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Trane Engineers Newsletter Live

Decarbonization/Electrification of HVAC Systems

with Trane Application Engineer, Charlie Jelen, and Centrifugal Chiller Product Support Engineer, Dan Gentry

Trane program number: APP-CMC074-EN
November 2020

Agenda

Trane *Engineers Newsletter Live* Series

Decarbonization/Electrification of HVAC Systems

Abstract
Many municipalities throughout the United States are taking action to reduce their carbon emissions. One of the tactics they are using that effects the HVAC industry is the reduction, or removal, of natural gas for heating. This means our Industry will face the challenge of heating our buildings with electric heat. This ENL will cover the motivation to electrify, areas currently affected by this trend, and potential systems to meet electrification needs.

Presenters: Trane engineers Dan Gentry and Charlie Jelen

After viewing attendees will be able to:

1. Explain the concept and goals of electrification of HVAC systems
2. Understand the impact of policy to drive toward electrification
3. Identify areas in the U.S. that are moving toward electrification
4. Identify various systems and solutions that can be applied in an electrified HVAC system

Agenda

- Introduction
- What is electrification/decarb
- Why is it happening
- Where is it happening
- Product Solutions
    - Unitary
    - Distributed
    - Applied
    - Potable Hot Water

Presenter biographies

Decarbonization/Electrification of HVAC Systems

DAN GENTRY | CENTRIFUGAL PRODUCT SUPPORT ENGINEER | TRANE

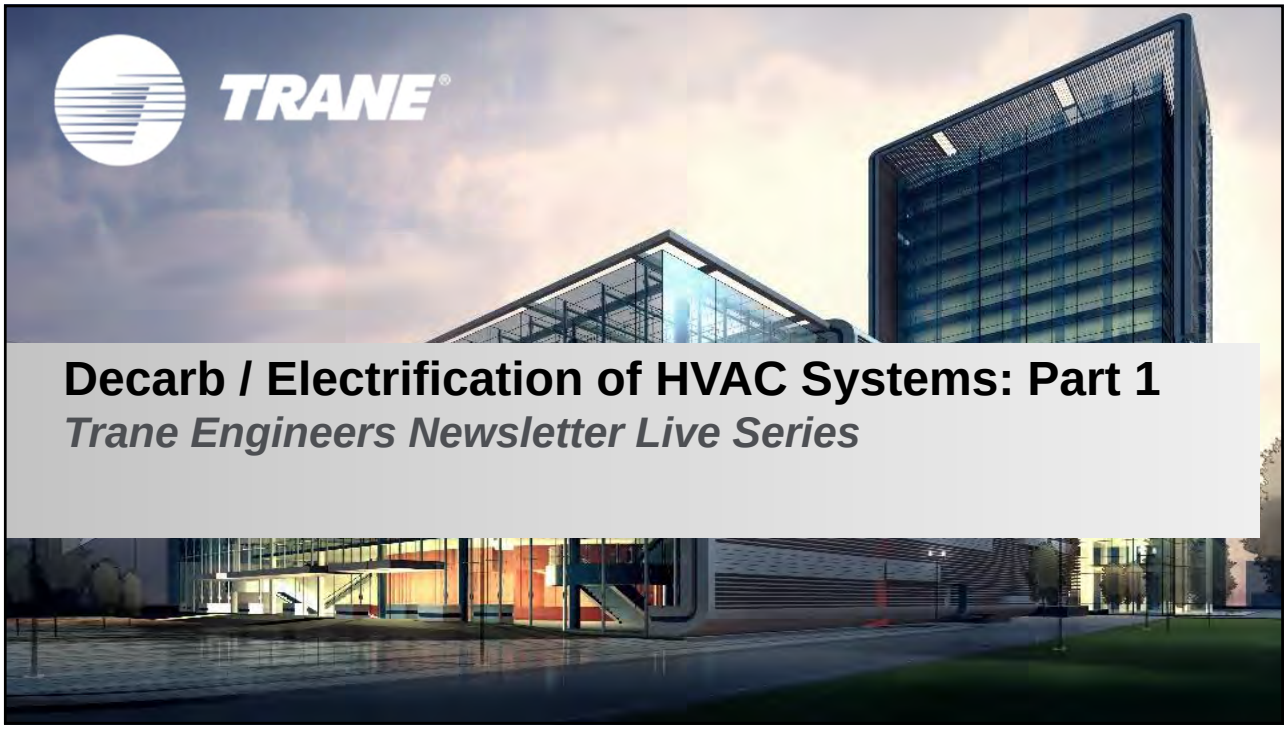
Dan Gentry is a Marketing Engineer in the Centrifugal Product Support group starting in the summer of 2018 where he provides pre-sale support to the field. Dan first interned at Trane in the Technology Lab while attending school through 2008.

Dan graduated from Ferris State University in 2011 with a Bachelor's Degree in HVAC Engineering Technology. He has worked several years in chiller sales prior to coming back to Trane. Dan enjoys spending time with his family on the river, at the family cabin up north and relaxing.

CHARLES JELEN | APPLICATIONS ENGINEER | TRANE

Charles Jelen is an Application Engineer based out of La Crosse, WI. He is primarily responsible for pre-sale support of Trane systems and system design concepts. His areas of expertise are in chilled-water systems, refrigerants, electrification, and system modeling. Charles has been with Trane for 9 years and has held roles as TRACE 700 Product Manager, Centrifugal and Water-Cooled Product Support Engineer, and C.D.S.(Customer Direct Service) Support Engineer.

Prior to joining Trane Charles worked as an application and sales engineer for a process automation company out of Minneapolis, MN. Charlesearned his bachelor's degree in Mechanical Engineering from the University of Minnesota and is a member of ASHRAE.



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Learning Objectives

- Understand why electrification is happening.
- Understand the type of policy that might be impacting your city and state.
- Learn which products are currently available to help electrify HVAC systems

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Agenda

- Introduction
  - What is electrification/decarb
  - Why is it happening
  - Where is it happening
- Product Solutions
  - Unitary
  - Distributed
  - Applied
  - Potable Hot Water

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Today's Presenters

Charles Jelen
Applications Engineer

Dan Gentry
Marketing Engineer – Centrifugal Chillers

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Sections

- What is Decarb / Electrification
- Heat Pump Considerations
- Product Solutions

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What is Decarb / Electrification ?

DECARBONIZE

Reduce carbon emissions

ELECTRIFICATION

Utilizing electricity in place of burning fossil fuels

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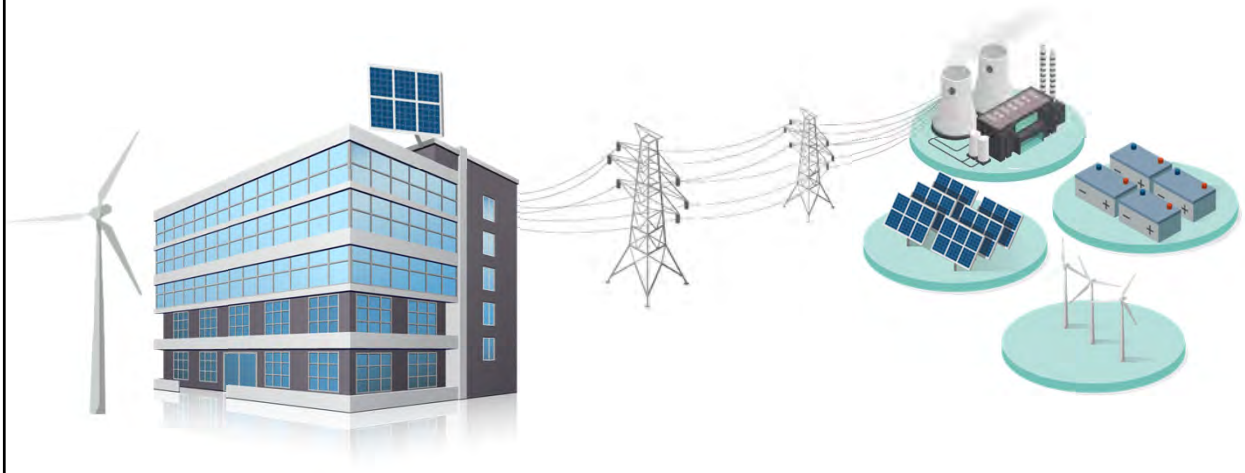
Why are we doing this?



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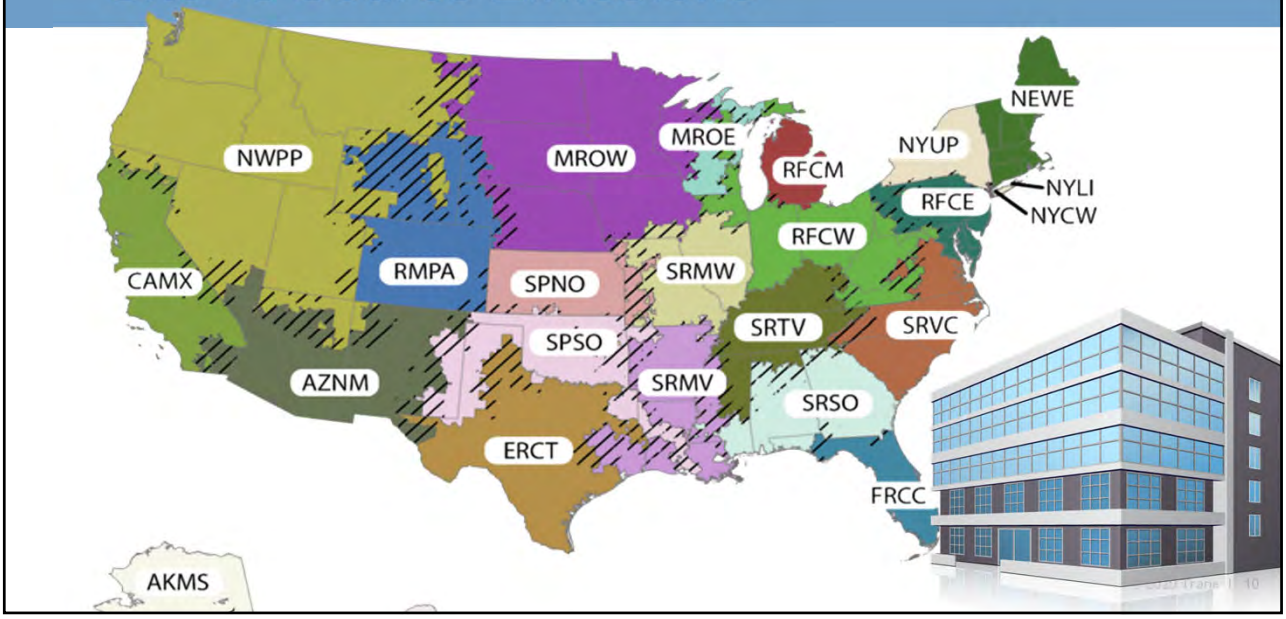
Site vs Source Emissions



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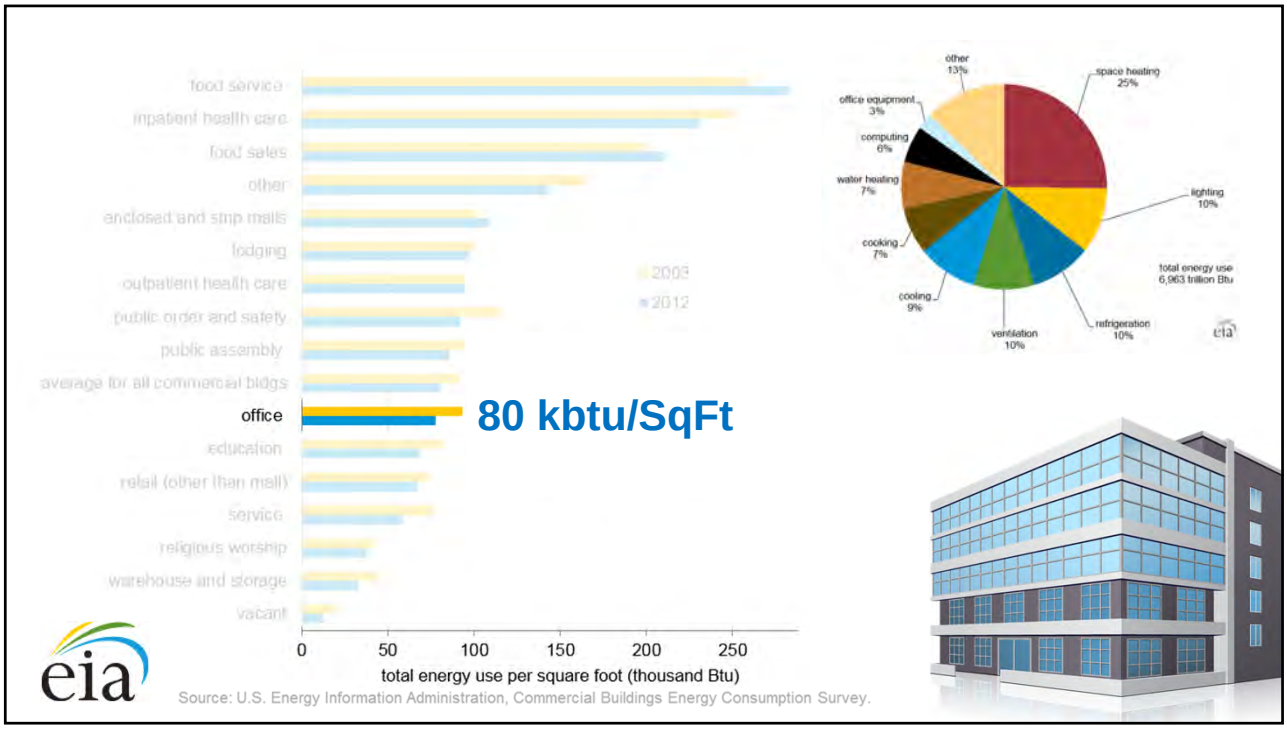
food service
inpatient health care
food sales
other
enclosed and strip malls
lodging
outpatient health care
public order and safety
public assembly
average for all commercial bldgs
office
education
retail (other than mall)
service
religious worship
warehouse and storage
vacant
2003
2012
0
50
100
150
200
250
total energy use per square foot (thousand Btu)
80 kbtu/SqFt
other 13%
space heating 25%
office equipment 3%
computing 6%
water heating 7%
lighting 10%
cooking 7%
total energy use 6,963 trillion Btu
cooling 9%
ventilation 10%
refrigeration 10%
eia
Source: U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey.

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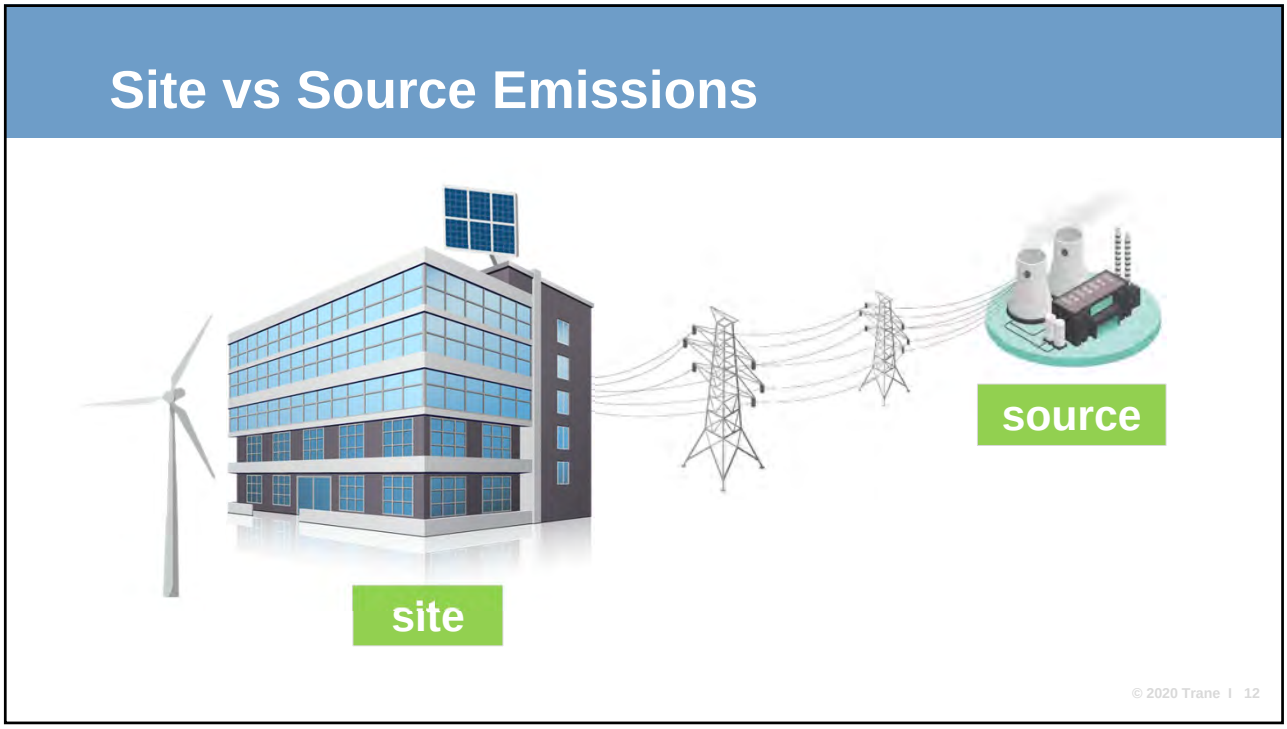
Site vs Source Emissions
source
site
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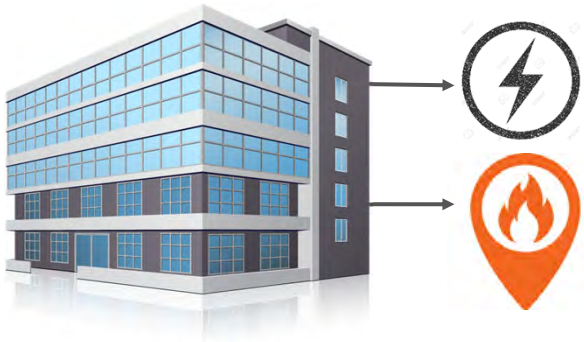
Site vs Source Emissions

Total Energy = 8 Billion BTU



70% Electric = 5.6 Billion BTU

30% Natural Gas = 2.4 Billion BTU

Site Carbon Emissions = 140 Tons CO2e

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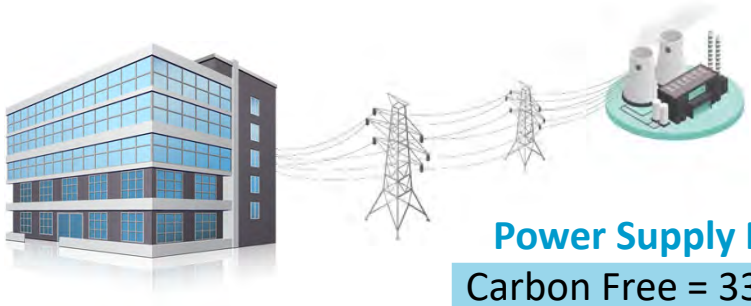
Site vs Source Emissions



Power Supply Mix:

Carbon Free = 33.5%
Coal = 44.4%
NG = 22.1%

1,166 lbs CO2e/MWh

Source Carbon Emissions = 957 Tons CO2e

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Site vs Source Emissions

	Gas/Electric Today
Total Energy	8 Billion BTU
On Site Natural Gas	2.4 Billion BTU
Electricity	5.6 Billion BTU
Site Carbon CO2 Emissions	140 Tons
Source Carbon CO2 Emissions	957 Tons
Total CO2 Emissions	**1,097 Tons**

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Site vs Source Emissions

	Gas/Electric Today	All Electric Today
Total Energy	8 Billion BTU	6.4 Billion BTU
On Site Natural Gas	2.4 Billion BTU	0 BTU
Electricity	5.6 Billion BTU	6.4 Billion BTU
Site Carbon CO2 Emissions	140 Tons	
Source Carbon CO2 Emissions	957 Tons	
Total CO2 Emissions	**1,097 Tons**	

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Site vs Source Emissions

Power Supply Mix:

Carbon Free = 33.5% 67%
Coal = 44.4% 10%
NG = 22.1% 23%

	Gas/Electric Today	All Electric Today	Gas/Electric 2030
Total Energy	8 Billion BTU	6.4 Billion BTU	
On Site Natural Gas	2.4 Billion BTU	0 BTU	
Electricity	5.6 Billion BTU	6.4 Billion BTU	
Site Carbon CO2 Emissions	140 Tons	0 Tons	
Source Carbon CO2 Emissions	957 Tons	1,094 Tons	
Total CO2 Emissions	**1,097 Tons**	**1,094 Tons**	

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Site vs Source Emissions

Power Supply Mix:

Carbon Free = 33.5% 67%
Coal = 44.4% 10%
NG = 22.1% 23%

	Gas/Electric Today	All Electric Today	Gas/Electric 2030	All Electric 2030 (67%)
Total Energy	8 Billion BTU	6.4 Billion BTU	8 Billion BTU	6.4 Billion BTU
On Site Natural Gas	2.4 Billion BTU	0 BTU	2.4 Billion BTU	0 BTU
Electricity	5.6 Billion BTU	6.4 Billion BTU	5.6 Billion BTU	6.4 Billion BTU
Site Carbon CO2 Emissions	140 Tons	0 Tons	140 Tons	
Source Carbon CO2 Emissions	957 Tons	1,094 Tons	404 Tons	
Total CO2 Emissions	**1,097 Tons**	**1,094 Tons**	**544 Tons**	

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Site vs Source Emissions

Power Supply Mix:
Carbon Free = 85%
Coal = 5%
NG = 10%

	Gas/Electric Today	All Electric Today	Gas/Electric 2030	All Electric 2030 (67%)	All Electric 2030 (85%)
Total Energy	8 Billion BTU	6.4 Billion BTU	8 Billion BTU	6.4 Billion BTU	6.4 Billion BTU
On Site Natural Gas	2.4 Billion BTU	0 BTU	2.4 Billion BTU	0 BTU	0 BTU
Electricity	5.6 Billion BTU	6.4 Billion BTU	5.6 Billion BTU	6.4 Billion BTU	6.4 Billion BTU
Site Carbon CO2 Emissions	140 Tons	0 Tons	140 Tons	0 Tons	0 Tons
Source Carbon CO2 Emissions	957 Tons	1,094 Tons	404 Tons	462 Tons	213 Tons
Total CO2 Emissions	**1,097 Tons**	**1,094 Tons**	**544 Tons**	**462 Tons**	**213 Tons**

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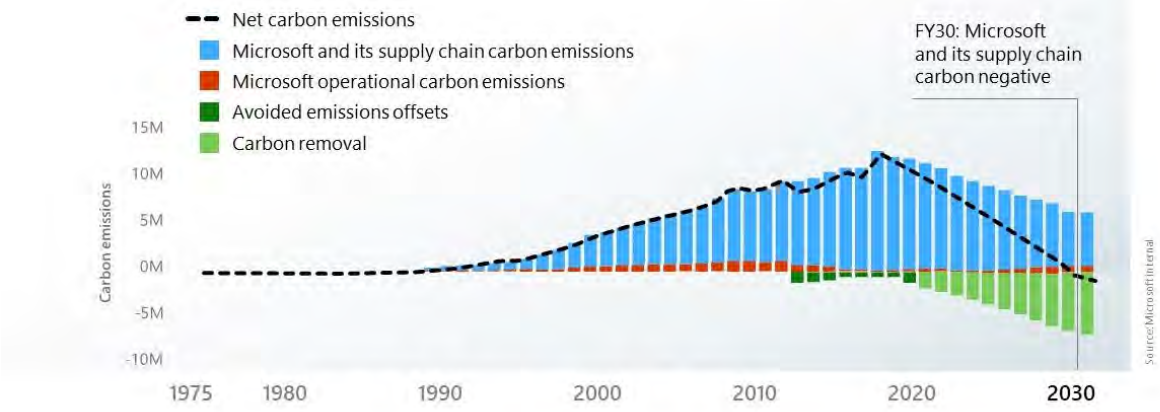
Where is this happening?

Microsoft

Annual carbon emissions

Commits to be Carbon Negative by 2030

https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/



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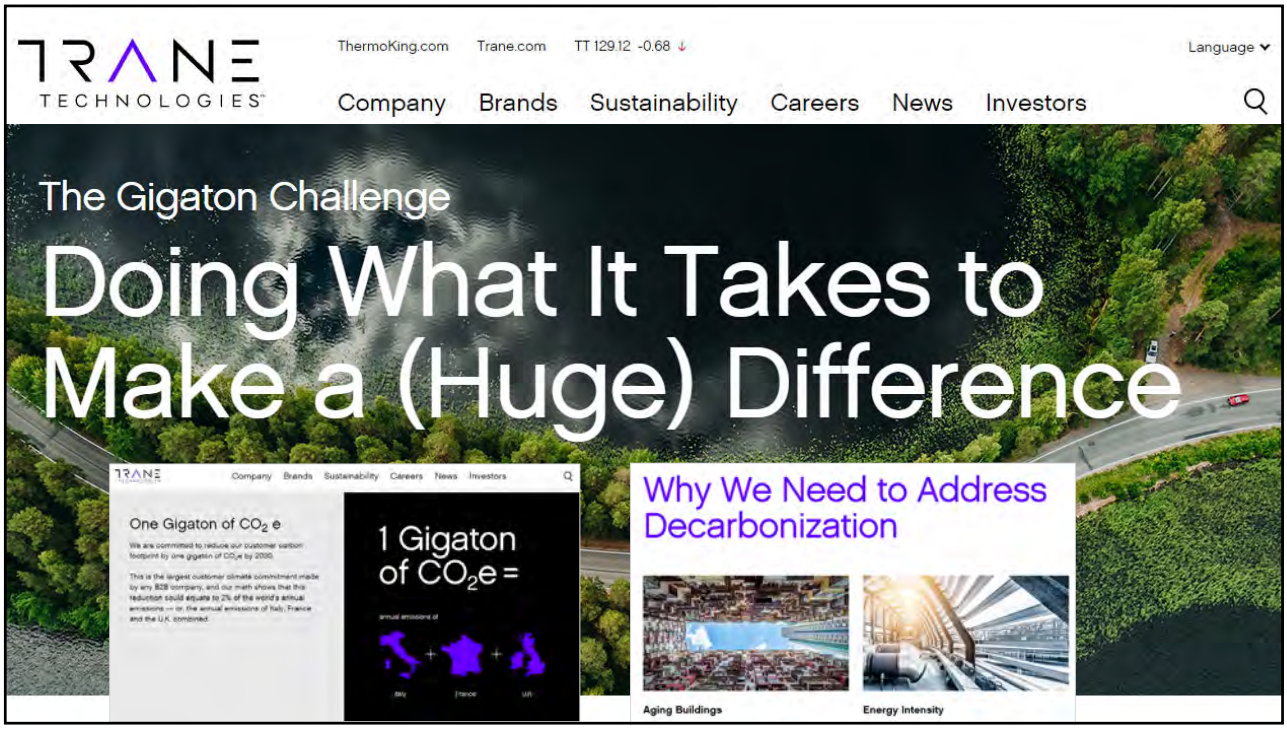

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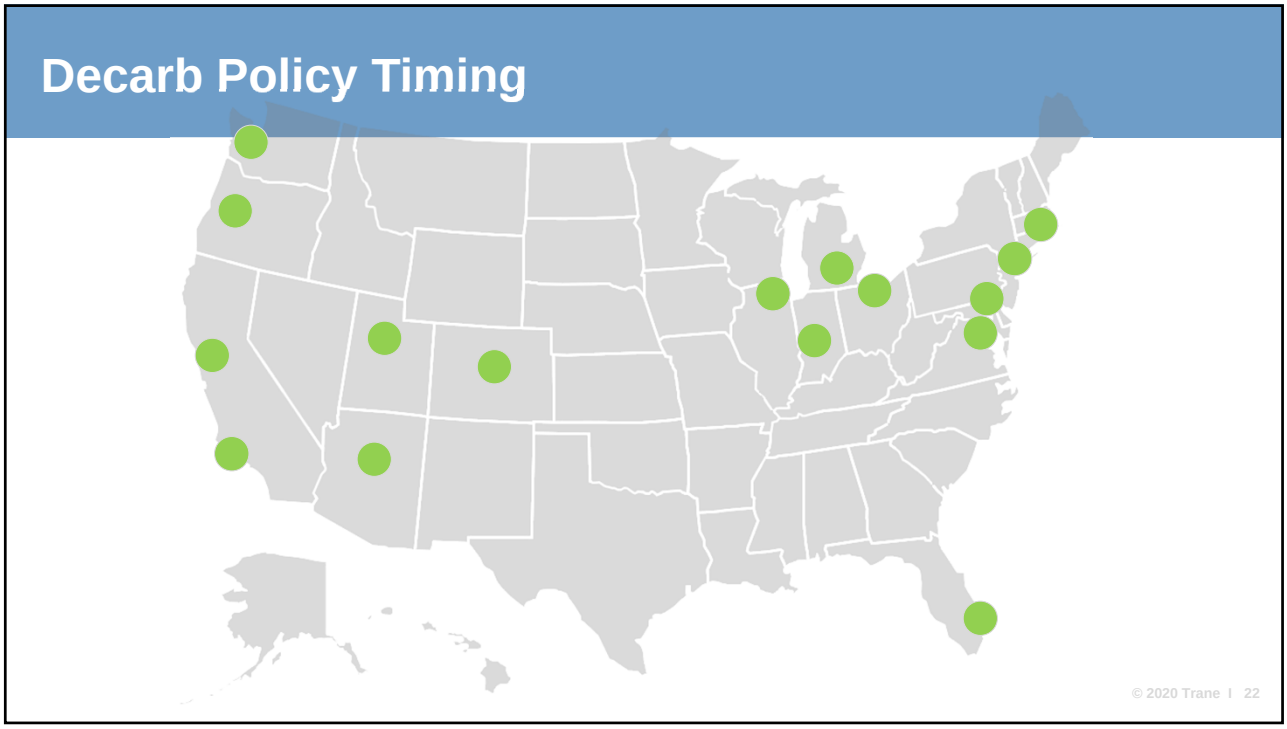

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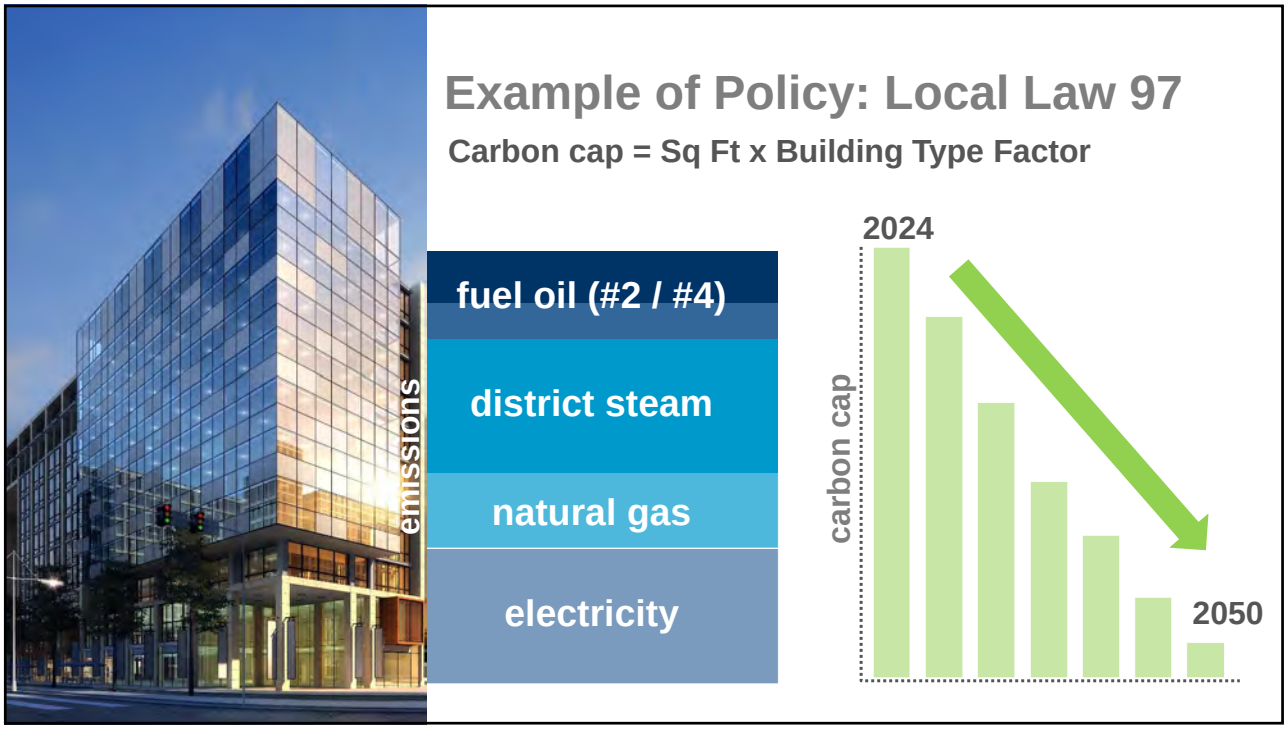

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Sections

- What is Decarb / Electrification
- Heat Pump Considerations
- Product Solutions

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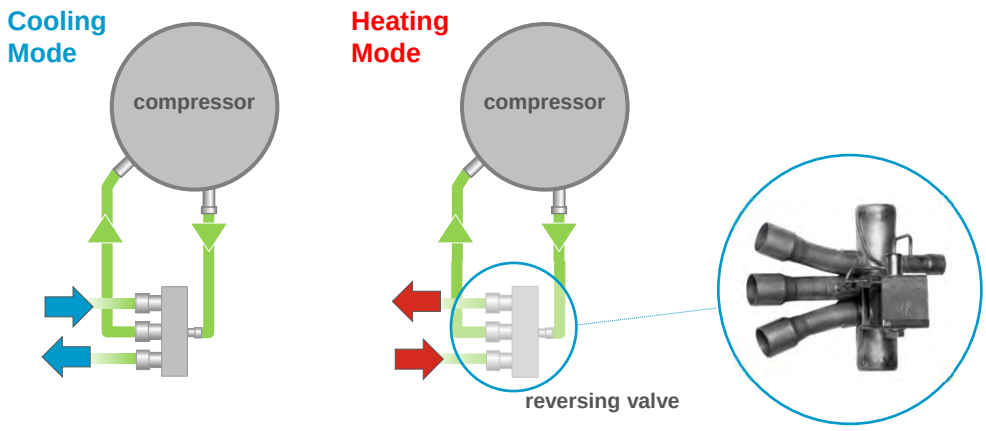
Heat Pumps



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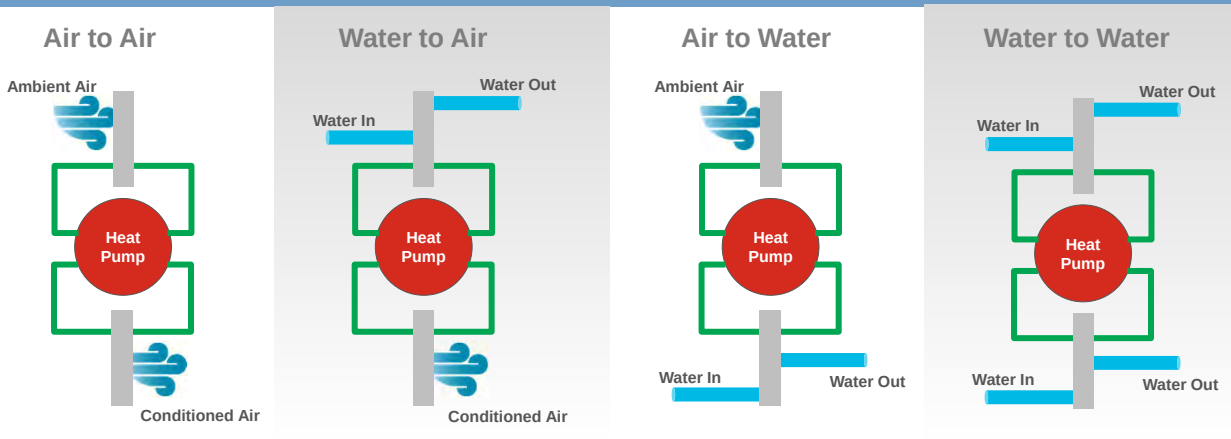
Heat Pumps



Example:
Rooftop Units
VRF

Example:
WSHP

Example:
Air-Source
Heat Pump Chiller

Example:
Water-Source
Chiller

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Cold Climate Heat Pumps

Lat:**40.779N** Long:**73.969W** Elev:**130** StdP: **14.63** Time zone:**-5.00** Period:**95-14** WBAN:**94728**

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6%			99%			0.4%		1%			
			DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
1	13.5	17.5	-5.0	4.2	16.4	-0.9	5.3	20.7	20.8	31.7	19.0	30.2	9.9	300

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	14.1	91.0	73.7	88.0	72.4	85.3	71.3	76.7	85.4	75.4	83.1	74.3	81.3	6.1	260

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Extreme Max WB
0.4%			1%			2%			0.4%		1%		2%		
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
74.4	129.0	79.8	73.2	123.7	78.8	72.0	118.8	78.2	40.1	85.5	38.9	83.3	37.7	81.1	81.9

Extreme Annual Design Conditions

Extreme Annual WS				Extreme Annual Temperature				n-Year Return Period Values of Extreme Temperature							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
18.4	16.2	13.6	DB	9.3	95.8	4.9	3.9	5.8	98.6	2.9	100.9	0.1	103.1	-3.5	105.9
			WB	6.8	79.3	4.2	1.3	3.7	80.3	1.2	81.1	-1.1	81.8	-4.2	82.8

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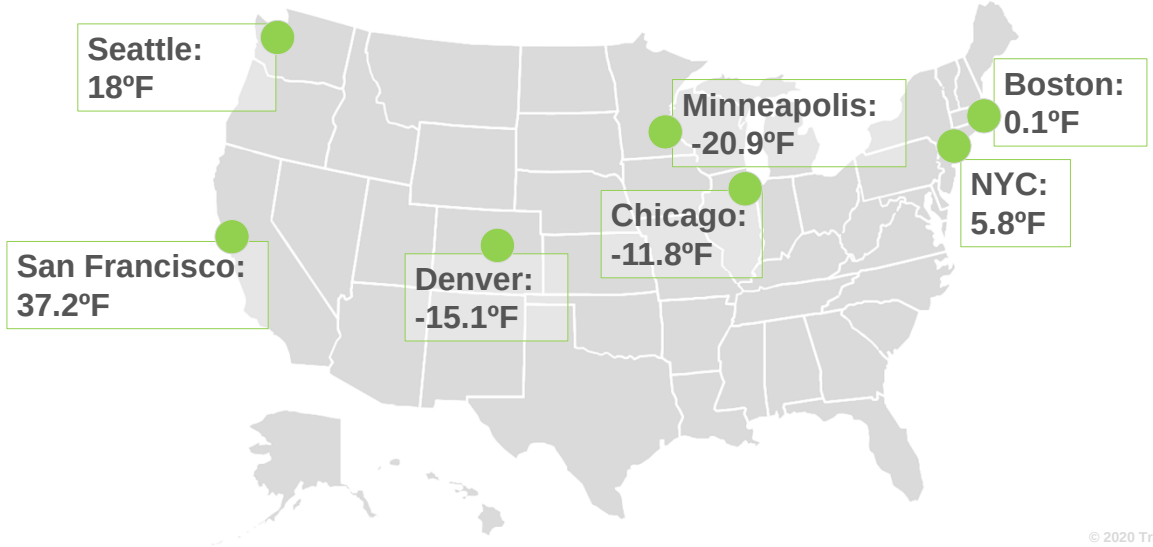
Cold Climate Heat Pumps



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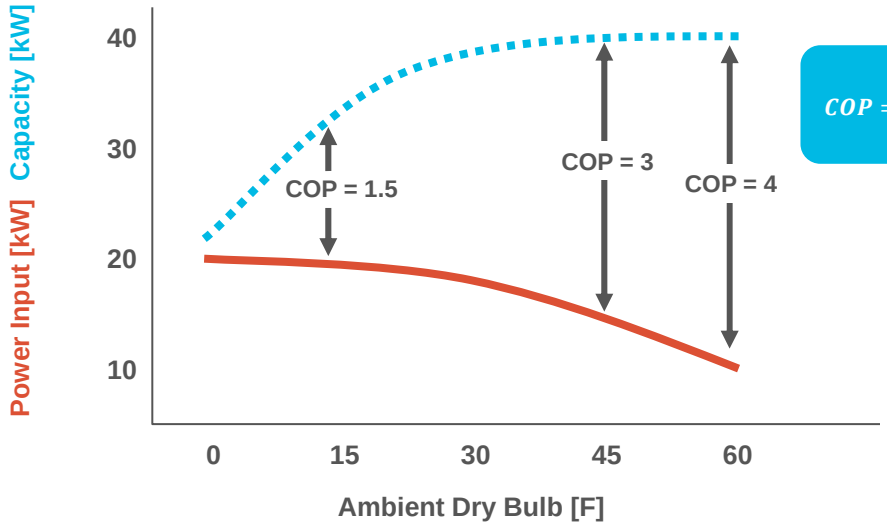
Cold Climate Heat Pump



$$COP = \frac{Capacity\ Output\ [kW]}{Power\ Input\ [kW]}$$

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Defrost: Occupant Comfort

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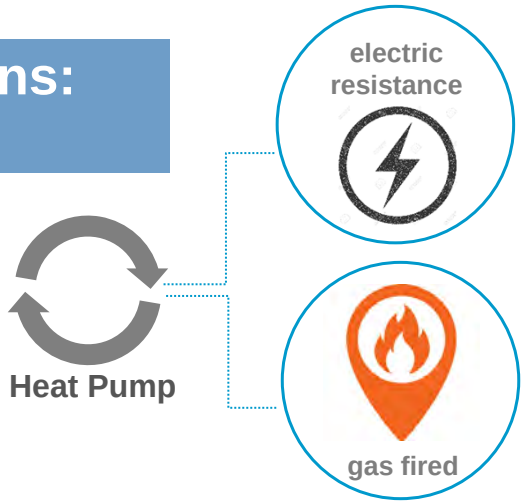
Heat Pump Considerations: Dual/Auxiliary Fuel



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Sections

- What is Decarb / Electrification
- Heat Pump Considerations
- Product Solutions
  - Split Systems
  - Packaged Units
  - Applied Systems
  - Potable/Domestic Water Systems

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Split System Heat Pumps

Sizes: <20 Tons

Applications:
- Classrooms
- Small Office
- Small Retail

Options:
- ⊕ Dual / Aux Fuel
- ⊗ Cold Climate Operation

Retrofits Capability:

do-able — difficult

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Variable Refrigerant Flow (VRF)

Sizes: <40 Tons

Applications:
- Schools
- Office
- Mixed Use

Options:
- ⊕ Dual / Aux Fuel
- ⊕ Cold Climate Operation
- ⊕ Smart Defrost

Retrofit Capability:

do-able — difficult

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Roof Top Unit (RTU) Heat Pump

Sizes: <20 Tons

Applications:
- Classrooms
- Small Office
- Retail
- Warehouse/Distribution Center

Options:
- ⊕ Dual / Aux Fuel
- ⊗ Cold Climate Operation

Retrofit Capability:

do-able — difficult

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Packaged Terminal Heat Pump

Sizes: <3 Tons

Applications:
- Hotels
- Apartments
- Dormitory
- Long Term Care

Options:
- ⊕ Dual / Aux Fuel
- ⊗ Cold Climate Operation

Retrofit Capability:
do-able — difficult

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Water Source Heat Pump (WSHP)

Sizes: <25 Tons

Applications:
- Apartments
- Office
- School
- Clinic

Options:
- ⊕ Dual / Aux Fuel
- ⊕ Cold Climate Operation

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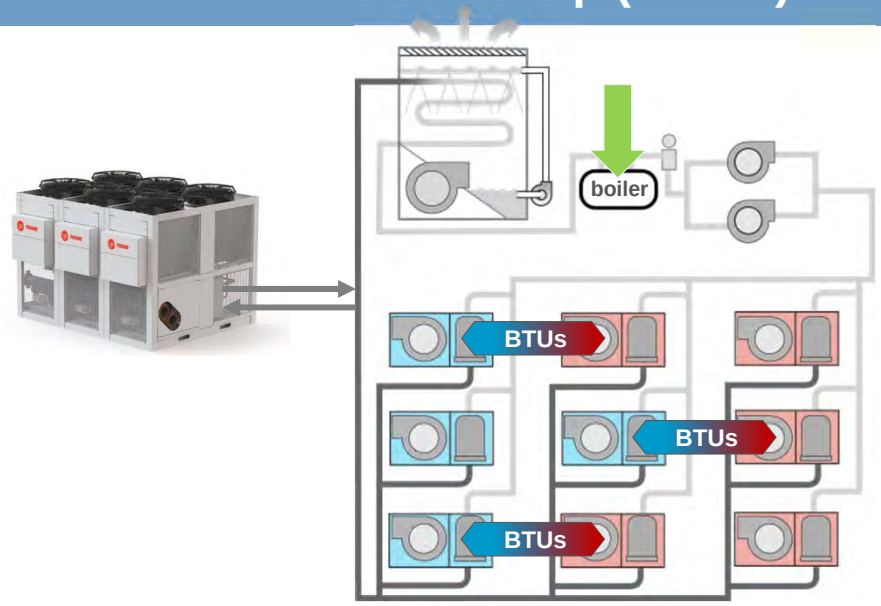
Water Source Heat Pump (WSHP)



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Applied Systems

- Introduction to Applied Systems
- Descriptions
  - Heat Pump and Heat Recovery
- Products
  - Air Source and Water Source
- Applications
- Source/Sinks

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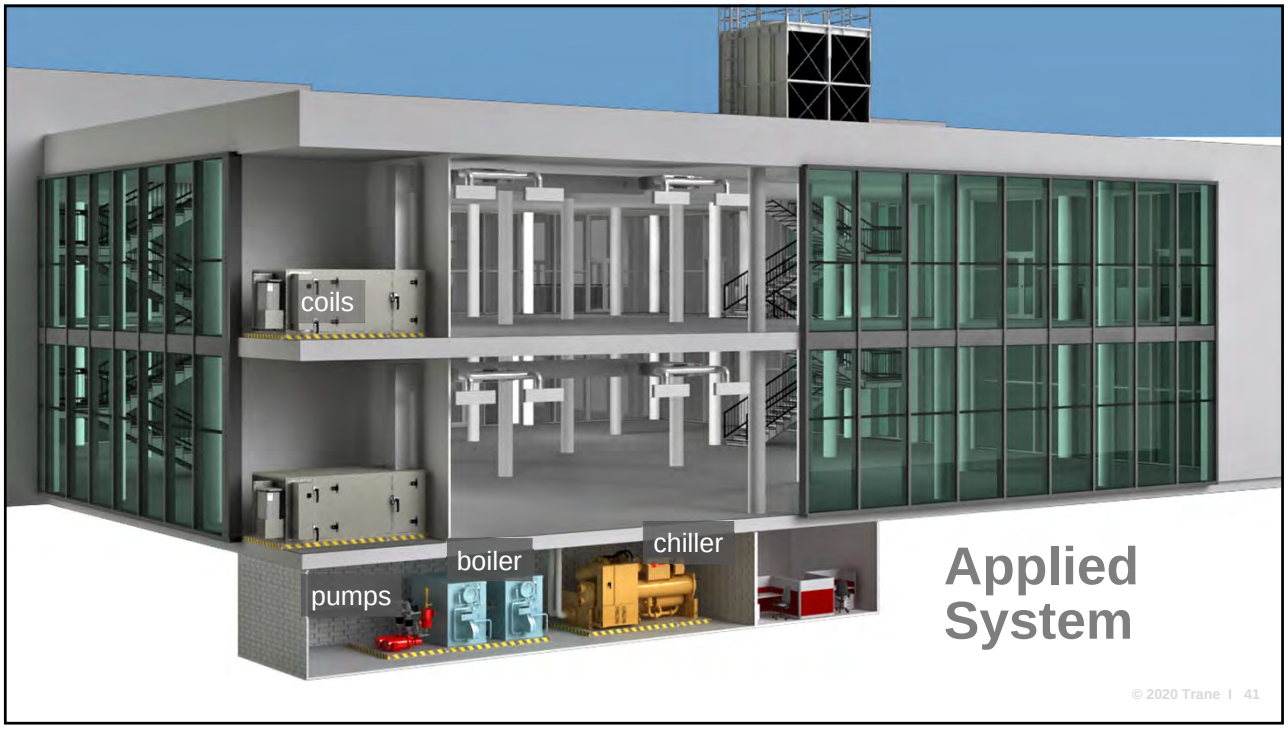

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Descriptions

HEAT PUMP

HEAT RECOVERY

CHILLER/HEATER

HEATER

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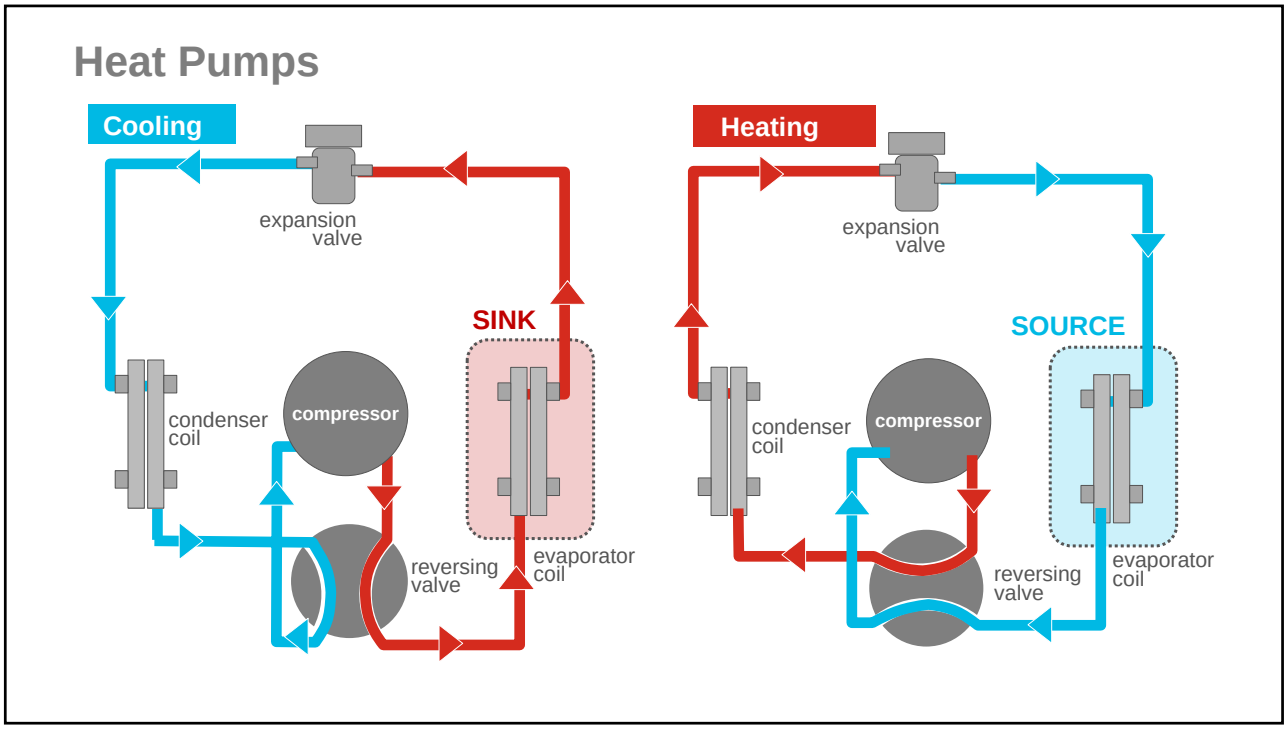
Heat Pumps
Cooling
expansion valve
SINK
condenser coil
compressor
reversing valve
evaporator coil
Heating
expansion valve
SOURCE
condenser coil
compressor
reversing valve
evaporator coil

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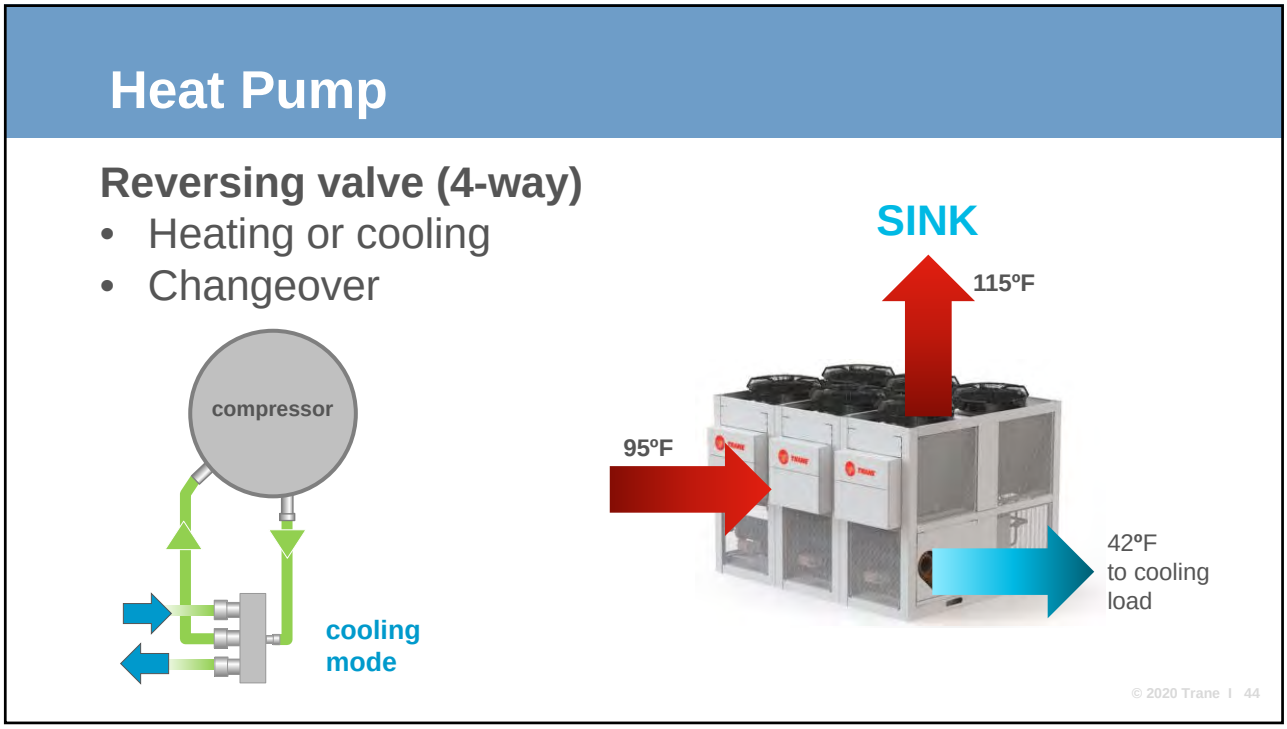
Heat Pump
Reversing valve (4-way)
• Heating or cooling
• Changeover
compressor
cooling mode
SINK
115°F
95°F
42°F to cooling load
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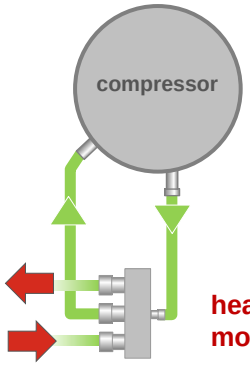
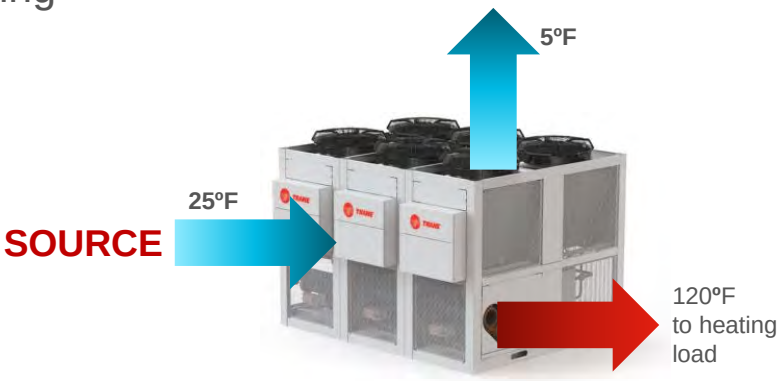
Heat Pump

Reversing valve (4-way)

- Heating or cooling
- Changeover





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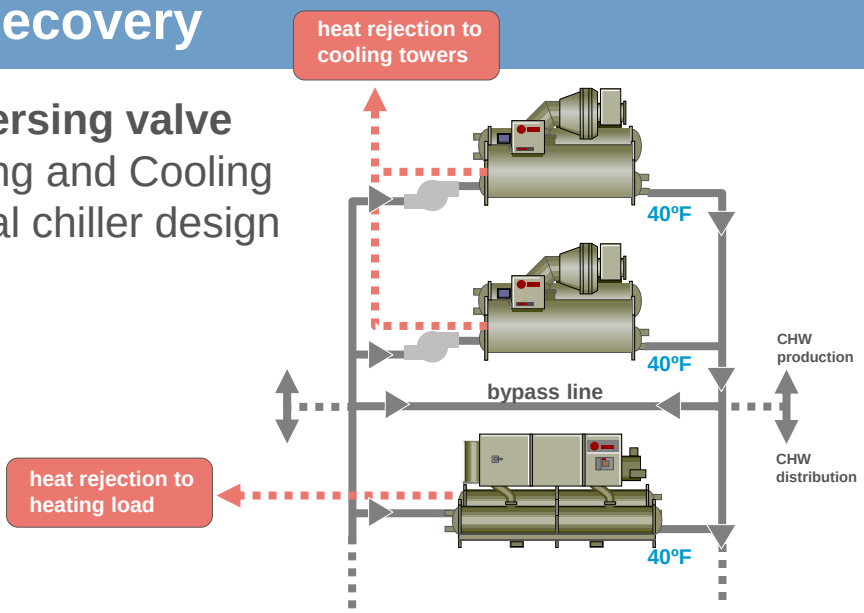
Heat Recovery

No Reversing valve

- Heating and Cooling
- Typical chiller design



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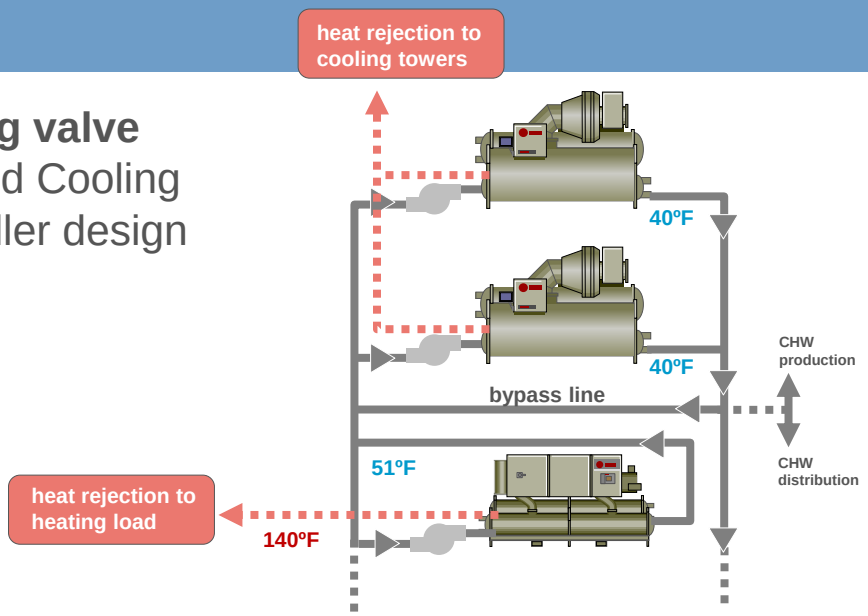
Heater

No Reversing valve

- Heating and Cooling
- Typical chiller design



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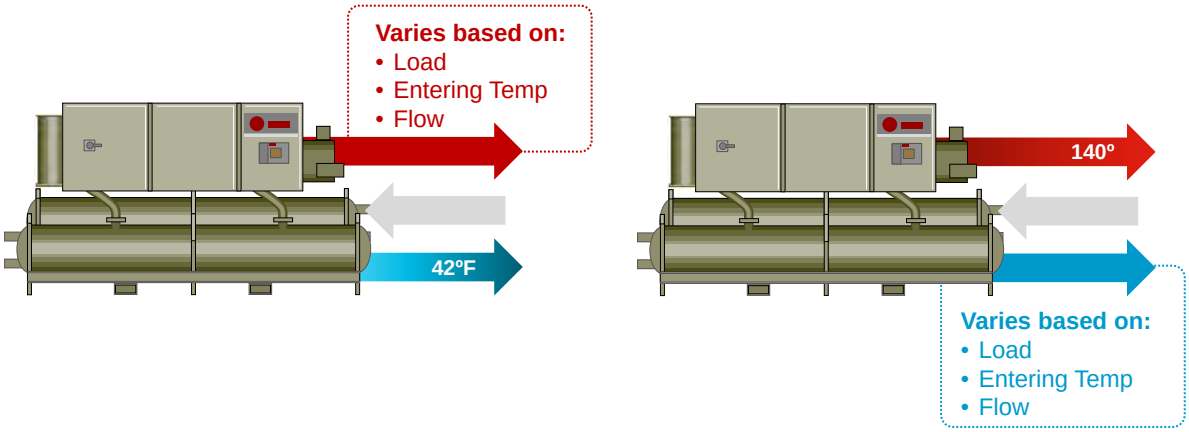
Chiller/Heater

Cooling Mode | **Heating Mode**



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Products

- **Air Source**
  - Apps
- Water Source
  - Apps

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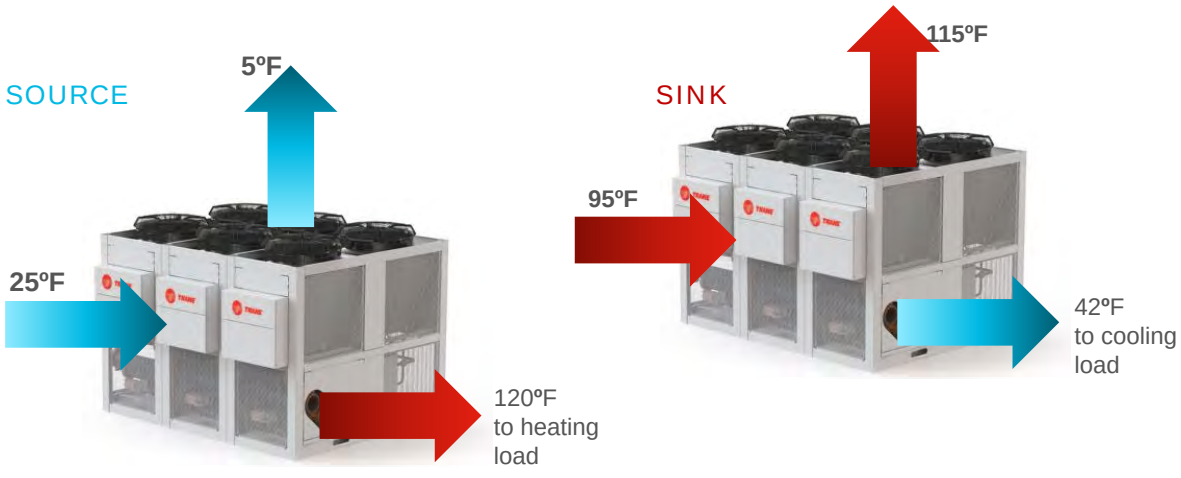
Air-Source Products



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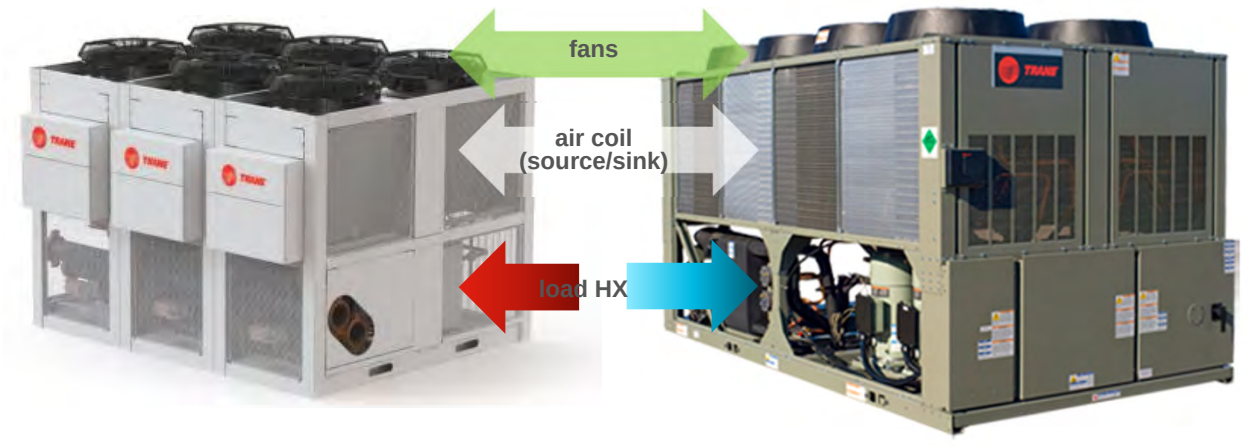
Air-Source Heat Pumps



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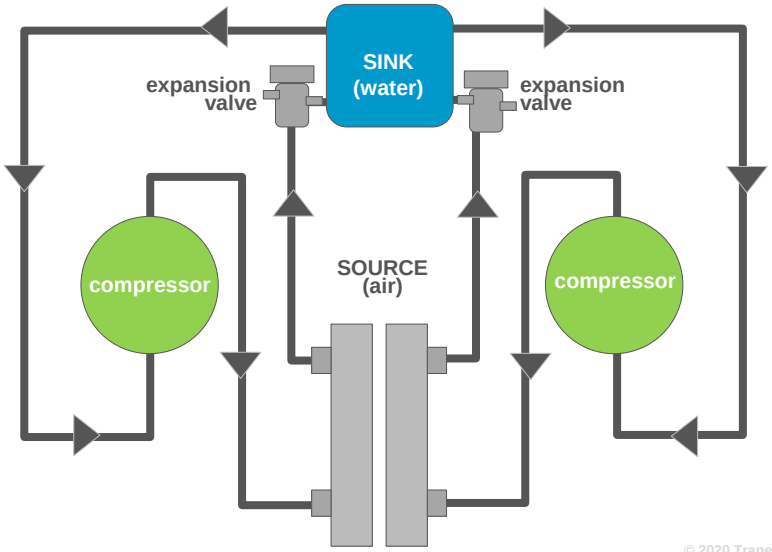
Air-Source Products



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Air-Source Products

Packaged or Modular?

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Air-Source Products

Packaged

- 2-200+ tons
- Lower cost
- Ideal for larger projects
- Pumps

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Air-Source Products

Modular

- Multiple circuits
- Redundancy
- Flexible capacity
- Good for variable flow
- Pump package

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Applications

- Air Source
  - **Off-load Boiler**
  - WSHP
  - Lower temp hydronics
- Water Source
  - Heating with a cooling load
  - Heating without a cooling load

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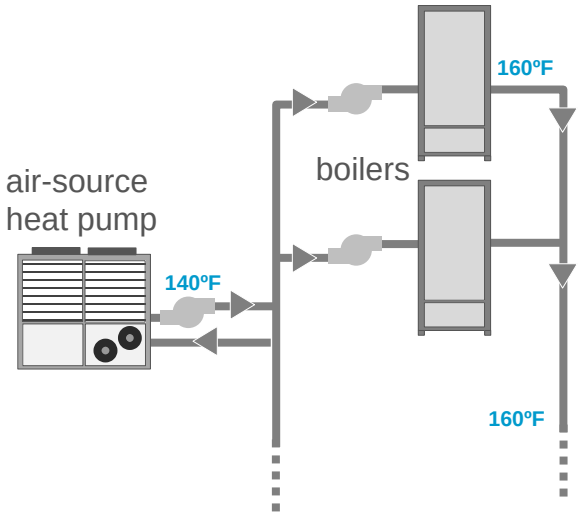
Air-Source Applications

Off-load boiler load (preheat)

Limitations

- Temperatures



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Air-Source Applications

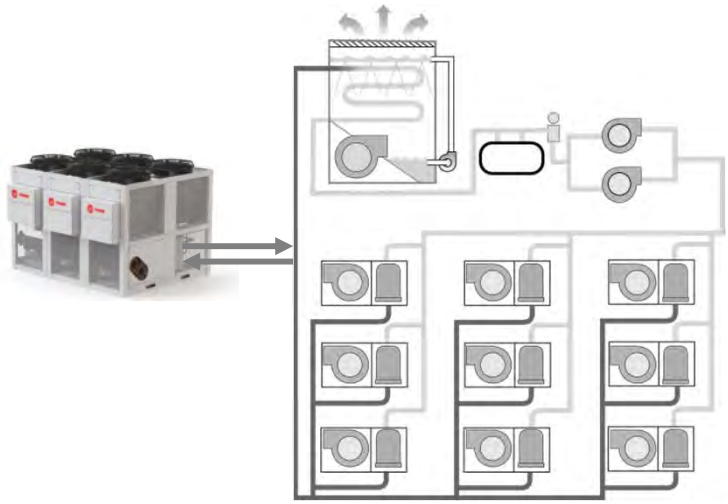
Water-source Heat Pump (loop tempering)

Applications:

- WSHP
  (loop tempering)

Design Considerations

- Loop temperatures
  (60-90ºF common)
- Ambient
  (down to 0ºF)



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Air-Source Applications

Lower Temperature Hydronics

HOT WATER TEMPERATURE

Applications:

- Lower temp hydronics

Design Considerations

- Loop temperatures (90-120ºF common)
- Ambient (down to 0ºF)
- Defrost

INCREASED SYSTEM EFFICIENCY

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Products

- Air Source
  - Apps
- **Water Source**
  - Apps

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Water-Source Products

Wide range of options…

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Applications

- Air Source
  - Off-load Boiler
  - WSHP
  - Lower temp hydronics
- Water Source
  - **Heating with a cooling load**
  - Heating without a cooling load

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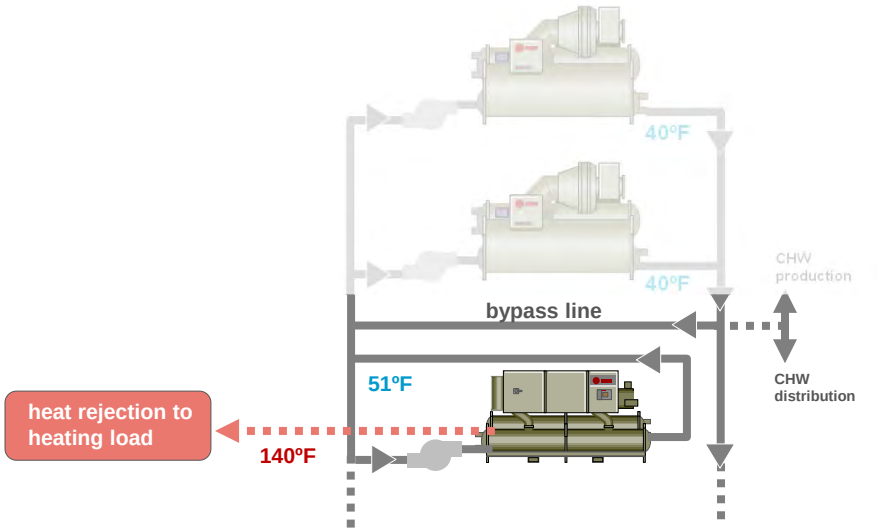
Water-Source Products

Heat Recovery with Cooling Load



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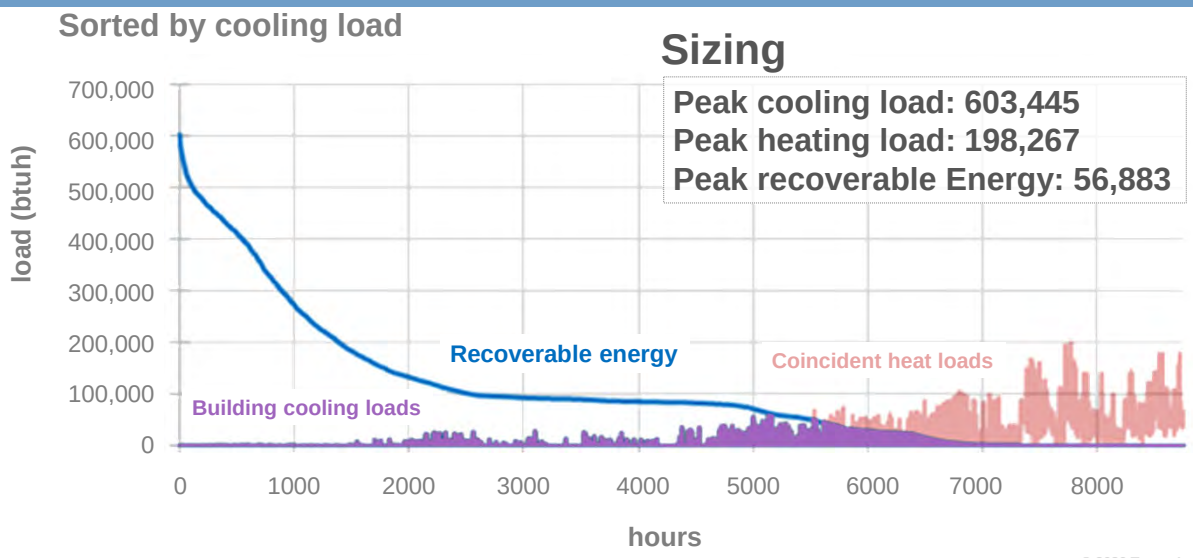
Water-Source Applications

Building Cooling and Heating loads

Sorted by cooling load



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Applications

- Air Source
  - Off-load Boiler
  - WSHP
  - Lower temp hydronics
- Water Source
  - Heating with a cooling load
  - **Heating without a cooling load**

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Water-Source Products

Heat Recovery without Cooling Load

How can I find BTU's to make heat?

66


sources/sinks
Borefield
borefield
Arctic

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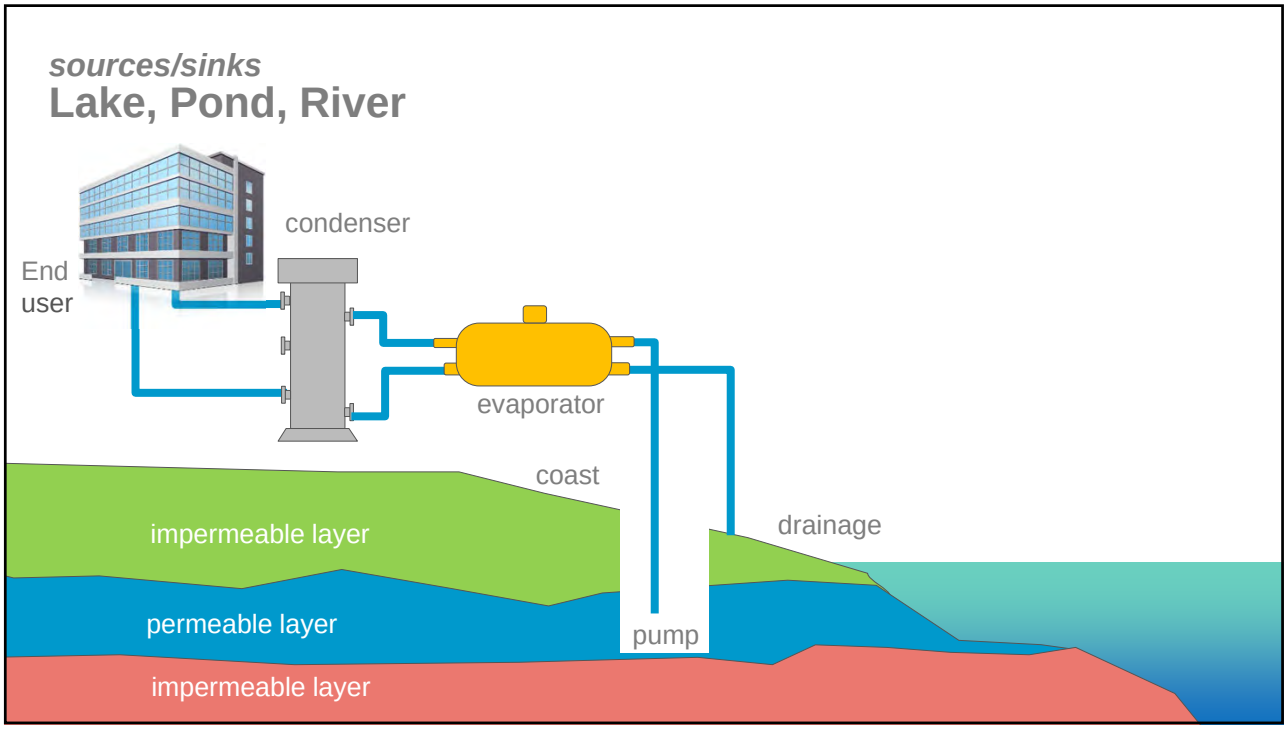
sources/sinks
Lake, Pond, River
End user
condenser
evaporator
coast
impermeable layer
permeable layer
impermeable layer
pump
drainage

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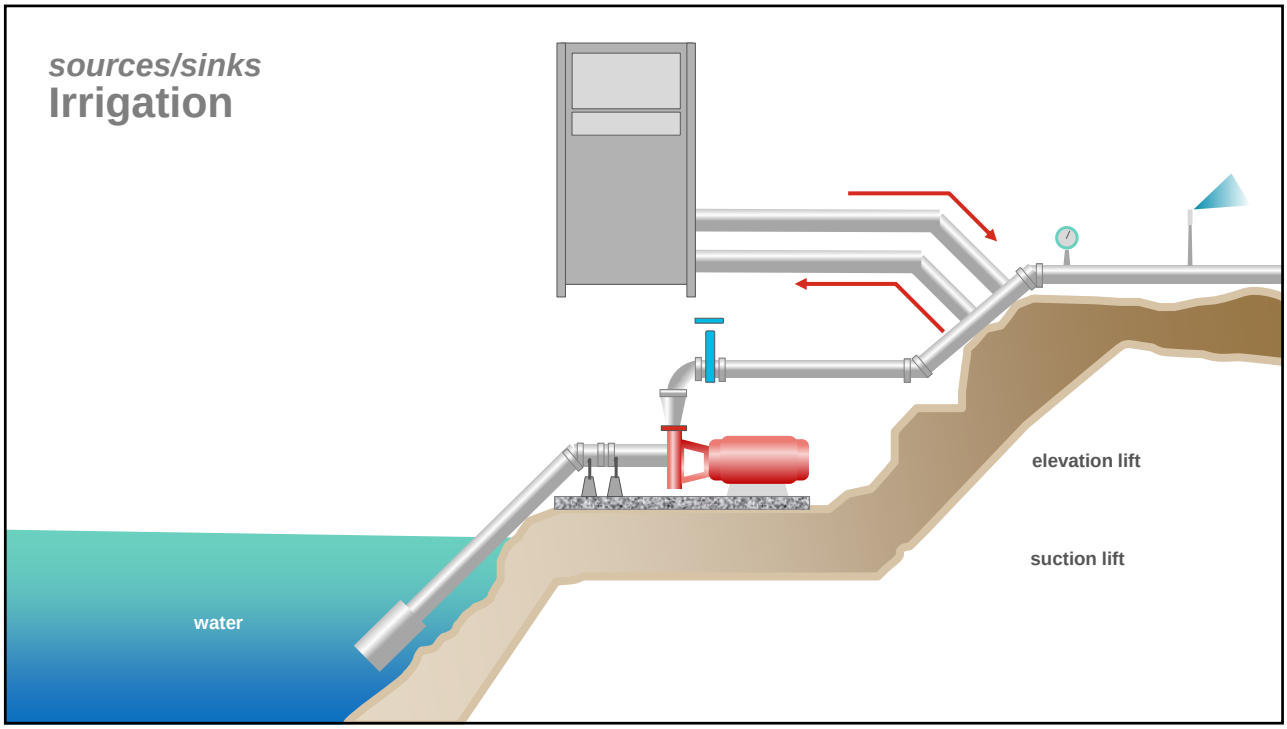

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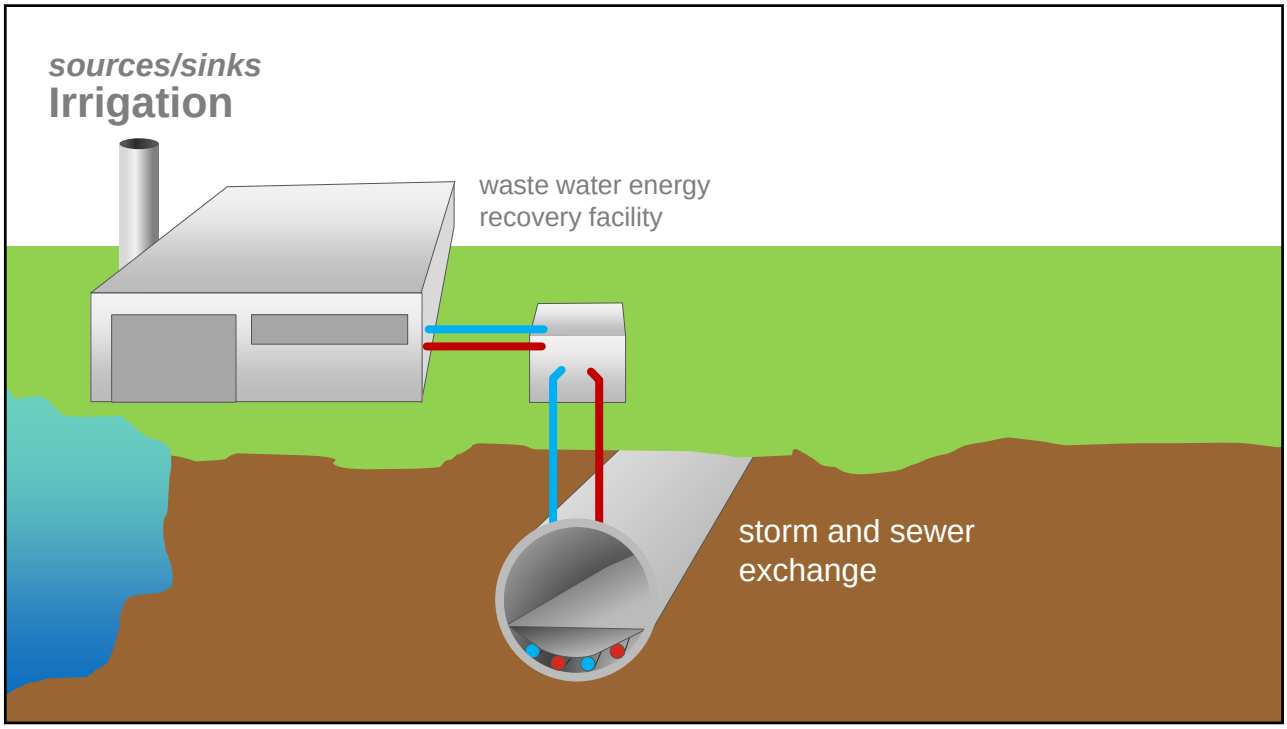

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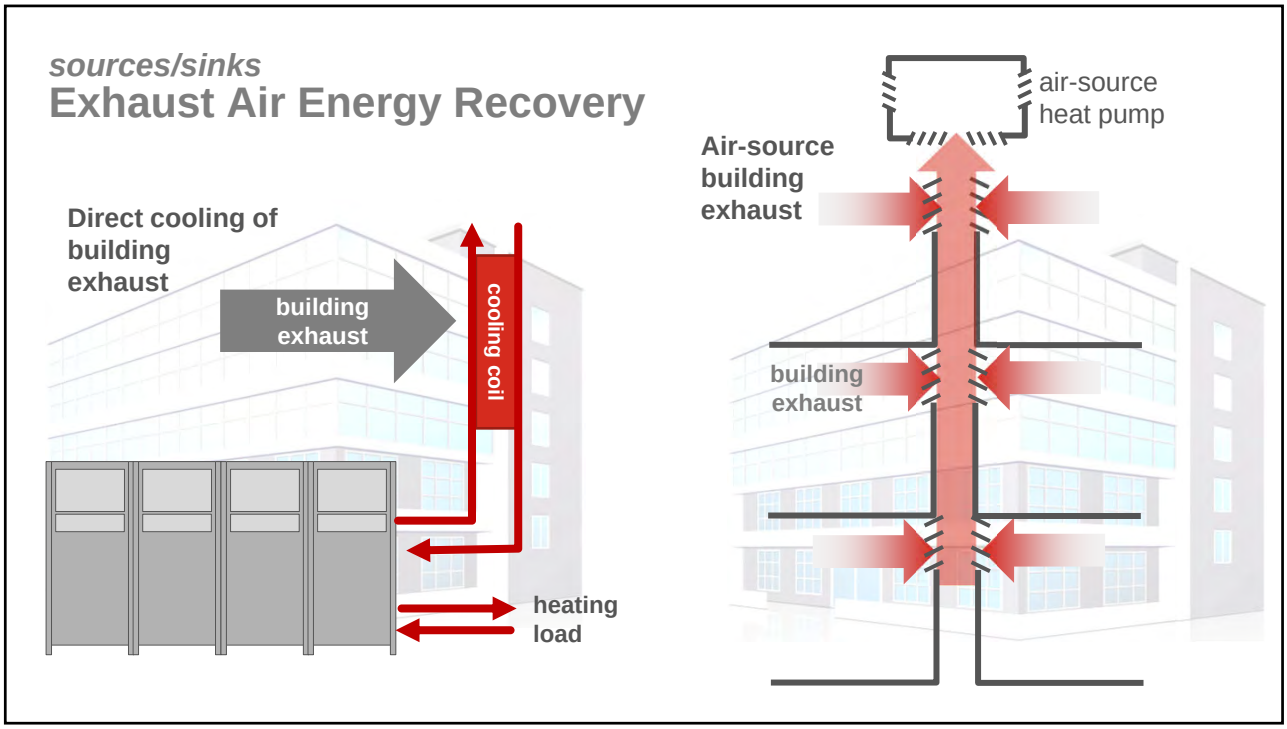

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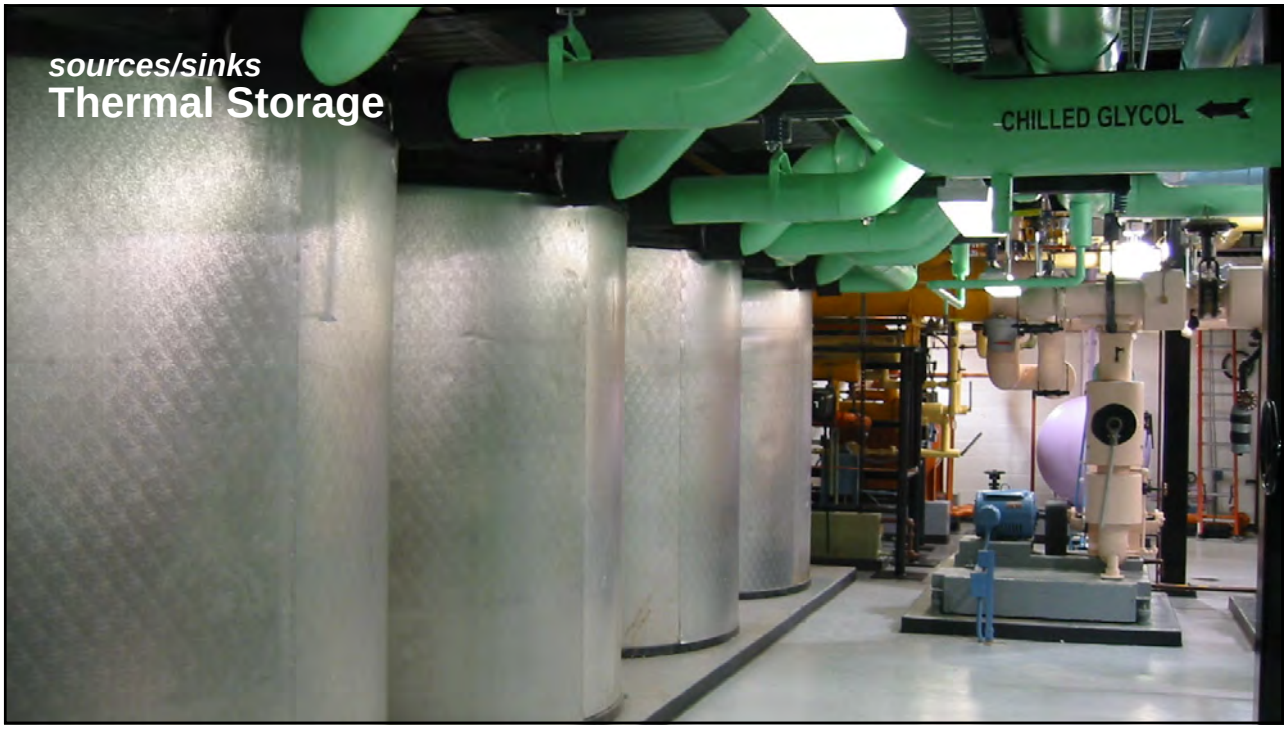

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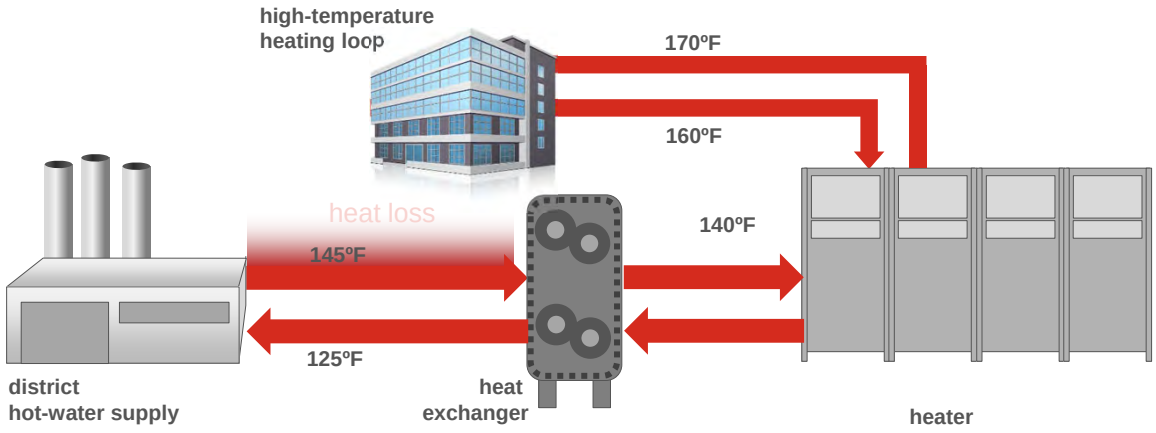
sources/sinks
Cascade



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Sections

- What is Decarb / Electrification
- Heat Pump Considerations
- Product Solutions
  - Split Systems
  - Packaged Units
  - Applied Systems
  - Potable/Domestic Water Systems

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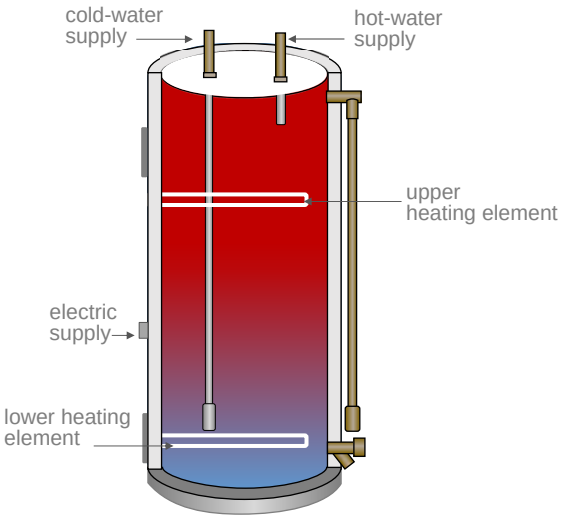
Potable Hot Water
Electric Resistance

Output Capacity:
15-350 MBH

Considerations:
- Electric service
- Storage capacity
- Cost to operate



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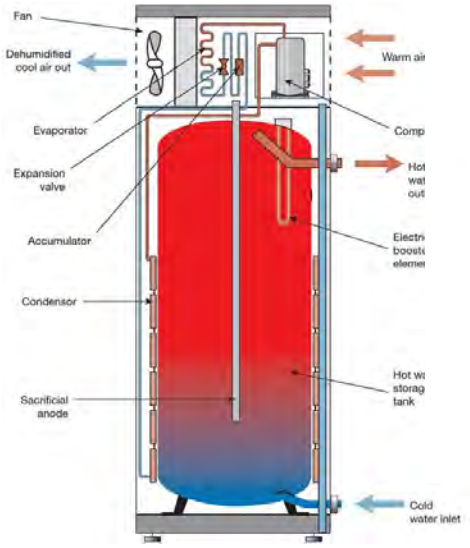

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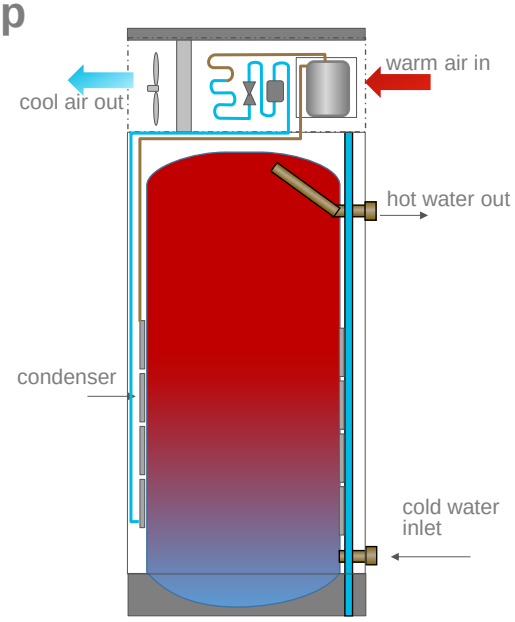
Potable Hot Water

Electric Packaged Heat Pump

Output Capacity:
15-60 MBH

Considerations:

- First cost
- Space impacts



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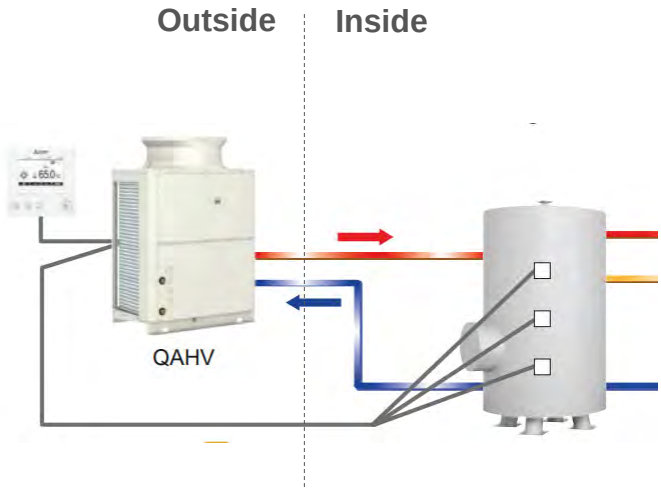
Potable Hot Water-Split Heat Pump



Output Capacity: 15-2,000 MBH

Considerations:
-Ambient
-Freeze Protection

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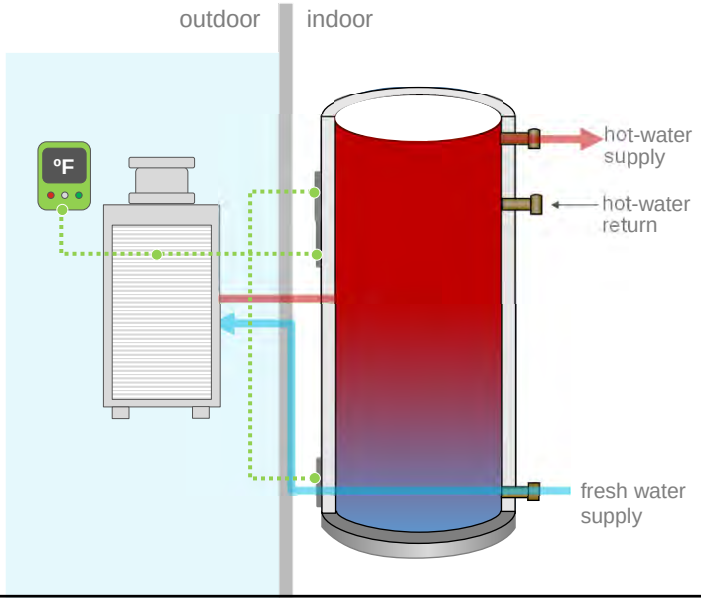
Potable Hot Water
Split Heat Pump

Output Capacity:
15-2000 MBH

Considerations:
- Ambient
- Freeze protection



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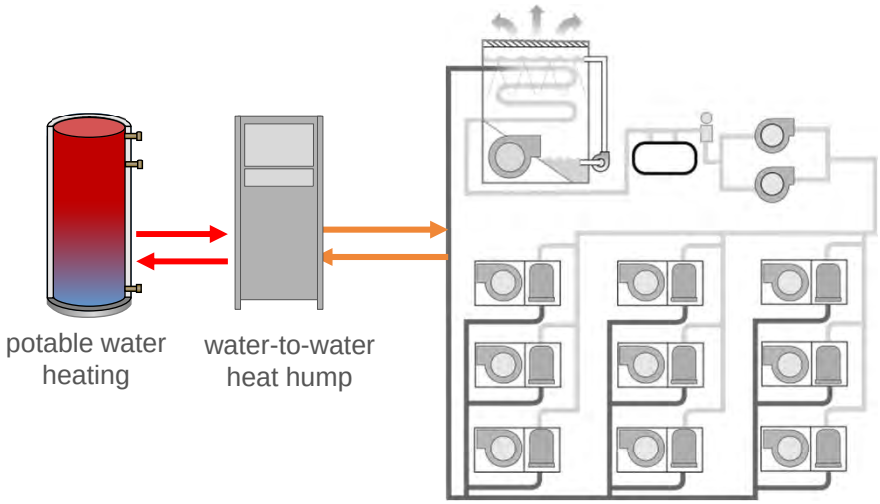
Potable Hot Water
Split Heat Pump - Variation



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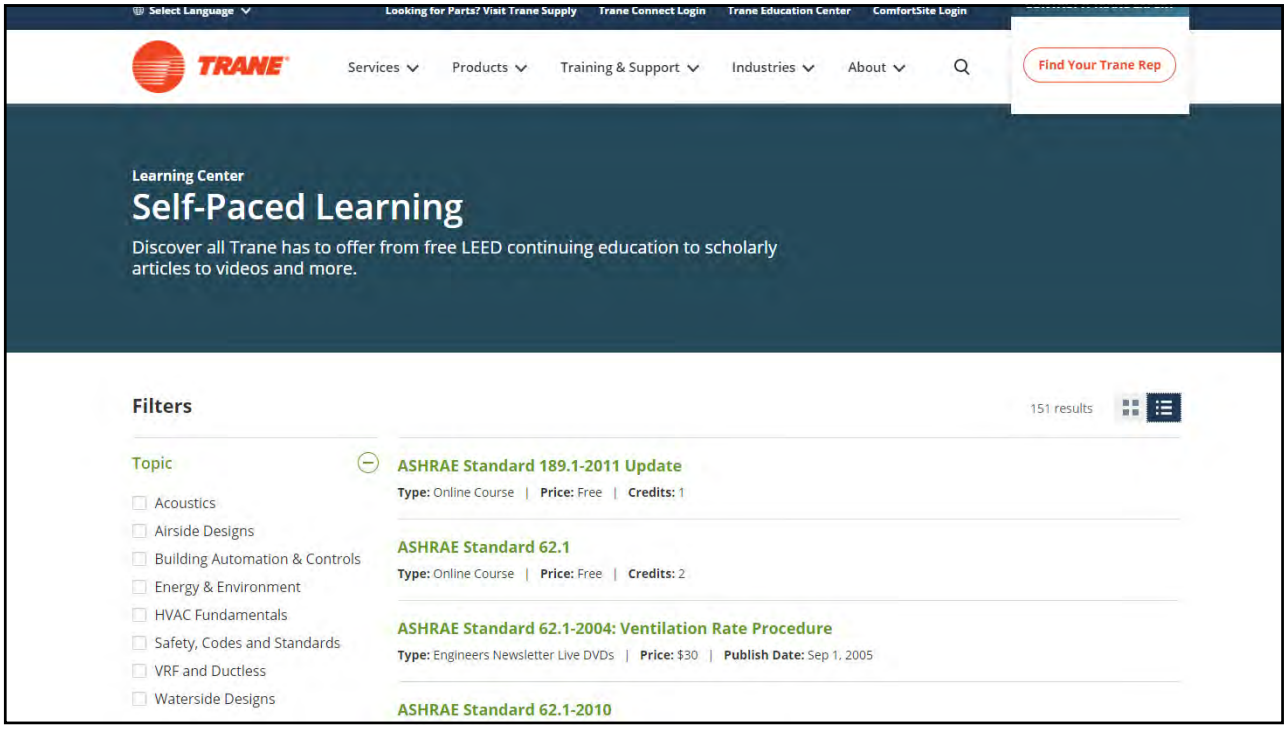

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Resources

Decarbonization/Electrification of HVAC Systems

https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/clean-energy-solutions/clean-energy-solutions.page?WT.mc_id=Vanity_cleanenergy

https://www.epa.gov/energy/egrid-subregion-representational-map

https://www.eia.gov/consumption/commercial/

https://www.xcelenergy.com/

https://www.comed.com/Pages/default.aspx