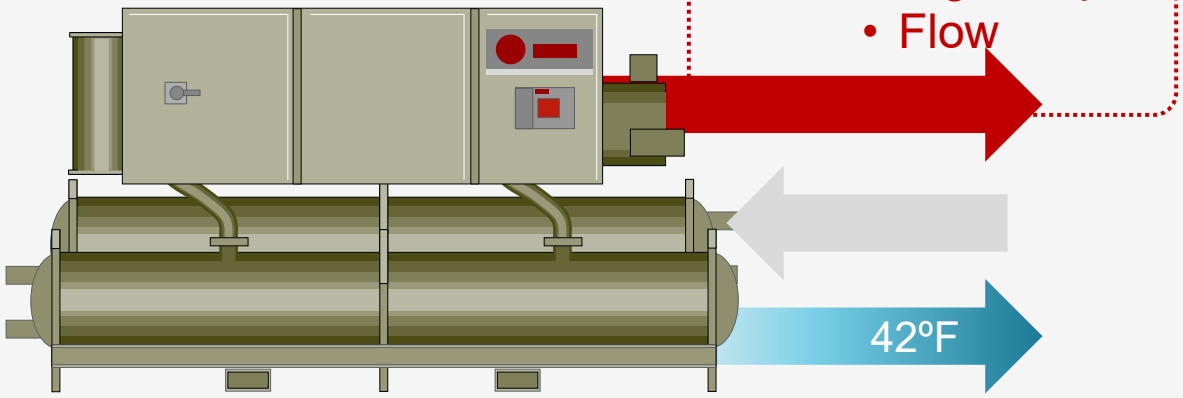
Lift: 160°F
Max: 210°F
Highest LWT

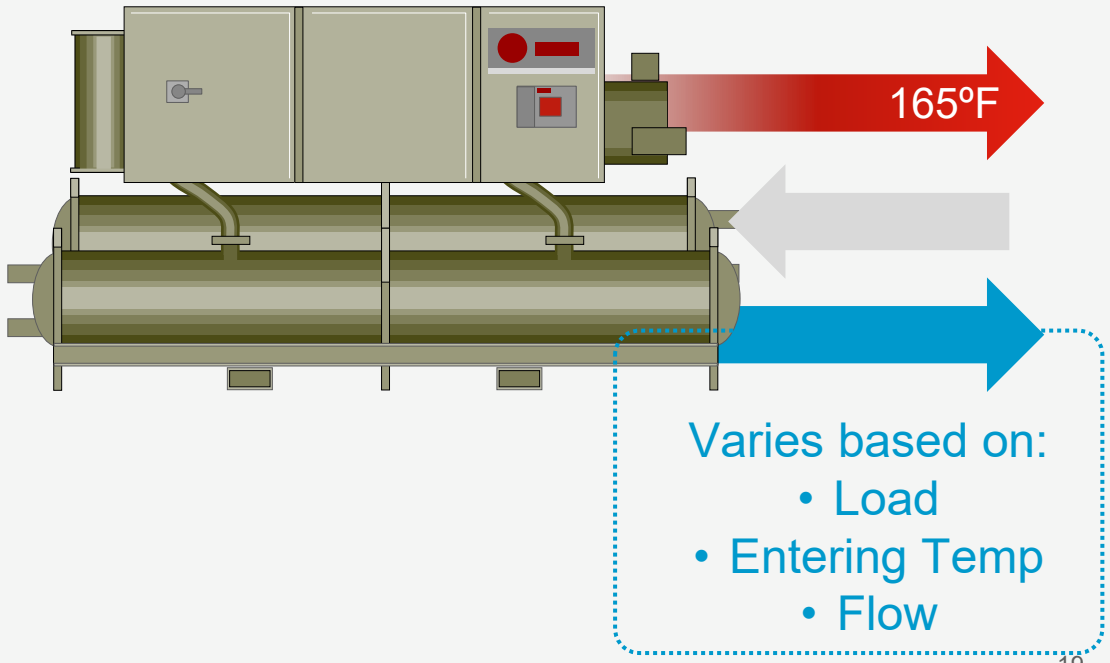
Chiller/Heater

(non-reversing HP)

Cooling Mode

Heating Mode





High Temp Chiller/Heaters

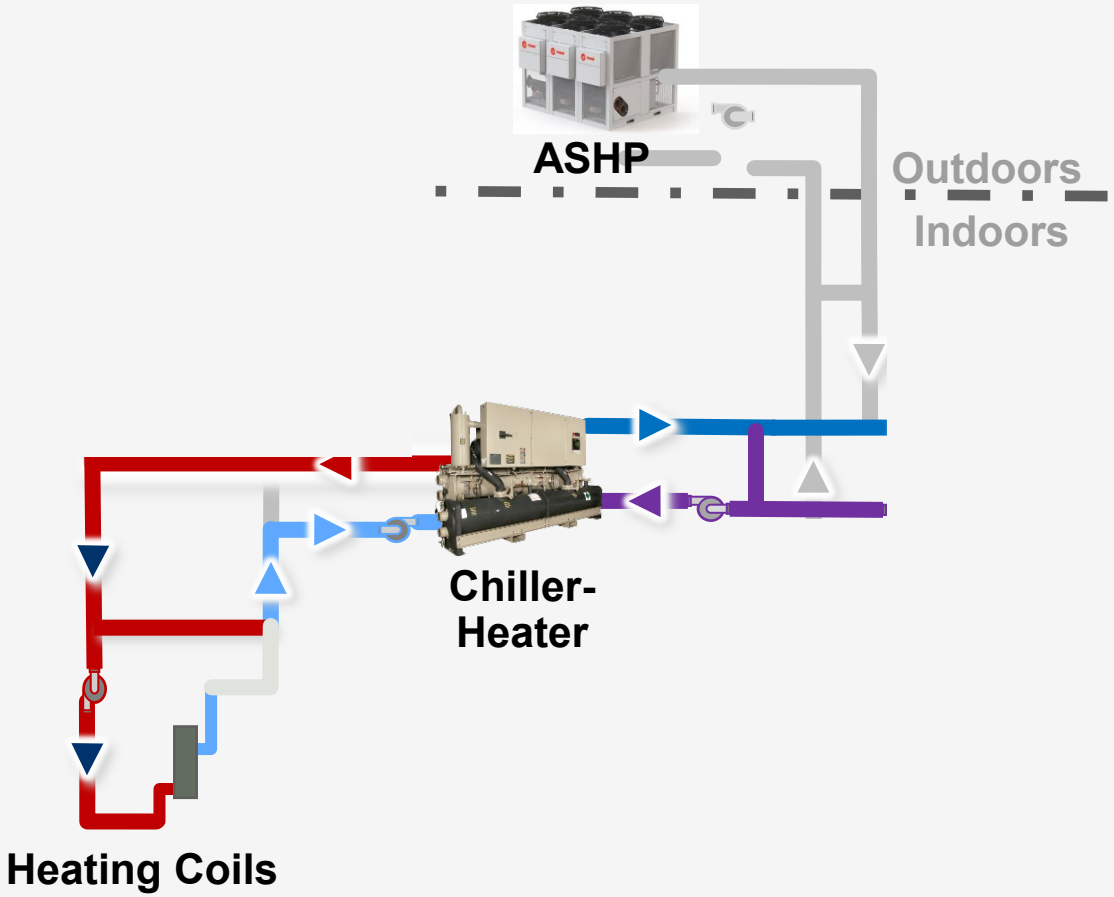
Screw (RTWD) HP

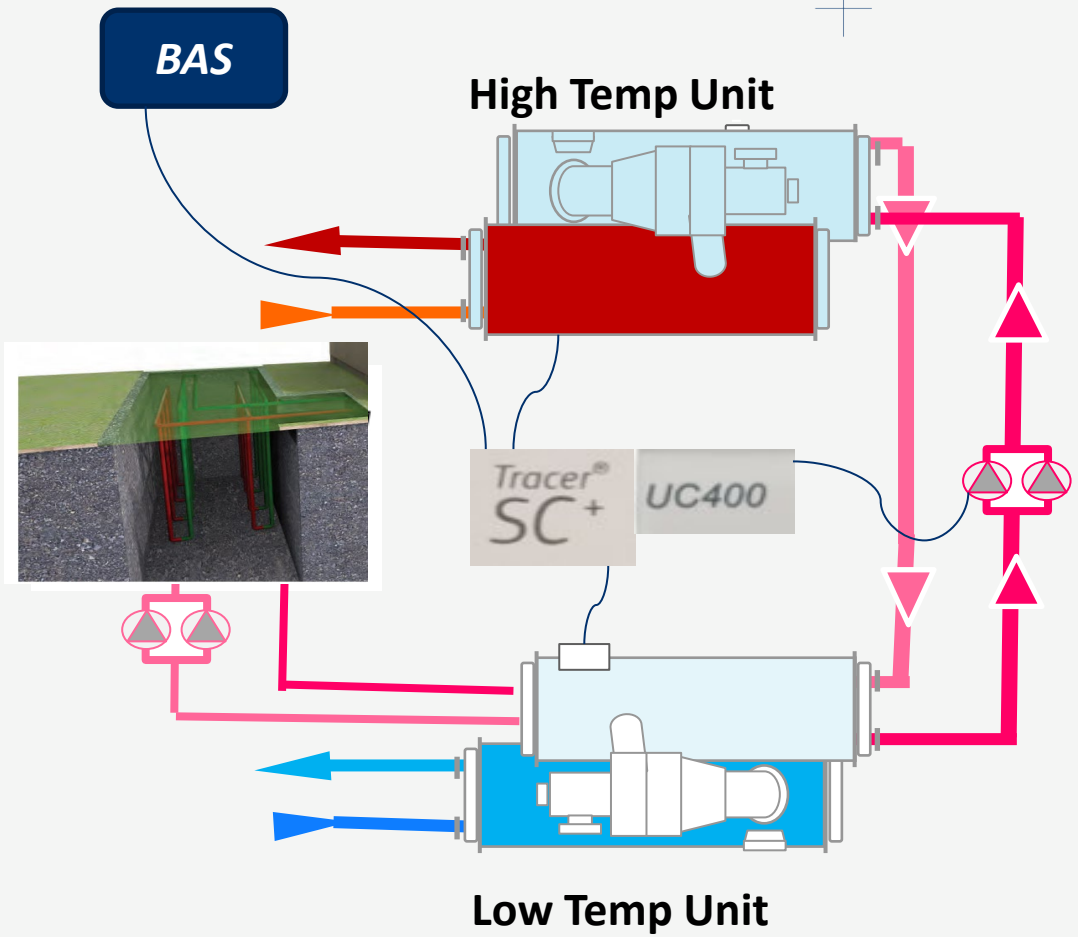
- <2.9 MMBtu with leaving HW temps up to 200°F
- 100F lift at 165F with R515b
- 80F lift at 200F with R1233zdE
- Turndown: 30%

Centrifugal (CenTraVac) HP

- 11-35 MMBtu with leaving HW temps up to 180°F
- 90F lift at 180F
- Turndown: 25%

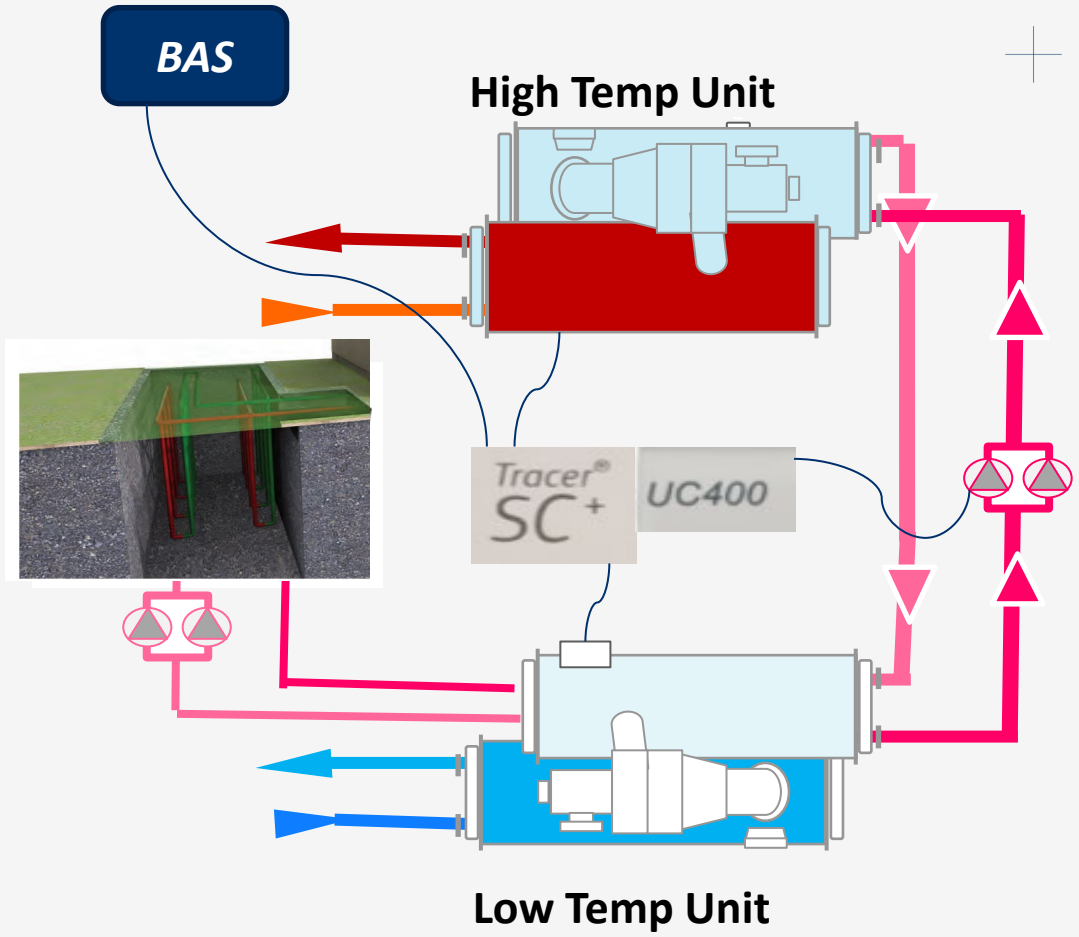
Cascaded Systems



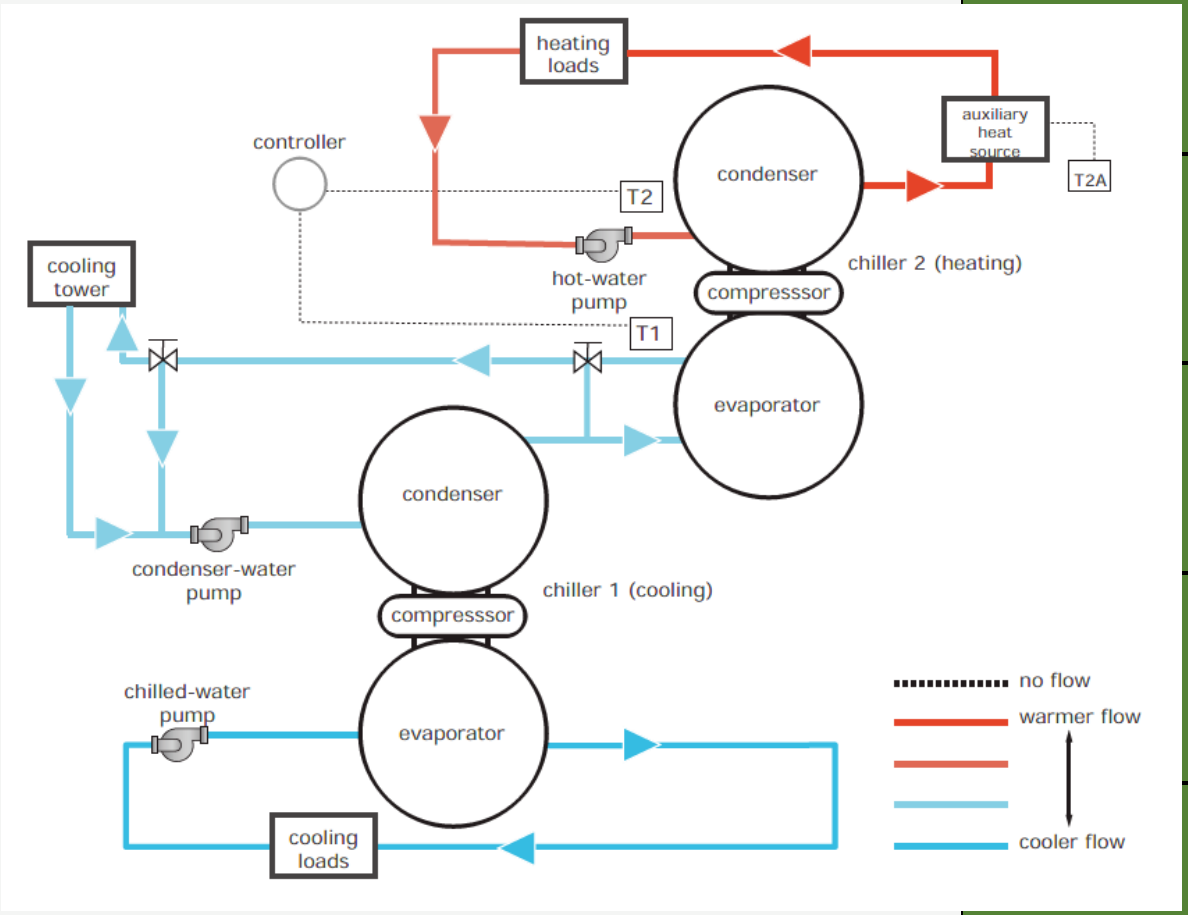


Cascaded System

- When to consider?
  - High temp or lift applications
  - Large systems
  - Dual temp systems/campuses
- Why?
  - Reduce first cost
  - Utilize more standard equipment/compressors
  - Allow for HR flexibility
  - High temp unit adds cooling redundancy
  - Utilize existing infrastructure for low temp side

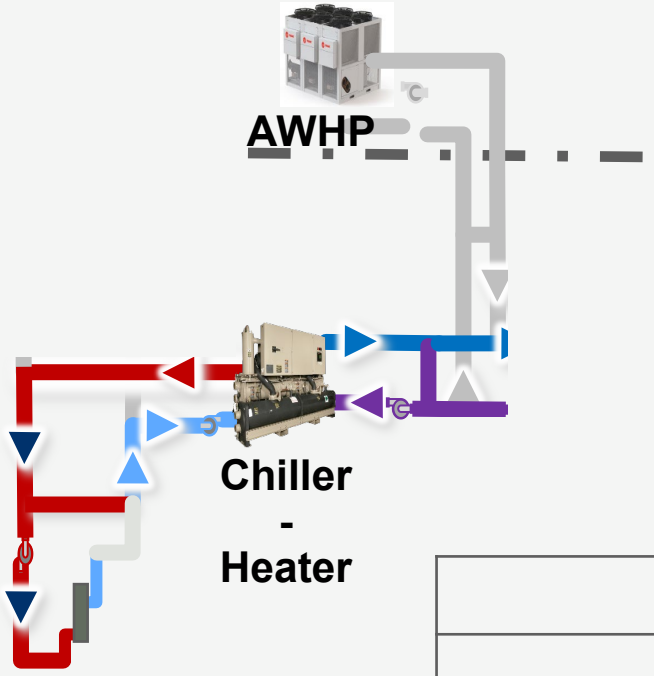


Cascaded Systems



		Cascade Leaving Cond Temp				
		180	170	160	150	140
Cascade Leaving Evap Temp	Refrigerant: Low Temp Unit Refrigerant: High Temp Unit	R1233zd R514A	R1233zd R514A	R1233zd R514A	R1233zd R1233zd	R1233zd R1233zd
35	Heating COP	2.81	2.95	3.13	3.27	3.3
35	Simultaneous COP	4.64	4.93	5.28	5.54	5.62
35	Cascade Heating Capacity MBH	30,000	30,000	30,000	30,000	30,000
35	Cascade Cooling Capacity Tons	1,629	1,674	1,721	1,732	1,763
35	LT PPDE	23.4	24.6	25.8	26.1	27
35	HT PPDC	8.4	8.5	8.6	8.7	8.9
40	Heating COP	2.85	3.04	3.21	3.38	3.59
40	Simultaneous COP	4.72	5.11	5.45	5.8	6.22
40	Cascade Heating Capacity MBH	30,000	30,000	30,000	30,000	30,000
40	Cascade Cooling Capacity Tons	1,642	1,700	1,743	1,783	1,827
40	LT PPDE	23.3	24.8	26	27	28.2
40	HT PPDC	8.4	8.5	8.6	8.7	8.9
45	Heating COP	2.98	3.14	3.32	3.49	3.74
45	Simultaneous COP	4.98	5.31	5.67	6.02	6.51
45	Cascade Heating Capacity MBH	30,000	30,000	30,000	30,000	30,000
45	Cascade Cooling Capacity Tons	1,682	1,725	1,769	1,807	1,854
45	LT PPDE	23.9	25.1	26.2	27.2	28.6
45	HT PPDC	8.4	8.5	8.6	8.7	8.9
50	Heating COP	3.03	3.3	3.45	3.64	3.91
50	Simultaneous COP	5.08	5.62	5.94	6.32	6.85
50	Cascade Heating Capacity MBH	30,000	30,000	30,000	30,000	30,000
50	Cascade Cooling Capacity Tons	1,695	1,763	1,798	1,837	1,884
50	LT PPDE	24	25.7	26.7	27.7	29
50	HT PPDC	8.4	8.5	8.6	8.7	8.9
55	Heating COP	3.17	3.34	3.58	3.76	4.08
55	Simultaneous COP	5.37	5.72	6.2	6.56	7.19
55	Cascade Heating Capacity MBH	30,000	30,000	30,000	30,000	30,000
55	Cascade Cooling Capacity Tons	1,734	1,774	1,825	1,858	1,910
55	LT PPDE	24.7	25.7	27.1	28	29.5
55	HT PPDC	8.4	8.5	8.6	8.7	8.9

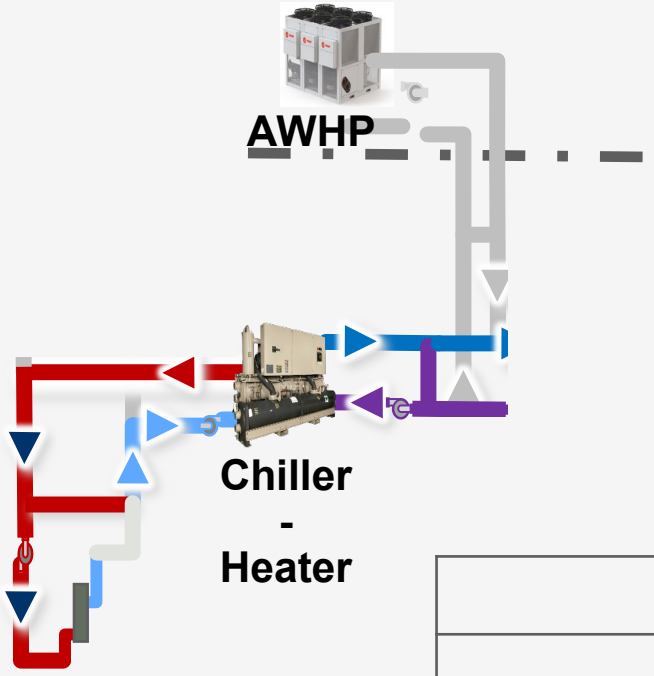
Cascaded Systems



- Design Ambient: 0F
- Heating load: 4,200,000 BTUs
- Design Temp: 160F
- Coincidental cooling load: 0 Tons
- 30% PG

	Modular AWHPs	Cascaded AWHPs
Equipment	(4) banks of (10) 30-ton ETO modules	(5) 230-ton AWHPs (75F LWT) (6) 220-ton chiller/heaters (160F LWT)
Budget (HP's only)	+$5-7 MM	$2 - 3.5 MM

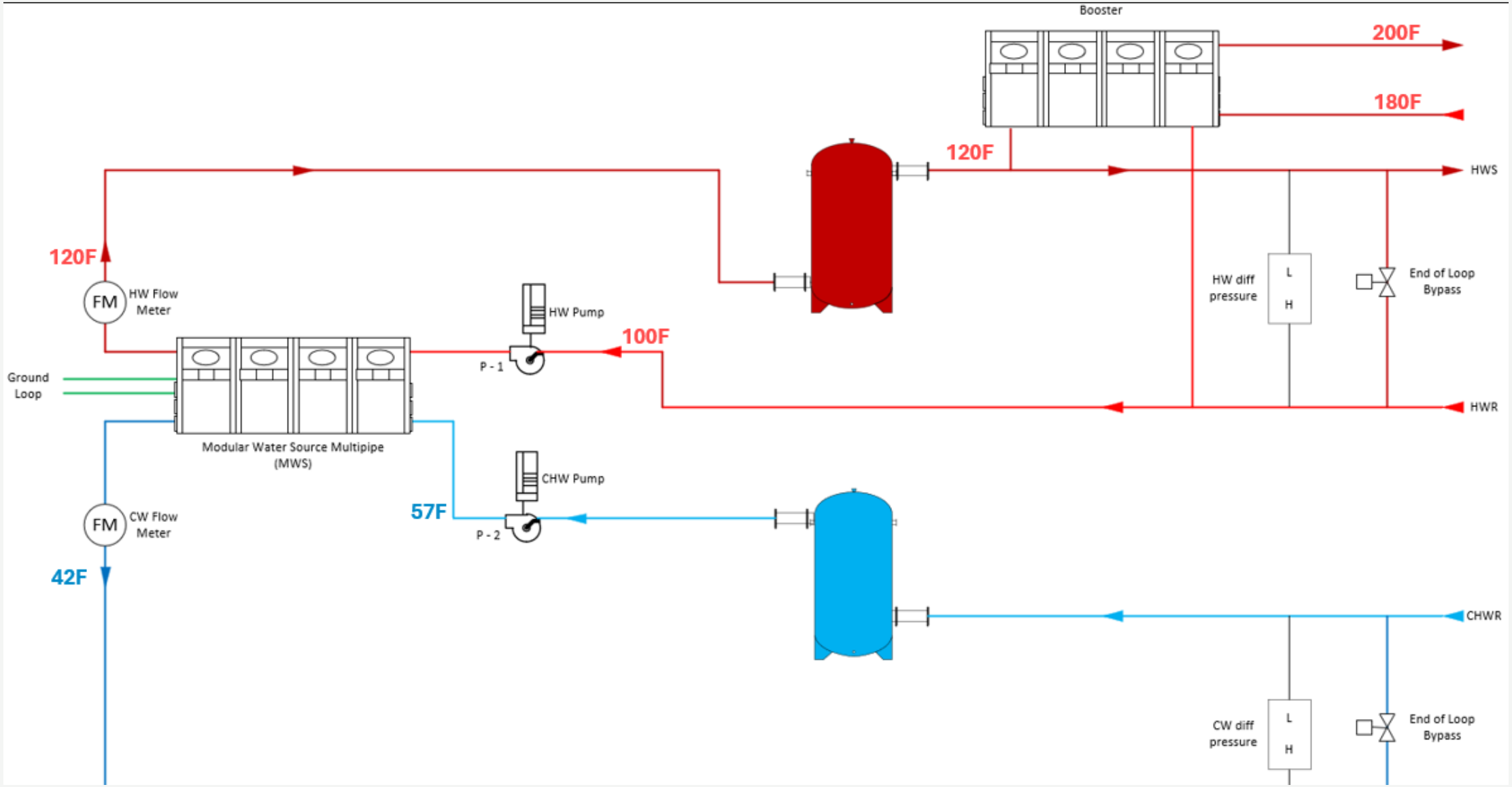
Cascaded Systems



- Design Ambient: 0F
- Heating load: 6,300,000 BTUs
- Design Temp: 120F
- Coincidental cooling load: 0 Tons
- 30% PG

	Modular AWHPs	Cascaded AWHPs
Equipment	(3) banks of (10) 30-ton modules	(4) 230-ton AWHPs (75F LWT) (2) 200-ton chiller/heaters (120F LWT)
Budget (HP's only)	~$3 MM	~$1.5 MM

Cascade Example



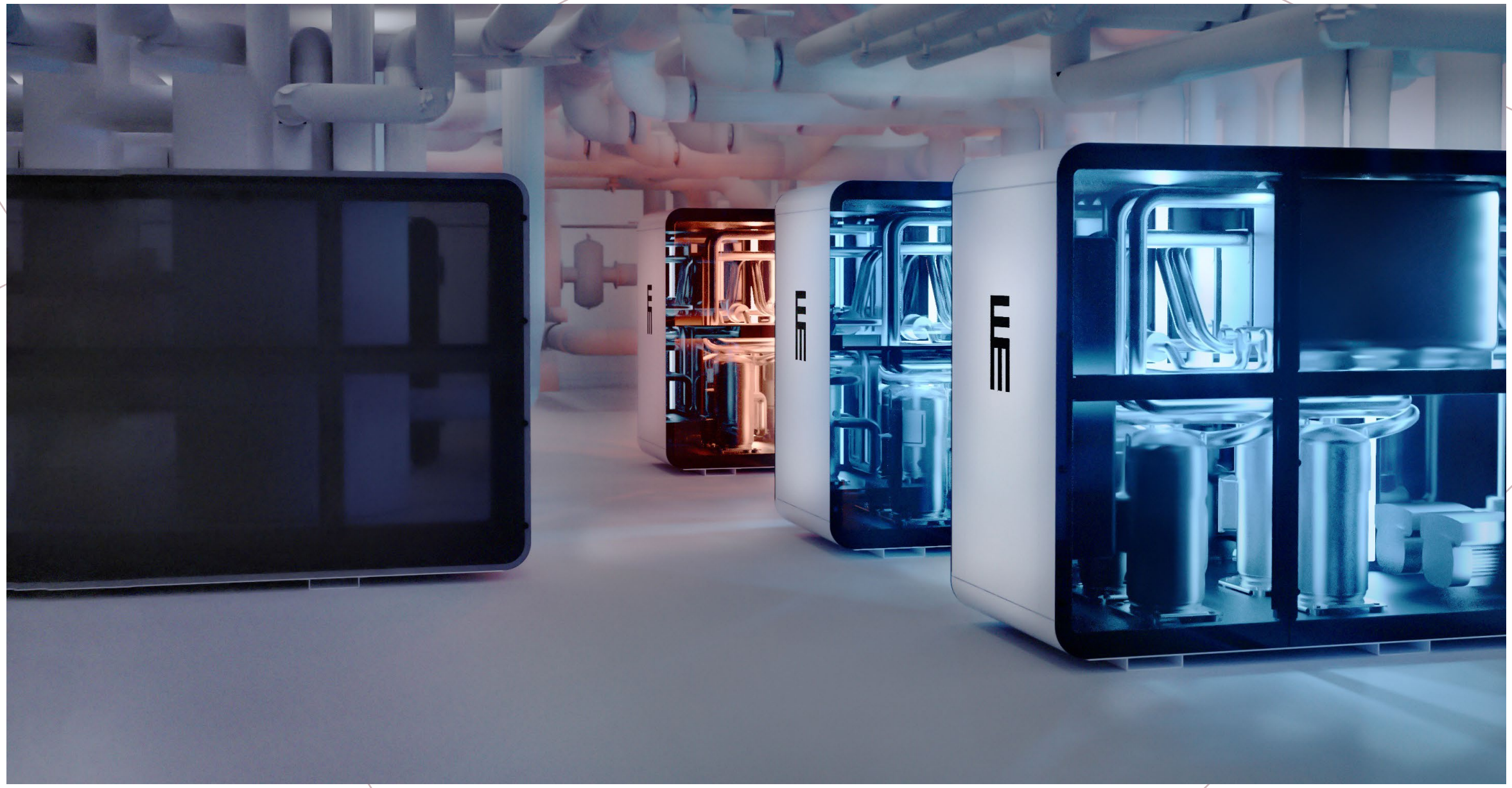
This is an energy machine

(in progress)

345 Hudson Street

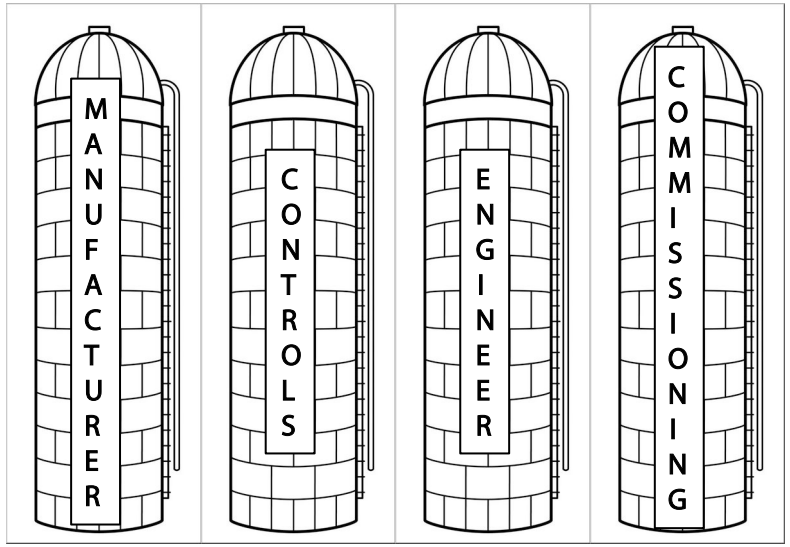
New York, USA

Retrofit of historic 90,885m² building
Heating and cooling are recycled throughout building and neighboring properties via heat pumps, high-efficiency air handling, and flexible system control



ENERGY MACHINES

Today's Standard Practice



VS

ENERGY MACHINES

Commissioning

↑

Energy Modeling / System Design Assistance

↑

System Automation / BMS

↑

Manufacturer

HEAT PUMP FAMILIES

Low HW Temp		CHW – 44F HW – 126F
Mid HW Temp		CHW – 44F HW – 150F
High HW Temp		CHW – 44F HW – 180F+

A1 low GWP or A2L Refrigerants

ENERGY MACHINES

No Minimum Flow

No Minimum Turn Down

Best In Class Efficiency COP: 4 to 10+

Self Balancing System

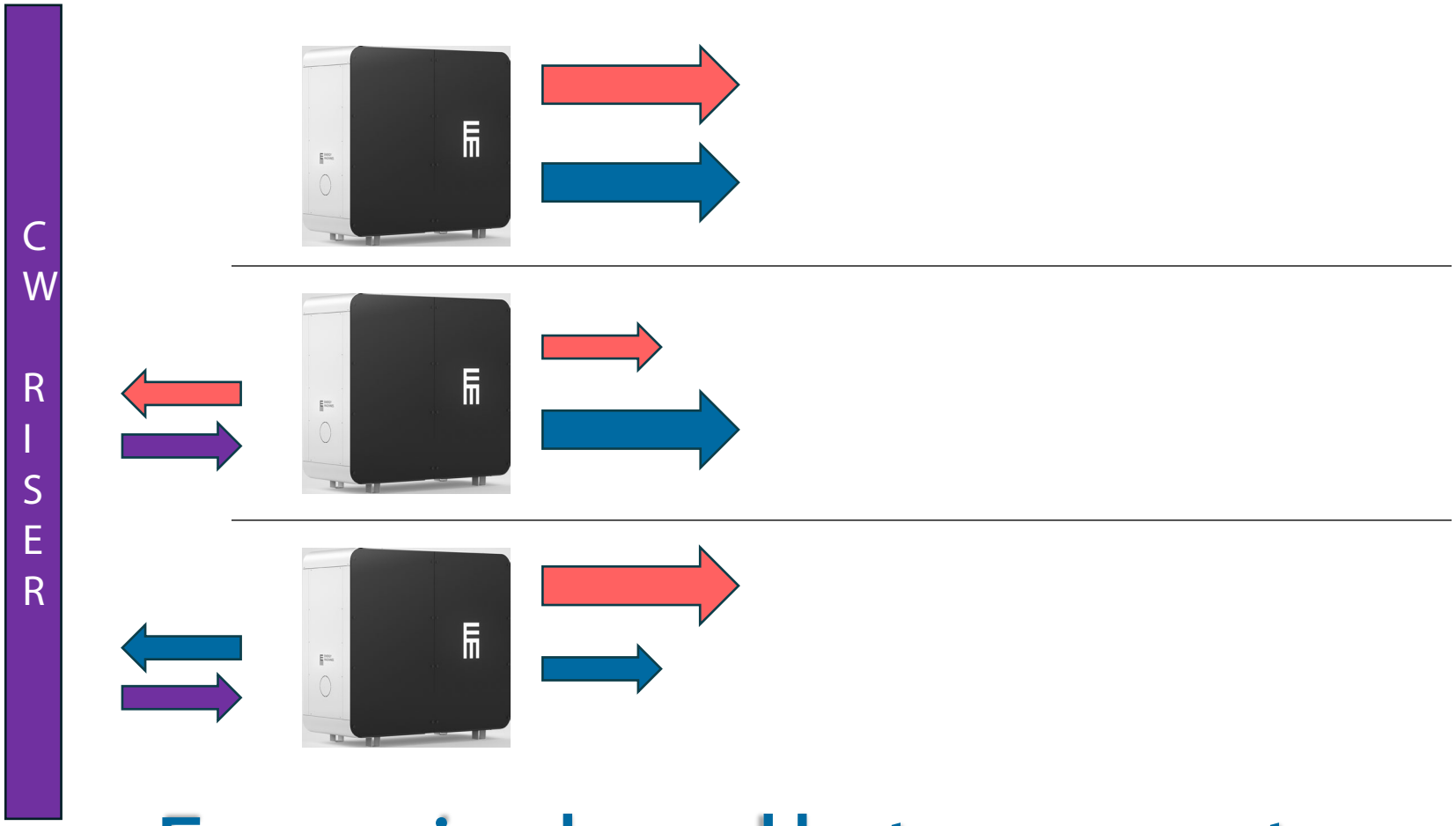
Easily Expandable or Contractible

Energy is Redirected

Manufacturer Controls Beyond the Chassis

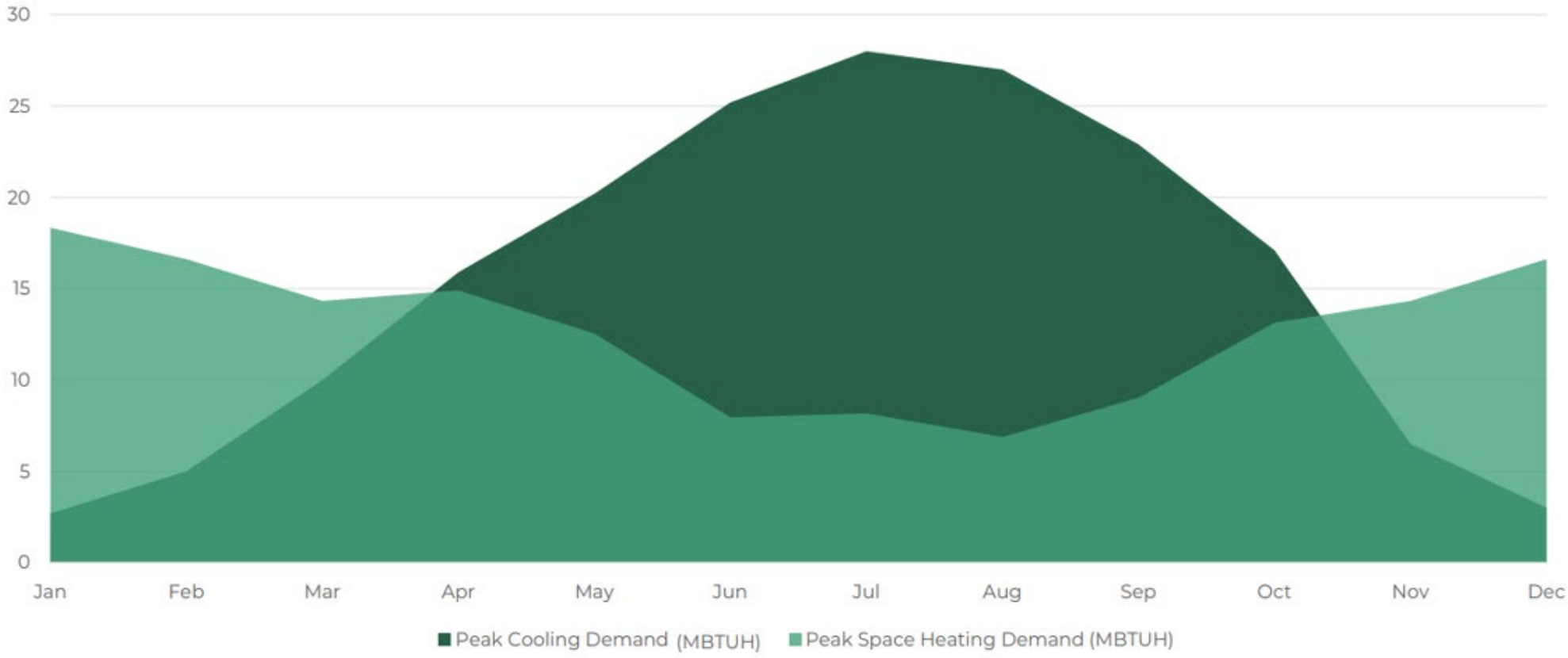
ENERGY MACHINES

THERMAL NETWORK

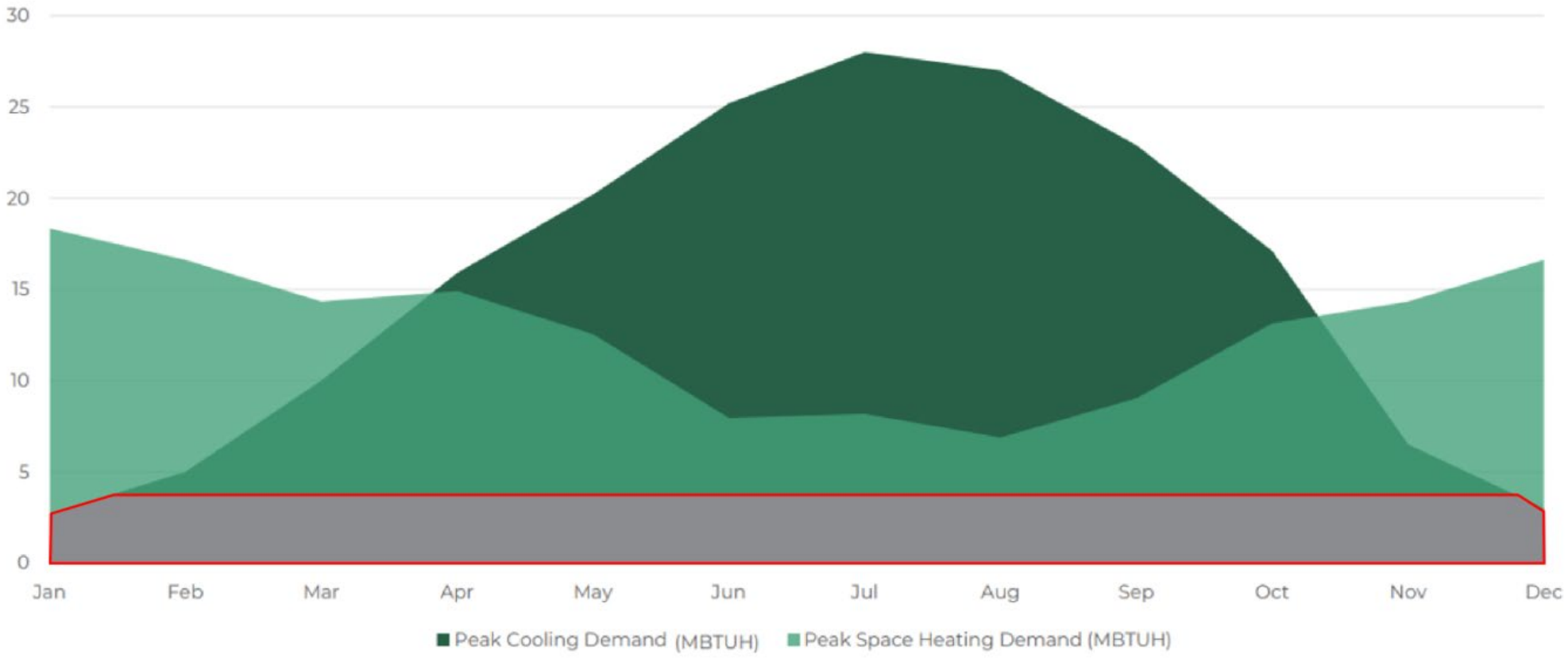


Energy is shared between systems.
Resulting in system wide energy efficiency.

ENERGY MACHINES



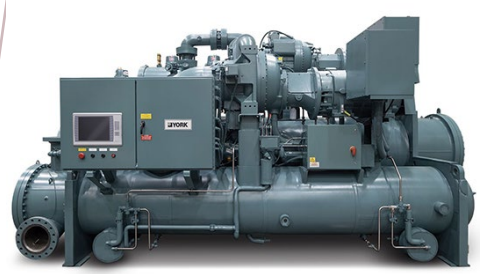
ENERGY MACHINES



ENERGY MACHINES

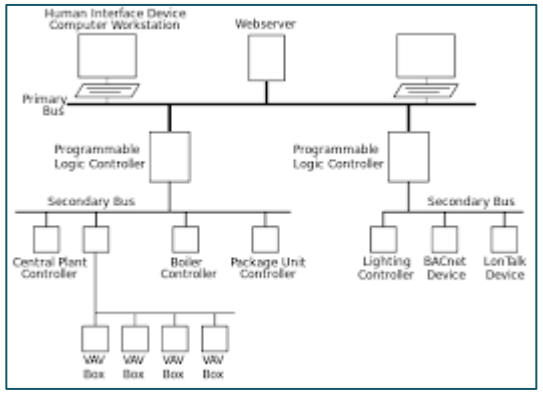
2,000 Ton Central Plant
150F Hot Water
44F Chilled Water

Cooling Tower
(Millions of Gallons of Water per year)



Heat Recovery Chiller
(Not Self Balancing)

Centrifugal Chillers



BMS

Modular Heat Pump Array

Fossil Fuel Steam Boiler

Extremely complicated to design mechanically. Even harder to commission!
This approach would lock in fossil fuels.

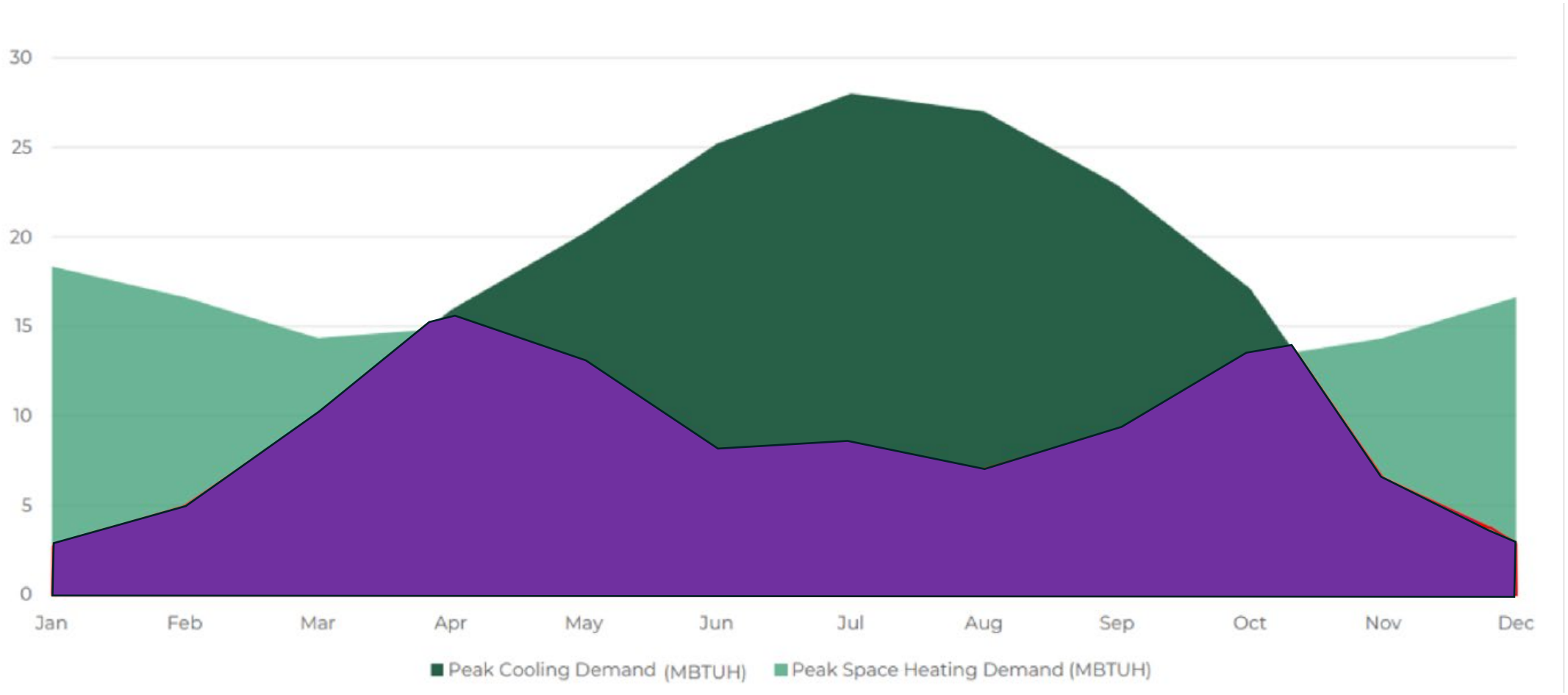
ENERGY MACHINES

2,000 Ton Central Plant
150F Hot Water
44F Chilled Water

Dry Cooler
(Bonus LEED points for Water Savings)

Energy Recovery in all possible scenarios.

ENERGY MACHINES

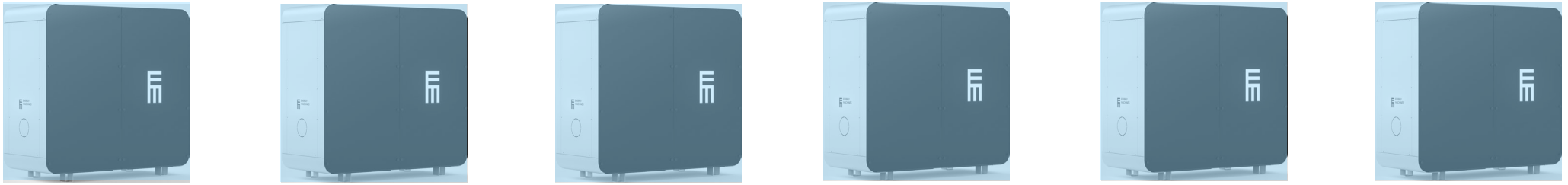


Energy Recovery in all possible scenarios.

ENERGY MACHINES

2,000 Ton Central Plant
150F Hot Water
44F Chilled Water

Dry Cooler
(Bonus LEED points for Water Savings)

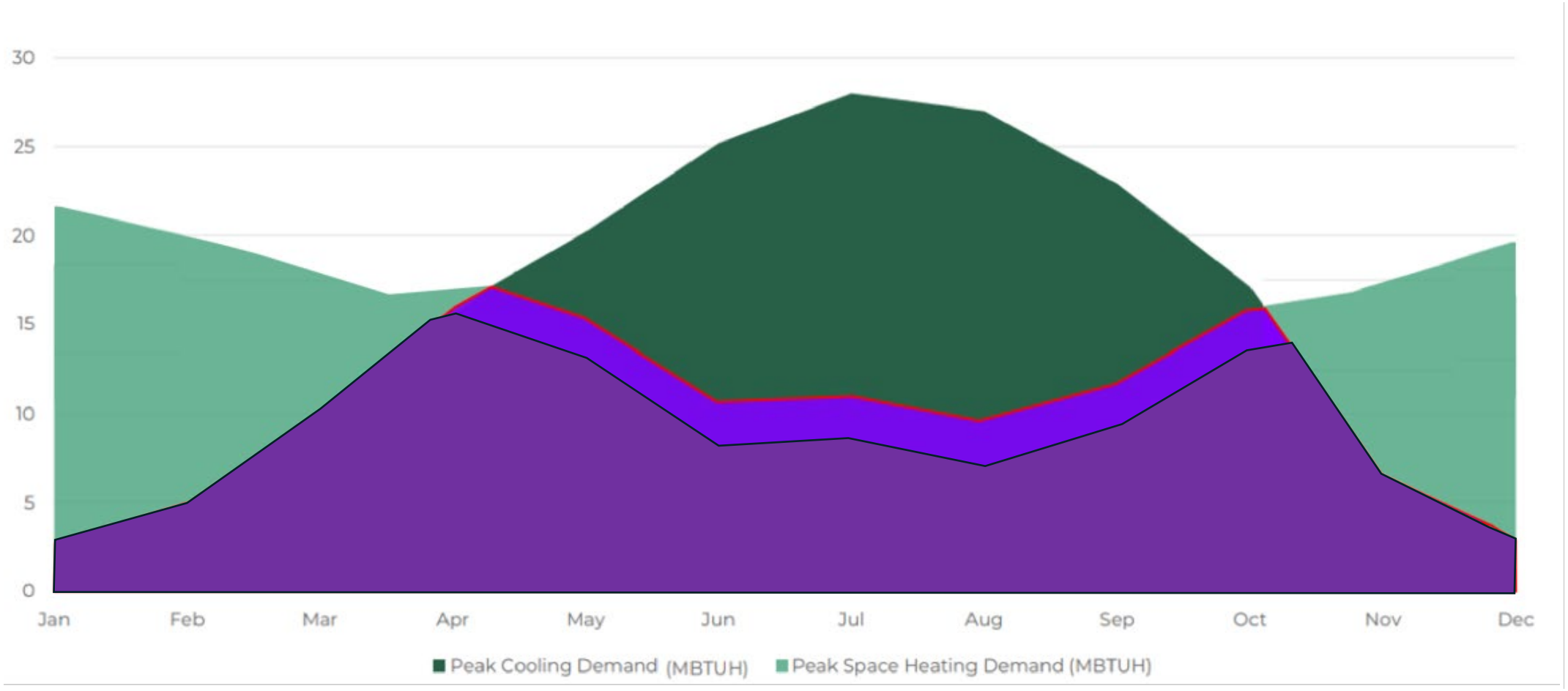


44F CHW
95F HW

44F CHW
150F HW

Efficient HVAC and DW Hot Water Decarb!

ENERGY MACHINES



What if the load changes in the future?

ENERGY MACHINES

2,000 Ton Central Plant
150F Hot Water
44F Chilled Water

Dry Cooler
(Bonus LEED points for Water Savings)

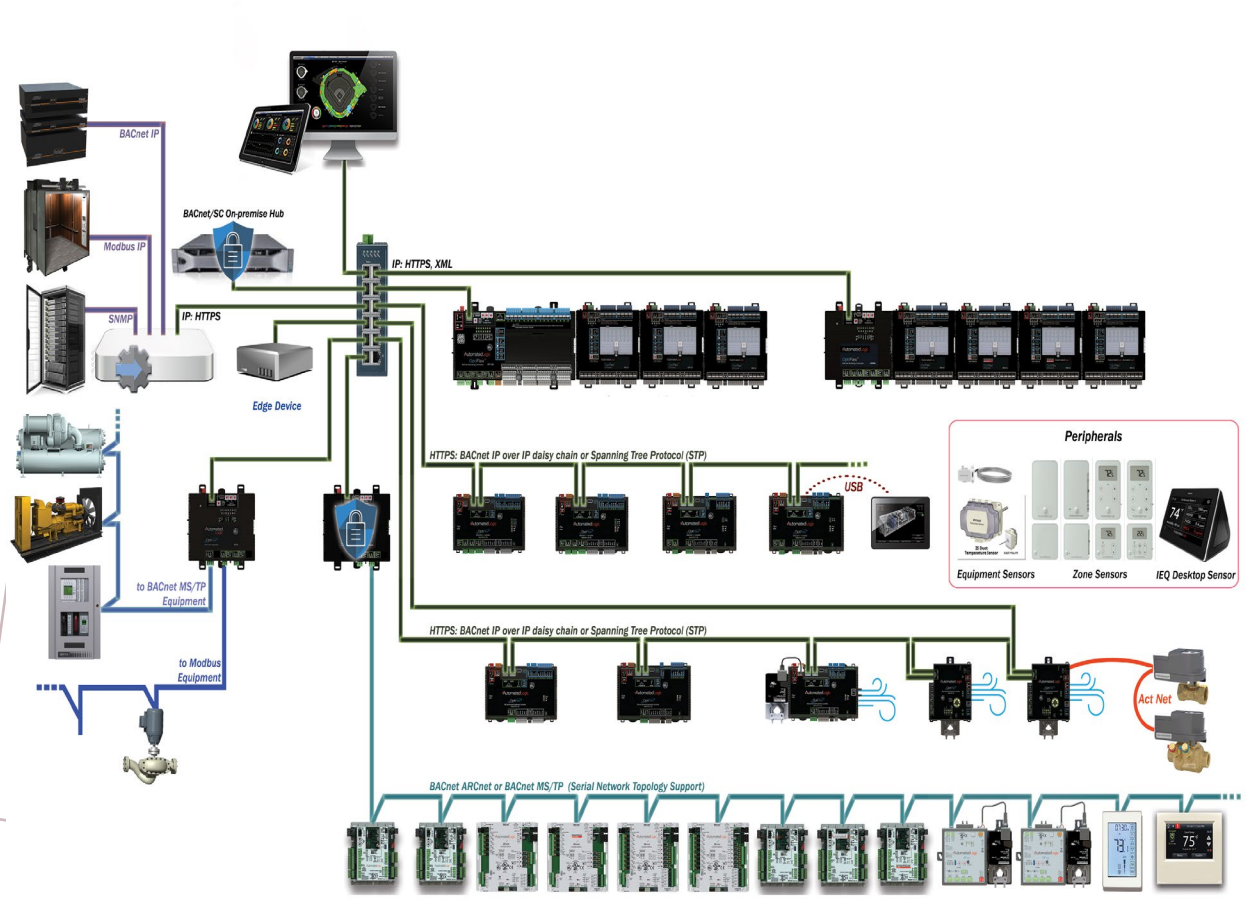
44F CHW
95F HW

44F CHW
150F HW

Efficient Energy Recovery with Complete Decarbonization.
Adaptive Reuse Redefined!

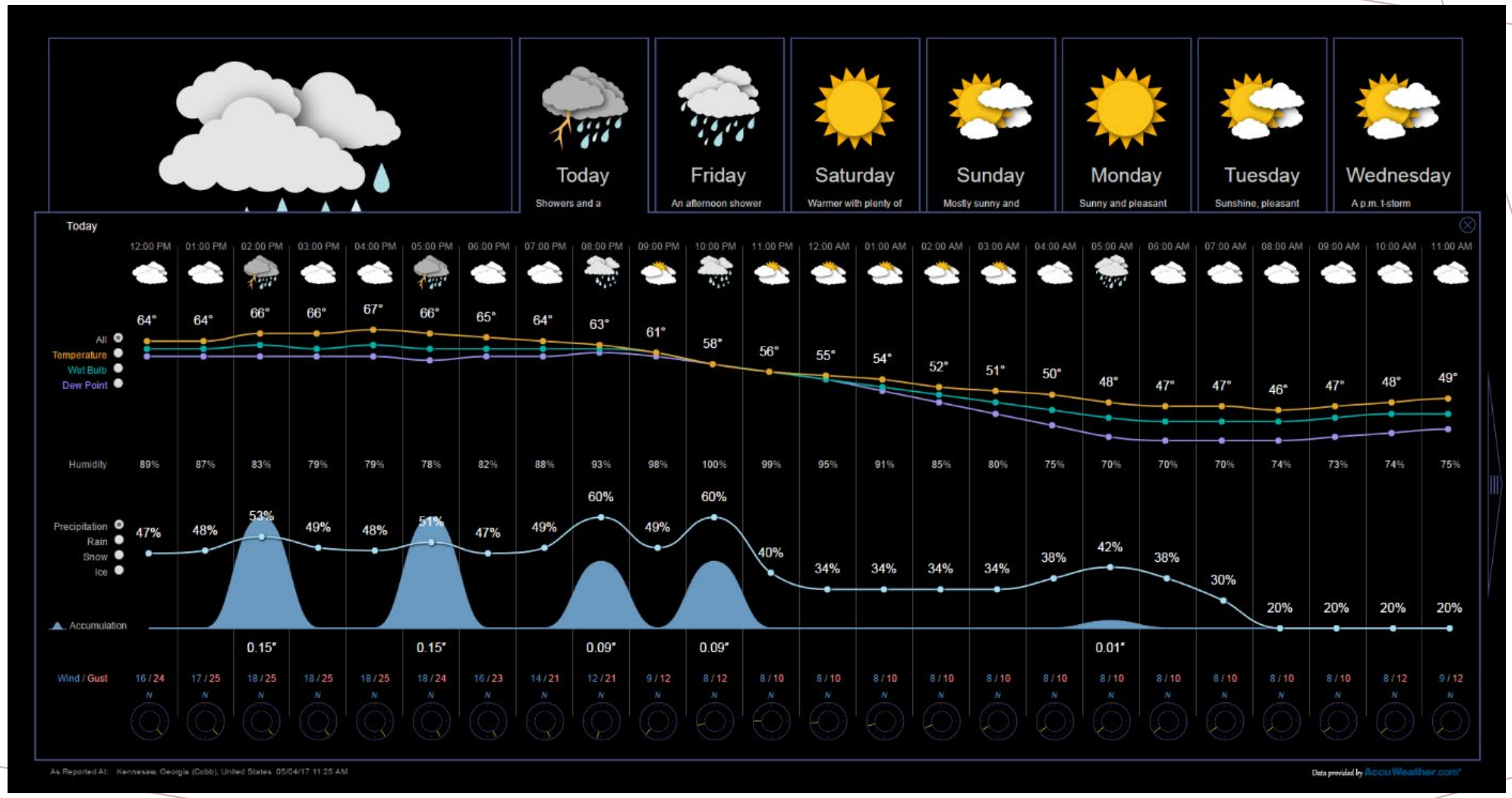
ENERGY MACHINES

BRINGING IT ALL TOGETHER

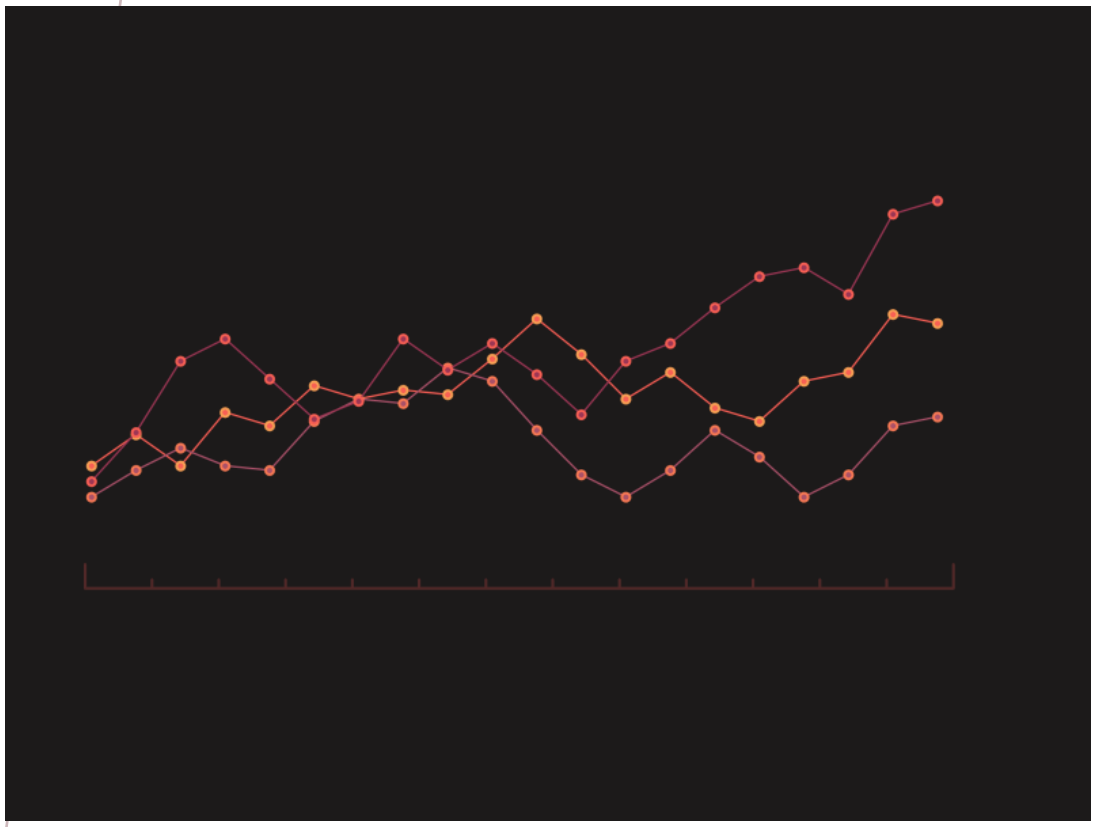


- BTU meters measure and trend performance.
- Real time calculation and trending of COP values for each system.
- You can see the future...

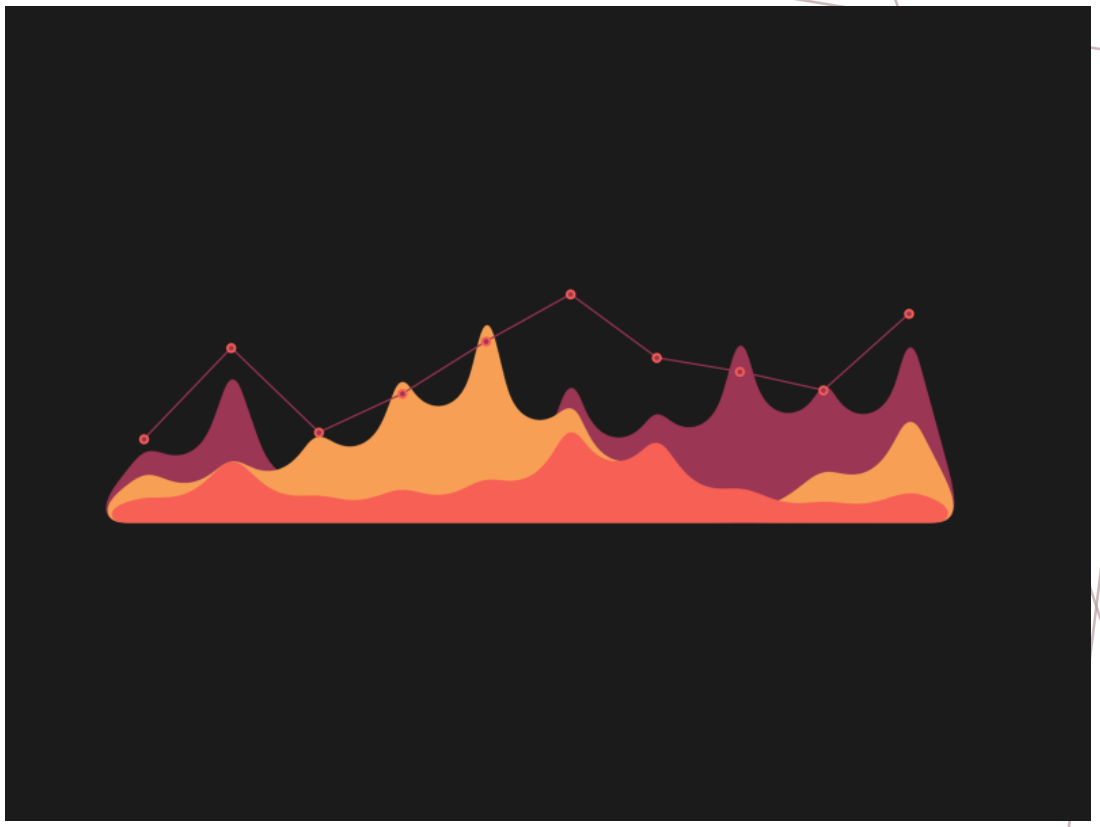
ENERGY MACHINES



ENERGY MACHINES



7 Day Forecast



Historical Data of Each System's Performance

Know Which Systems to Use to Satisfy Demand while Saving Money and Energy

Add ADR connectivity to the utility and you now have a Grid-Interactive Efficient Building!

ENERGY MACHINES

JAVIER ALEMAN

EXPERIENCE

- Competitive construction sales of BMS installations for Automated Logic.
- End user direct consultative sales for Honeywell focusing on turnkey installations involving BMS and equipment solutions.
- Equipment salesman for Carrier Corporation focusing on applied equipment and custom engineered solutions.

EDUCATION AND CERTIFICATIONS

- Certified Energy Manager (CEM)
- LEED AP, BD+C
- MBA in Finance and Marketing
- Computer Science and Computer Engineering Majors

ENERGY MACHINES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transition to a net-zero future
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