



Hosted by: 

Technical Round Table: Heat Pump Technology

HTS New England
1 Corporation Way
Peabody, MA 01960



November 6, 2024
8:00am-12:00pm

Agenda:

- 8:00 – 8:10** Arrival, registration
- 8:10 – 9:00** Heating with lower temperature hot water (Joe Bliss, B2Q)
- 9:00 – 9:20** Refrigerants & Heat Pumps (JS Rancourt, DXS)
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- 9:30 – 9:45** Heat Pumps & Decarb, overview of heat pumps and types (Mark Lafrance, HTS)
- 9:45 – 10:20** Distributed DX heat pumps (including training center tour) (JS)
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- 10:30 – 11:00** ASHP RTUs, AHUs and Air-to-Water heat pumps (Mark)
- 11:00 – 11:20** DHW and high temp (JS)
-
- 11:30 – 12:00** Water Solutions (Chris Ouellette, Mitsubishi)

HTS / DXS Presenters:



Mark LaFrance

*Principal
HTS New England*



JS Rancourt

*Principal
DXS New England*

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Delivering Real Success®



We are: HVAC Manufacturer's Representatives & a Building Automation contractor

*AHUs (catalogued – modular – full custom), ERVs, Chillers, ASHP & WSHP
Chillers, Fans, Lab exhaust, Lab energy recovery, pre-fab plants, terminal
equipment, humidification, air purification, etc.*

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Agenda

- 1. Refrigerants (and how they fit in decarbonization)**
- 2. Where heat pumps fit in decarbonization**
- 3. Heat pump overview and types (in 2024!)**
- 4. Heat pump dive, by type**

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1. Refrigerants (and how they fit in decarbonization)
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Refrigerants: Why do we care?

1

Refrigerants are used in basically every type of cooling & dehumidification equipment, and in all heat pumps. *New tech**

2

Refrigerants impact the life cycle climate performance of a building (they can improve it if they are more efficient, they can worsen it if they have high GWPs and if there are leaks)

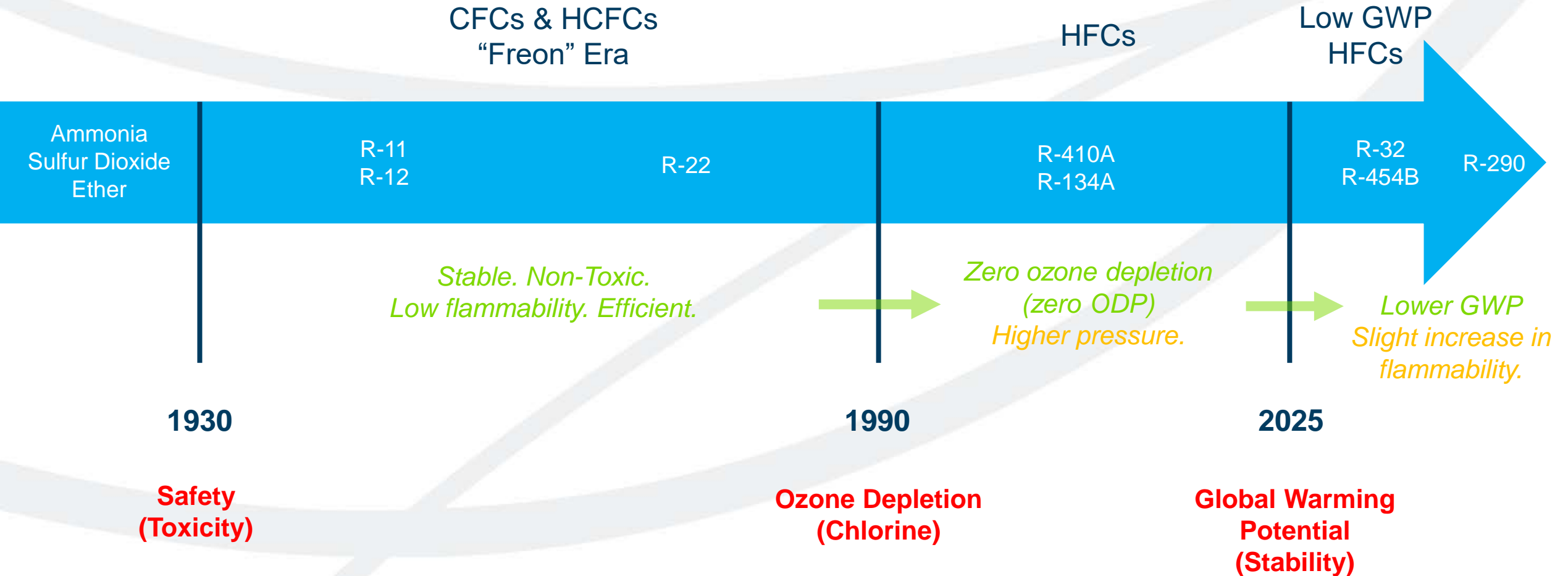
3

We are currently in the middle of a major refrigerant transition, with major impacts on the heat pump industry (all types).

This is a very positive change for heat pumps, but the transition will cause hiccups, and there are new codes and standards to understand.



Quick History of HVAC refrigerants...



2025 U.S. EPA HFC Phase Ruling (AIM Act)

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protect copyright



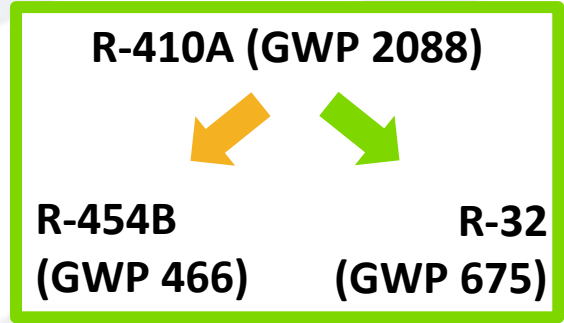
Air-Source **Heat Pump** Chillers:
High pressure refrigerants

140F Supply
Water



0F Ambient

124F



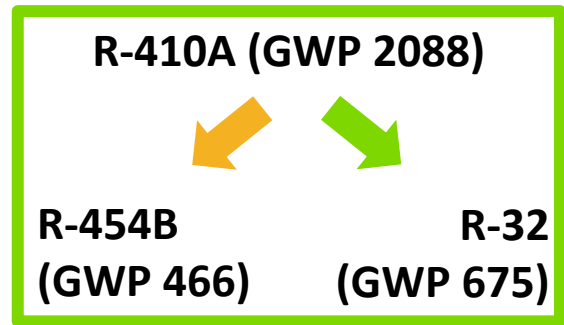
Air-Source **Heat Pump** VRV / Splits:
High pressure refrigerants

113F
Refrigerant
(condensing temp)



-22F
Ambient

135F



Water-Cooled Chillers:
Low / Medium pressure refrigerants



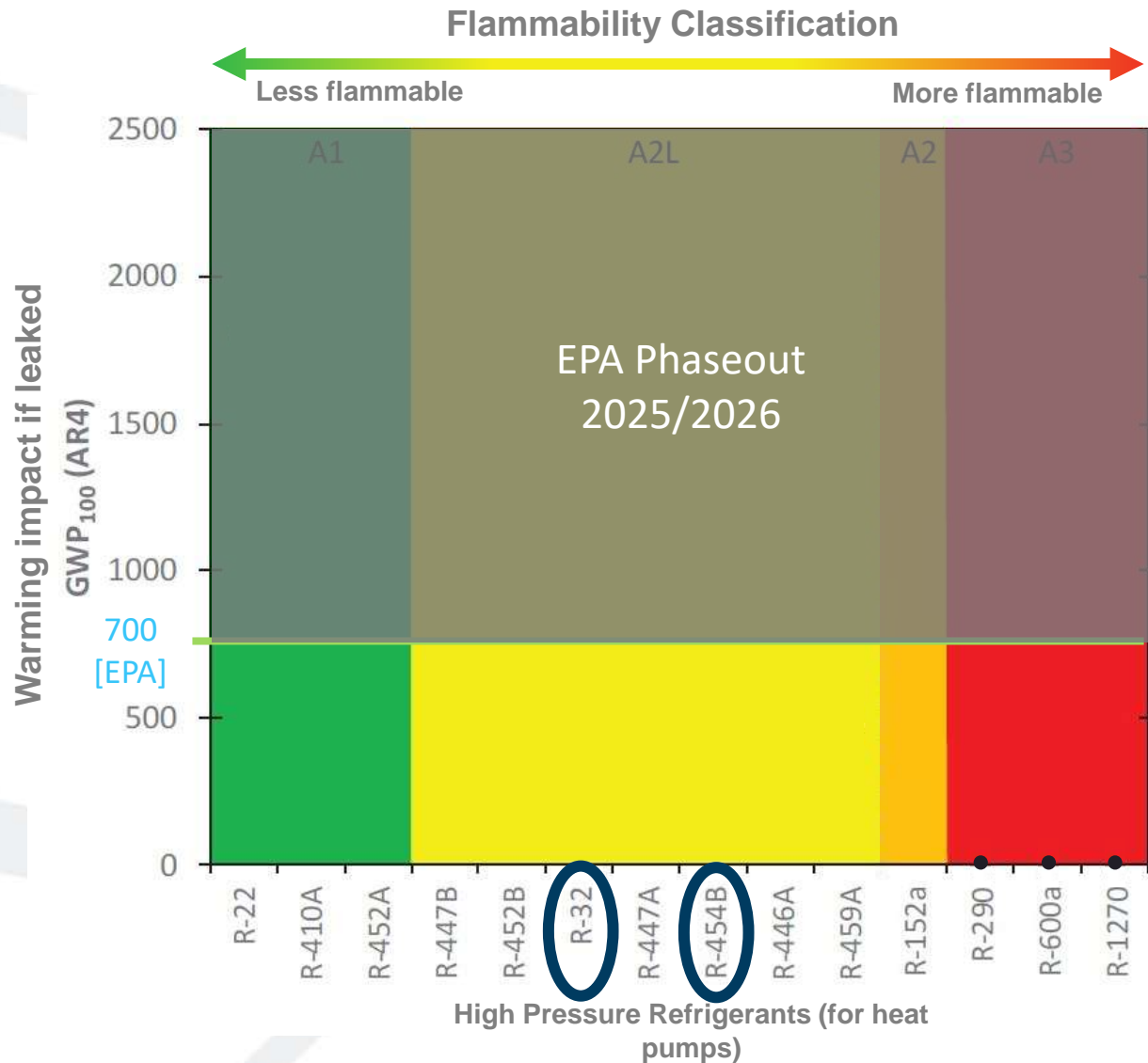
R-123 (GWP 79)
↓
R- 1233zd (GWP 1)*

Air-Cooled Chillers:
Medium / High pressure refrigerants



R-134A (GWP 1430)
↓
R- 513A (GWP 573)
↓
R-515B (GWP 292)
R-1234ze (GWP 1)

Where does this increased flammability problem come from?



- In high pressure refrigerants (for ASHPs) flammability and GWP are essentially inversely proportional

GWP vs Flammability

- More Fluorine results in more stable chemicals. Great to reduce flammability, bad for GWP as it doesn't breakdown

ASHRAE Standard 34 – Designation and Safety Classification of Refrigerants (2022)

Higher Flammability	A3	B3
Flammable	A2	B2
Lower Flammability	R-32 R-454B A2L	B2L*
No Flame Propagation	R-410A A1	B1
	Lower Toxicity	Higher Toxicity

↑

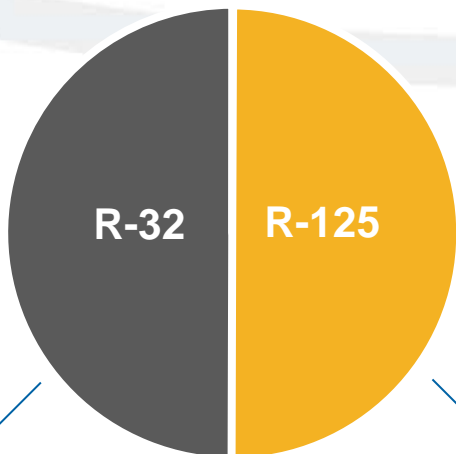
- Most refrigerants can and will combust when put into a high-energy situation such as a fire (ie. R-410a)
- There are (4) flammability classes, and no class called “non-flammable”
- **1:** Flame propagation Test (at testing standard of 140F)
 - No flame propagation = Class 1
- **2:** How much (needed to ignite), how hot, how fast
 - Concentration needed to ignite (LFL) < 0.10 kg/m³ = Class 3
 - Heat of Combustion HOC > 19 kJ/g = Class 3
 - Otherwise, high LFL and low HOC = Class 2
 - *If burn velocity < 10 cm/sec ~ 20ft/minute = Class 2L*

R-410a Alternatives

(high pressure, low GWP refrigerants for heat pumps)

R-410a

(non-proprietary)



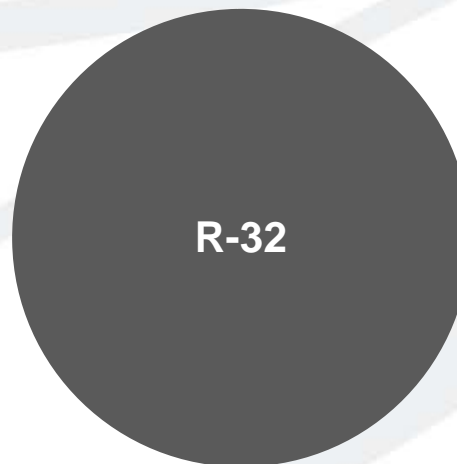
Class: A1

Awesome refrigerant.
Most efficient & highest capacity high-pressure refrigerant¹

Not so awesome refrigerant.
High fluorine content refrigerant with low performance but high stability resulting in the A1 classification

R-32

(non-proprietary)

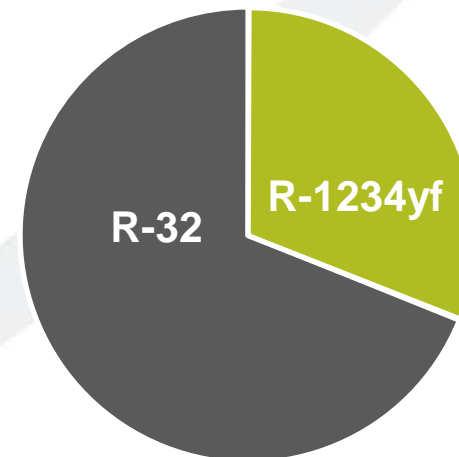


Class: A2L

R-32 is simply the removal of R-125 from R-410a, resulting in a pure refrigerant with the best performance across high pressure refrigerants¹

R-454B

(proprietary)



Class: A2L

R-32 mixed with HFO R-1234yf reduces the GWP but results in a blend with a slight glide (issue with distributed DX), and a slight reduction in capacity and efficiency

1. <https://www.nature.com/articles/ncomms14476/figures/3>



The result: timelines (by equipment type)

		2024	2025	2026	2027	2028
Mini / Multi Split ASHPs	Manufacture with R-410a	Yes	Only for replacement as "components"			
	Sell / install R-410a inventory	Yes	Yes (1-year sell-through)	No		
	R-32 Availability	On-going releases	Yes			
VRV / VRF	Manufacture with R-410a	Yes		Only for replacement as "components"		
	Sell / install R-410a inventory	Yes		Yes (1-year sell-through)*	No	
	R-32 Availability	No	On-going releases	Yes		

The result: timelines (by equipment type)

		2024	2025	2026	2027	2028
Chillers ASHP Chillers	Manufacture with GWP > 700	Yes (if permitted < 2024)	No			
	Sell / install inventory	Yes (if permitted < 2024)	No			
	New Refrigerants	On-going releases	Yes			
PTACs PTHPs RTUs	Manufacture with R-410a	Yes	No			
	Sell / install R-410a inventory	Yes	Yes (3-year sell-through)			No
	R-32 / R-454B Availability	On-going releases	Yes			

Existing R-410a Splits / VRV

- AIM act specifically protects existing systems, ensuring they can be operated, maintained, repaired and even replaced (with some restrictions) without forcing a refrigerant change
- EPA rules do not restrict manufacturing or import of R-410a equipment used for the replacement industry
 - R-410a condensing units can be replaced with R-410a condensing units (no end date)
 - R-410a indoor units can be replaced with R-410a indoor units (no end date)
- EPA's position on what constitutes a "new system"

Image retracted to protect copyright

- We expect a big R-410A VRV market to continue feeding this replacement industry



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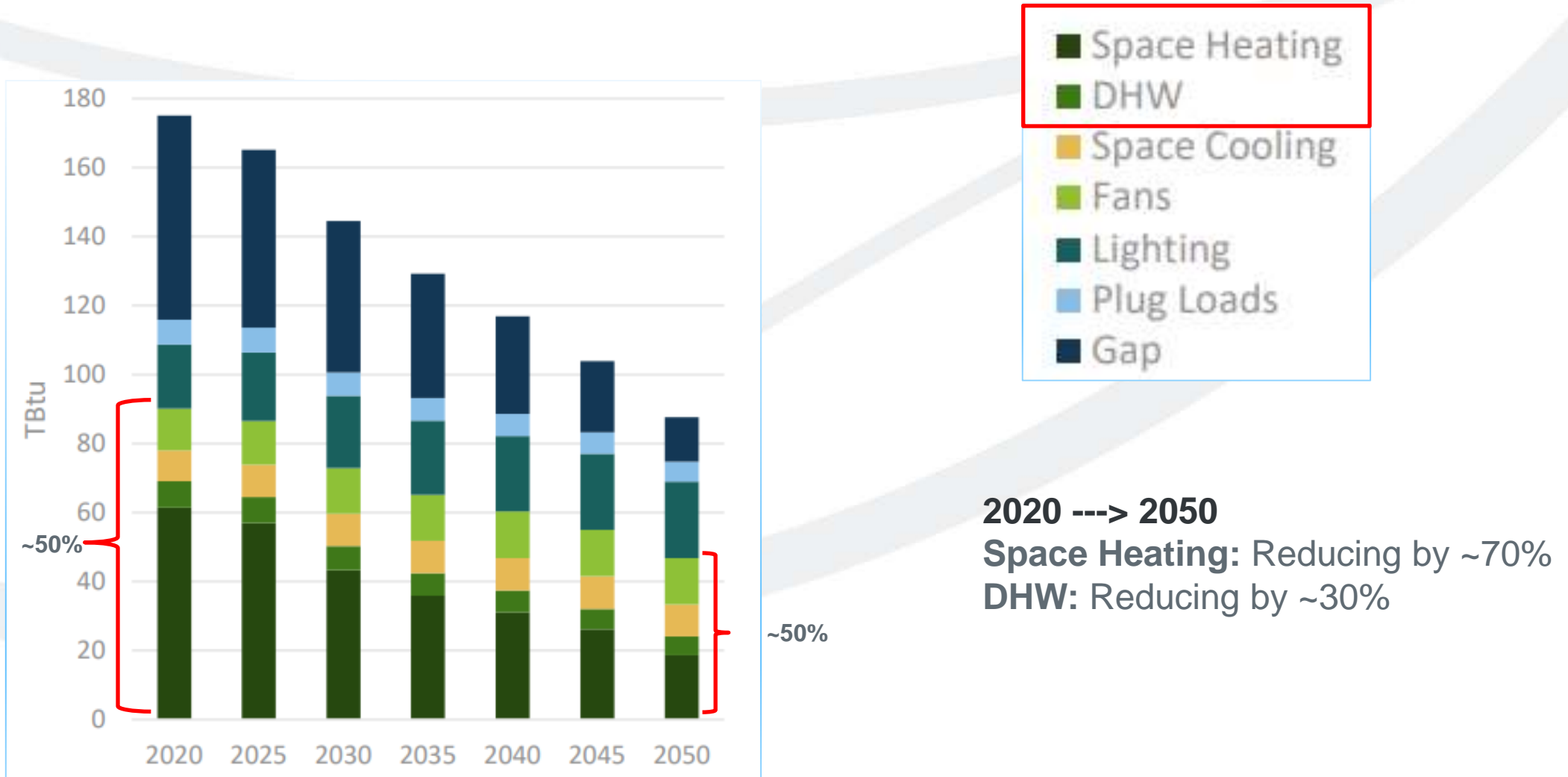
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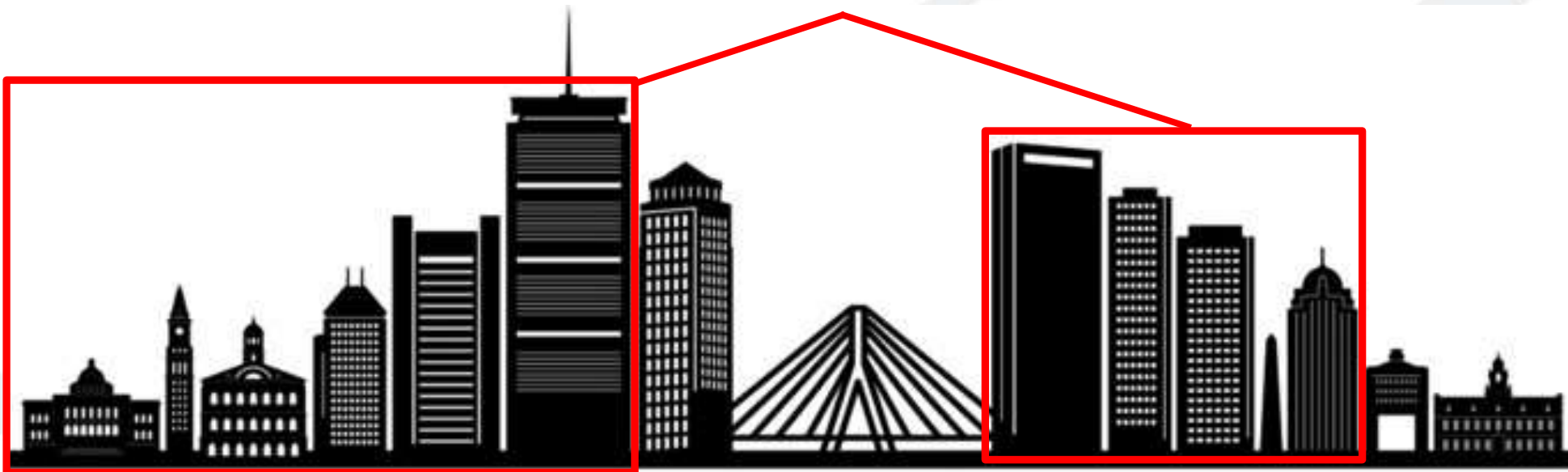
Decarbonization Pathway



Decarbonizing Existing Buildings

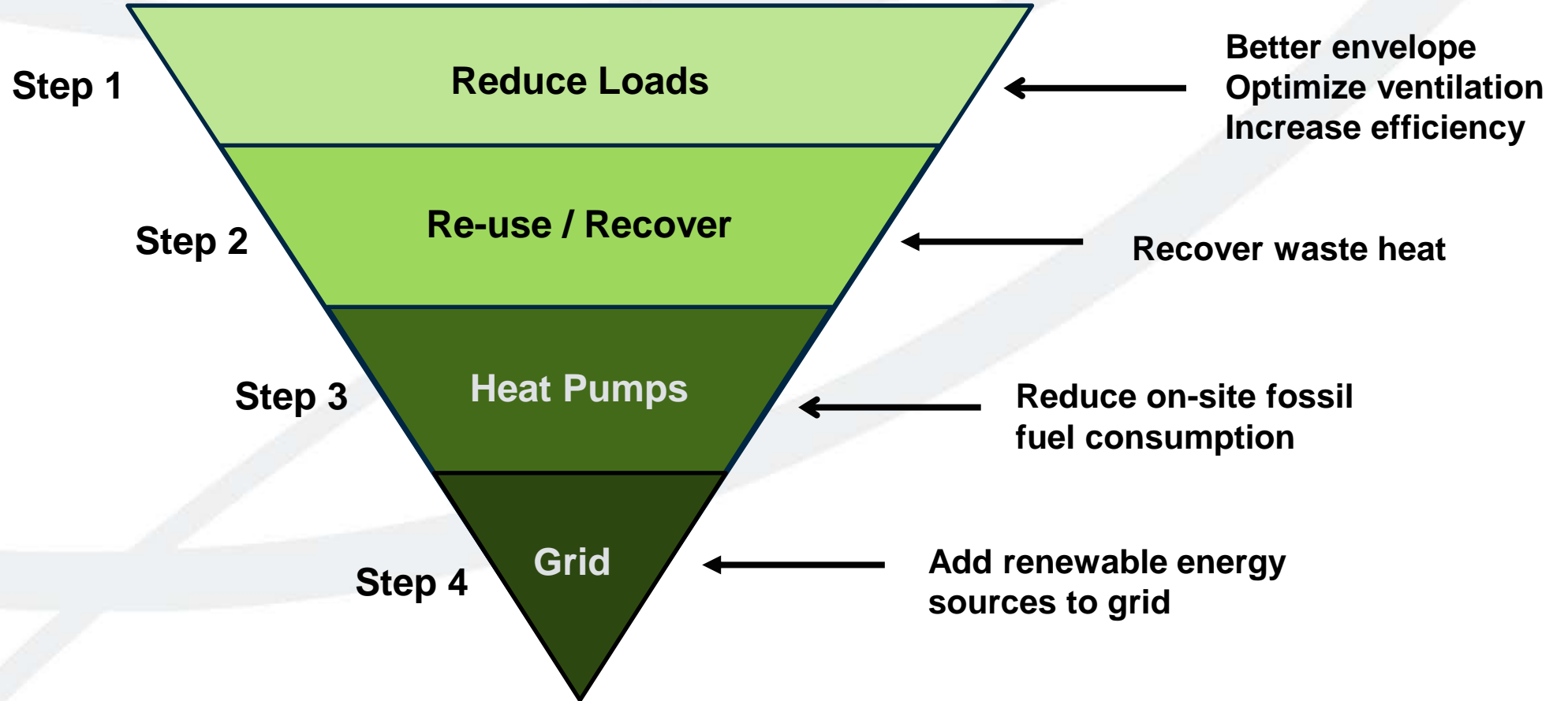
80% of the predicted building stock for 2050 are buildings that exist today

These exist today!

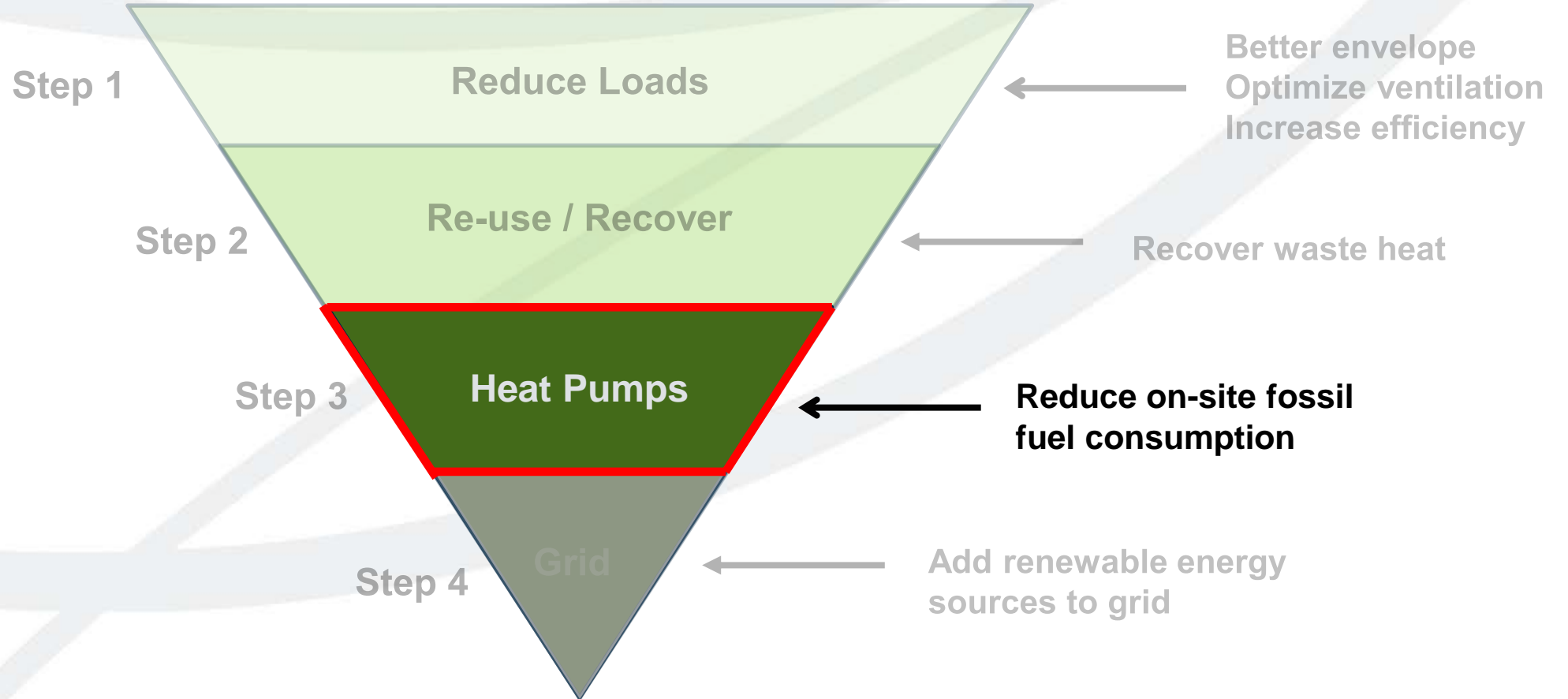


Circa 2050

Path to a Decarbonized Future



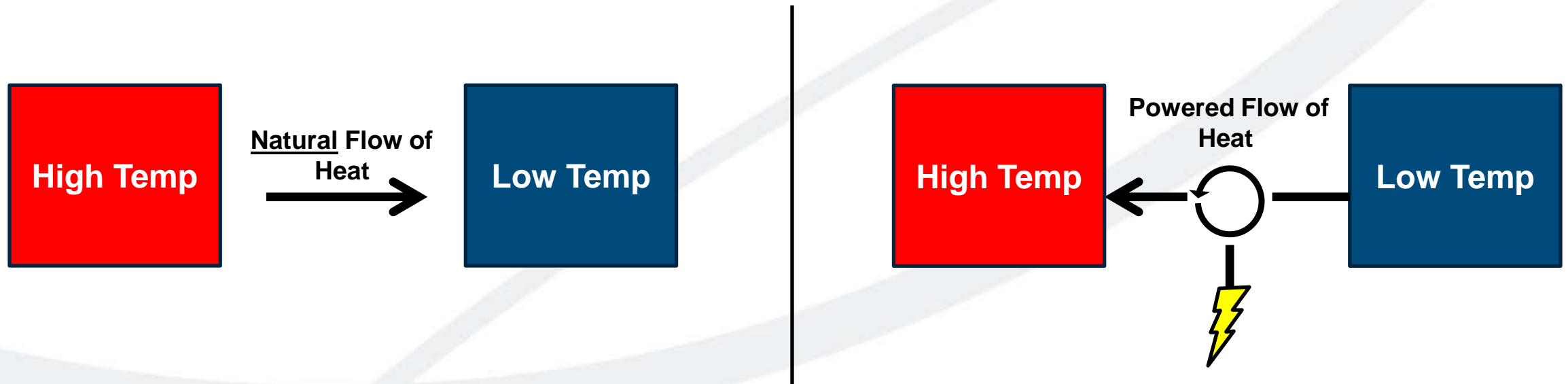
Path to a Decarbonized Future



Agenda

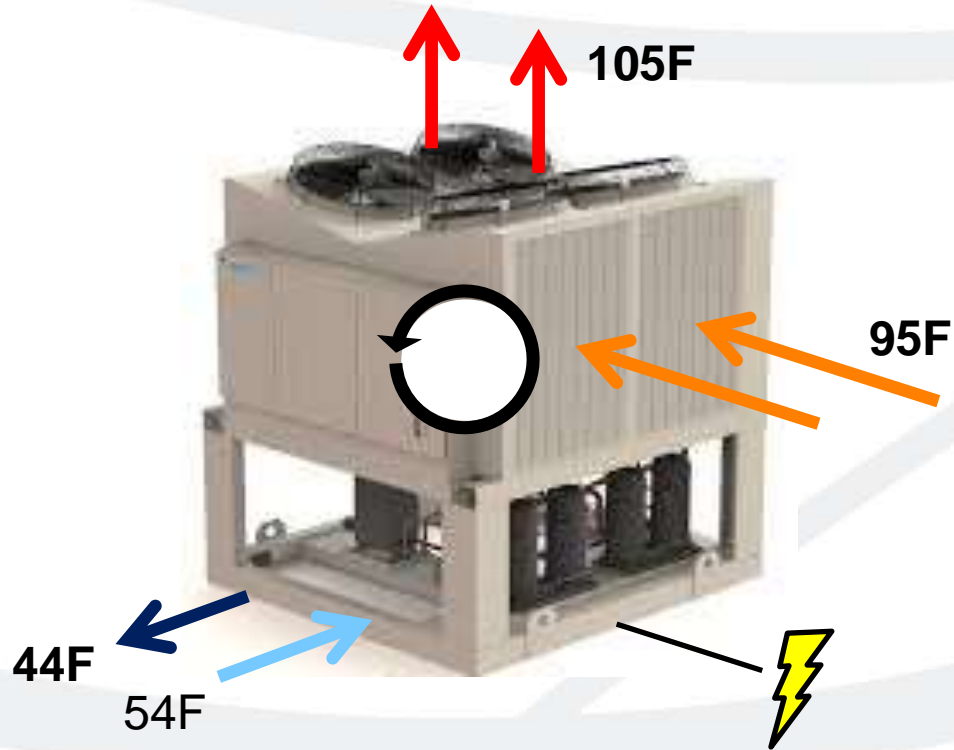
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What is a heat pump?

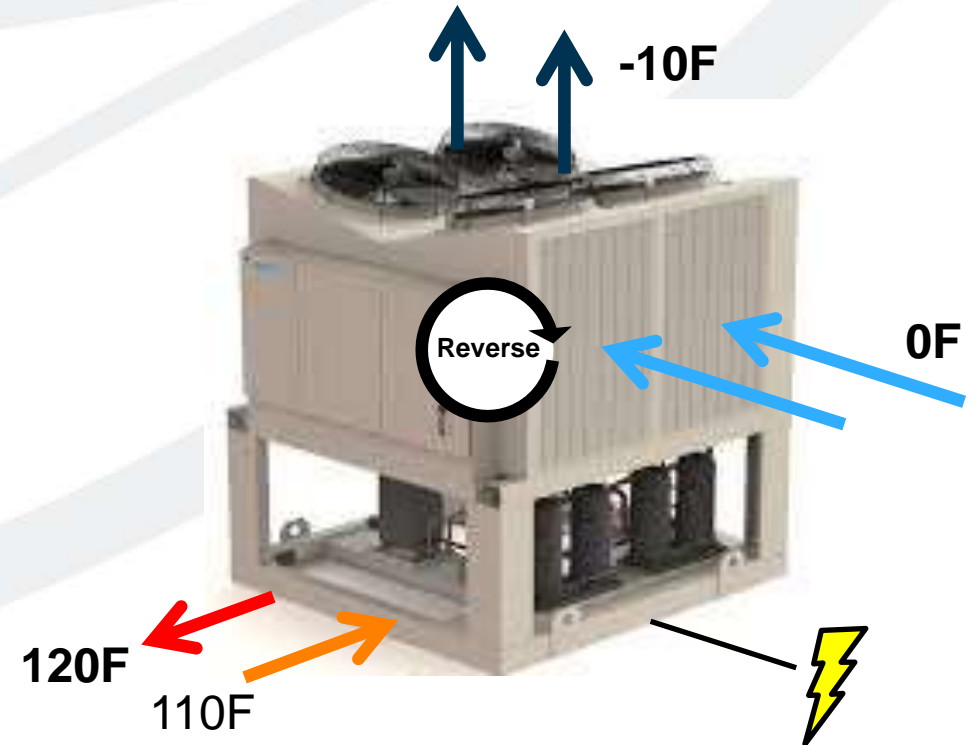


What is a heat pump?

Cooling Mode (Chiller)

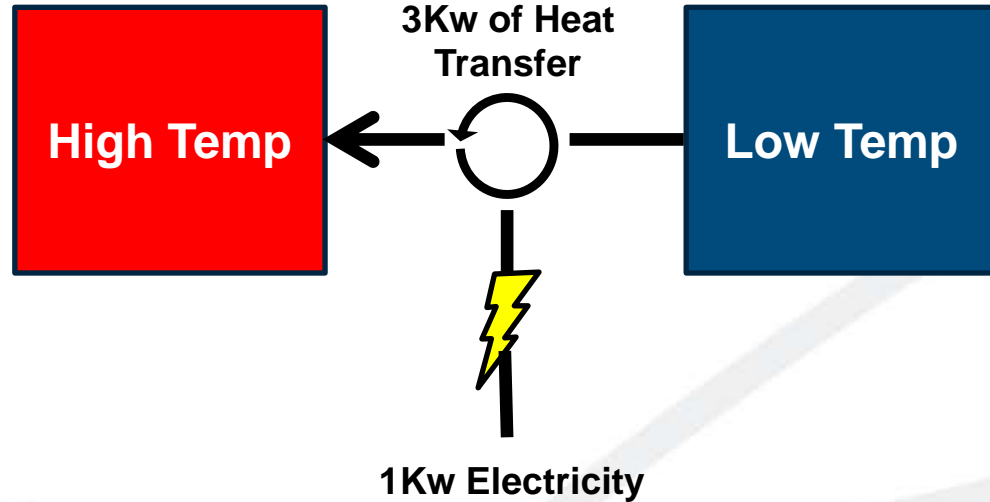


Heating Mode (Heat Pump)

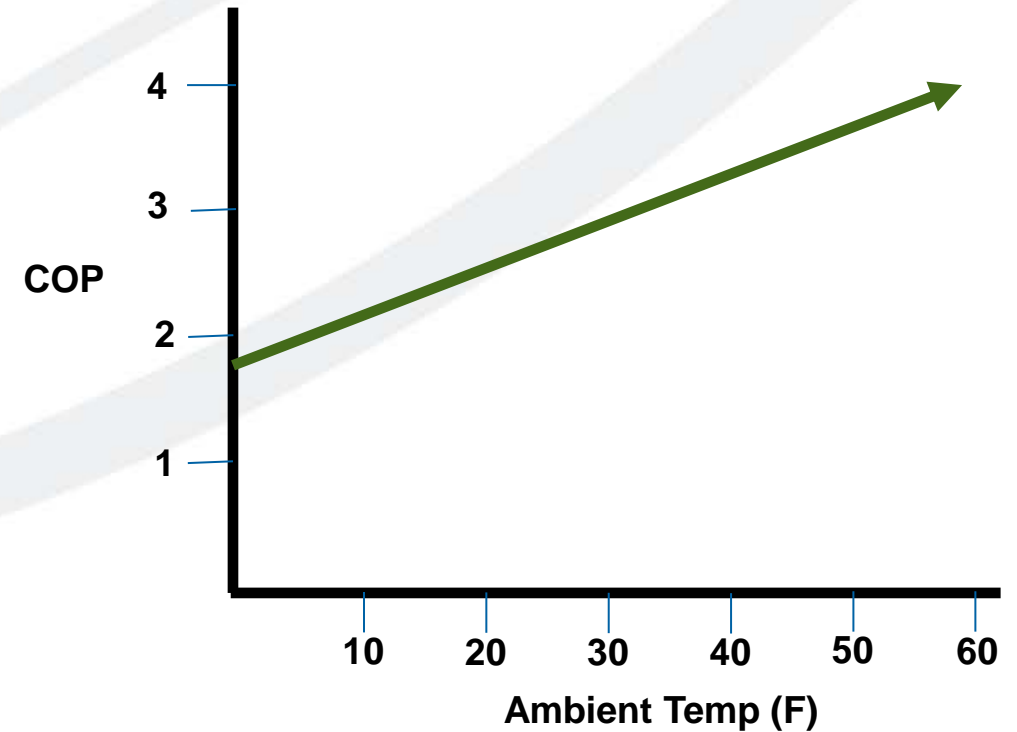


What is COP?

Coefficient Of Performance



COP = 3
Buy 1, Get 2 free



Types of heat pumps (2024 and beyond)

Mini/Multi Splits



Air / Water Source VRV/VRF



ASHP RTUs



Heat Pump Chillers



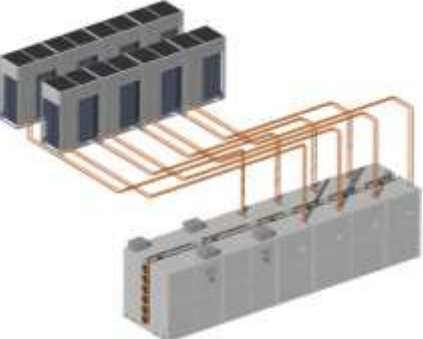
Ventilation / ERV Heat Pumps



Air / Water Source DHW



High Temp (180F) Air-to-Water



Waste-Water Recovery



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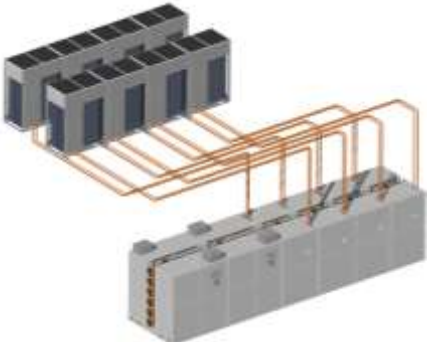


Ventilation / ERV Heat Pumps

Air / Water Source DHW

High Temp (180F) Air-to-Water

Waste-Water Recovery



Mini / Multi Splits: Cold Climate

R-410A → R-32
(1/1/2025)

Cold climate heat pumps:

- ¾ Ton → 5 Tons
- Horizontal discharge
- Inverter compressors (turndown)
- 100% Heat down to 5F, 0F or -4F
- No electric resistance heat
- Piping lengths
 - Upsizing for length vs turndown
- Accessories
 - stands, wind baffles, drain pan heaters



New drain pan design



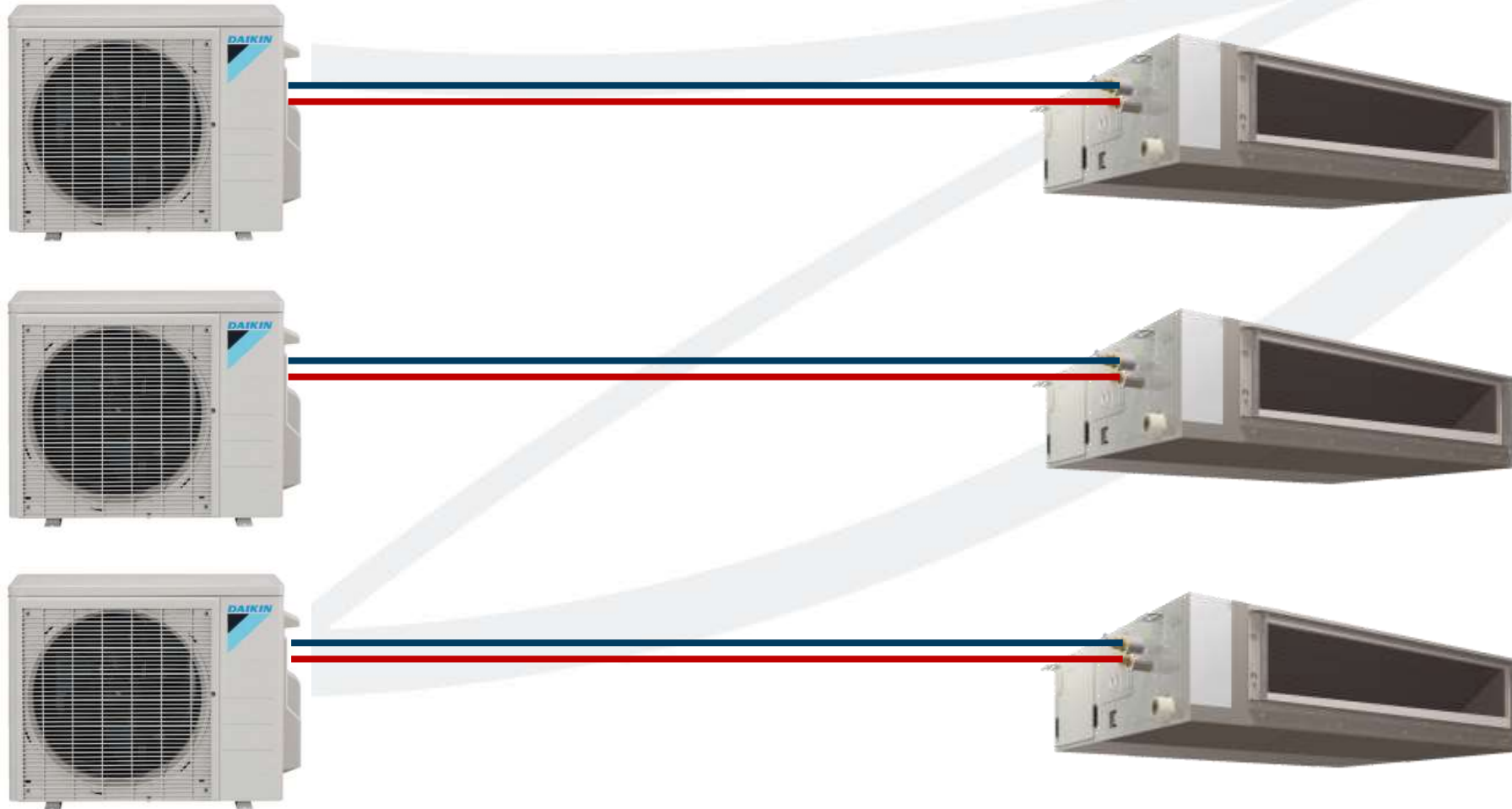
Single fan drain pan

Double fan drain pan



Mini-Splits

R-410A → R-32
(1/1/2025)

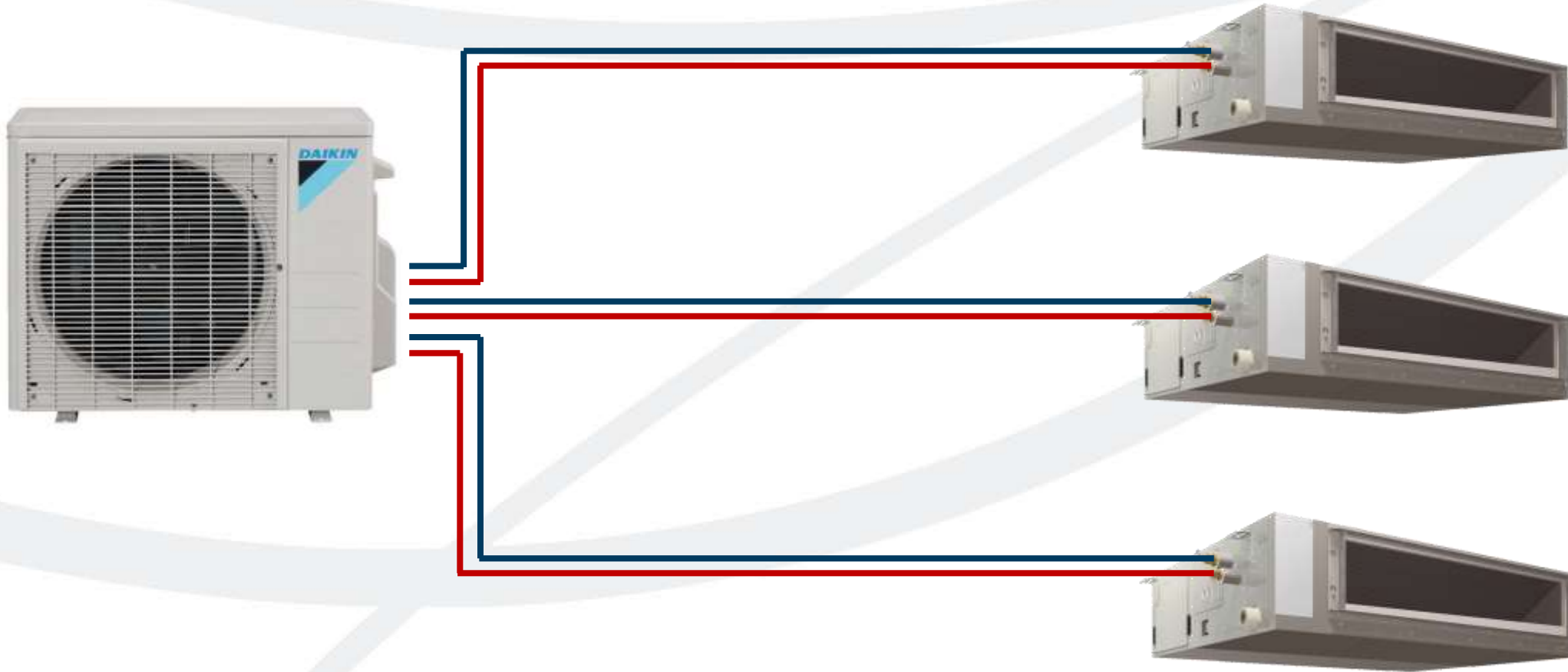


$\frac{3}{4}$ Ton → 4 Tons



Multi-Splits

R-410A → R-32
(1/1/2025)

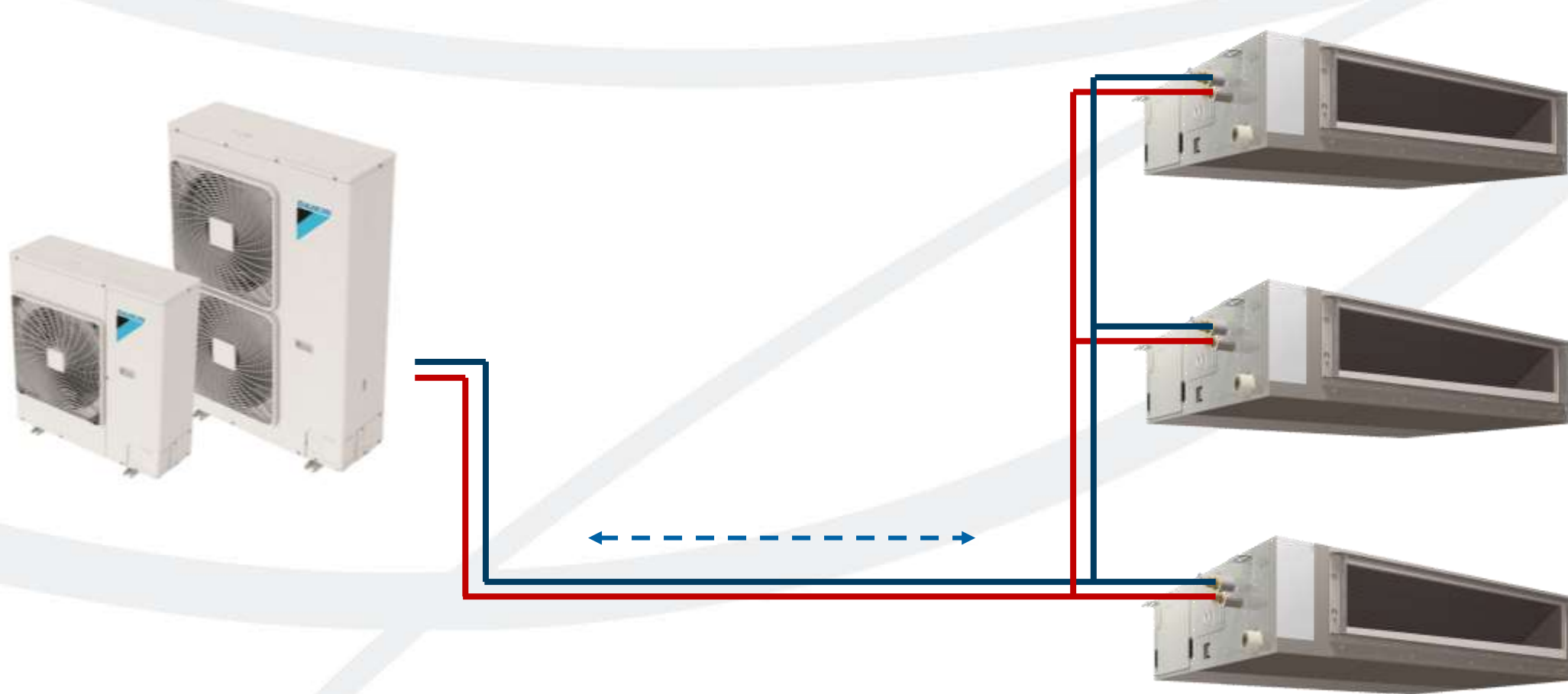


1.5 Ton → 4 Tons



VRV-S (Single Phase)

R-410A → R-32
(1/1/2025)

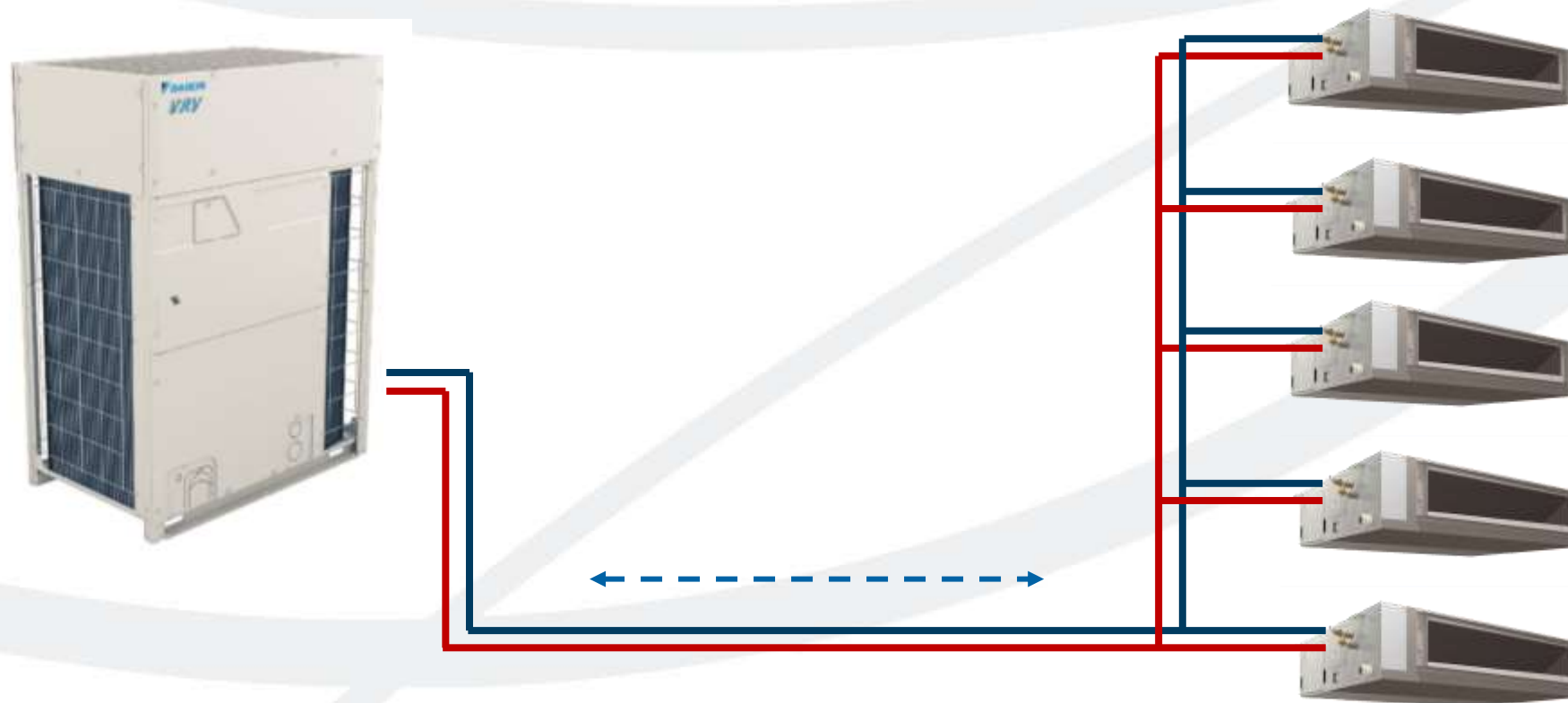


2 Ton → 5 Tons



VRV (Three Phase)

R-410A → R-32
(1/1/2026)



6 Ton → 40 Tons

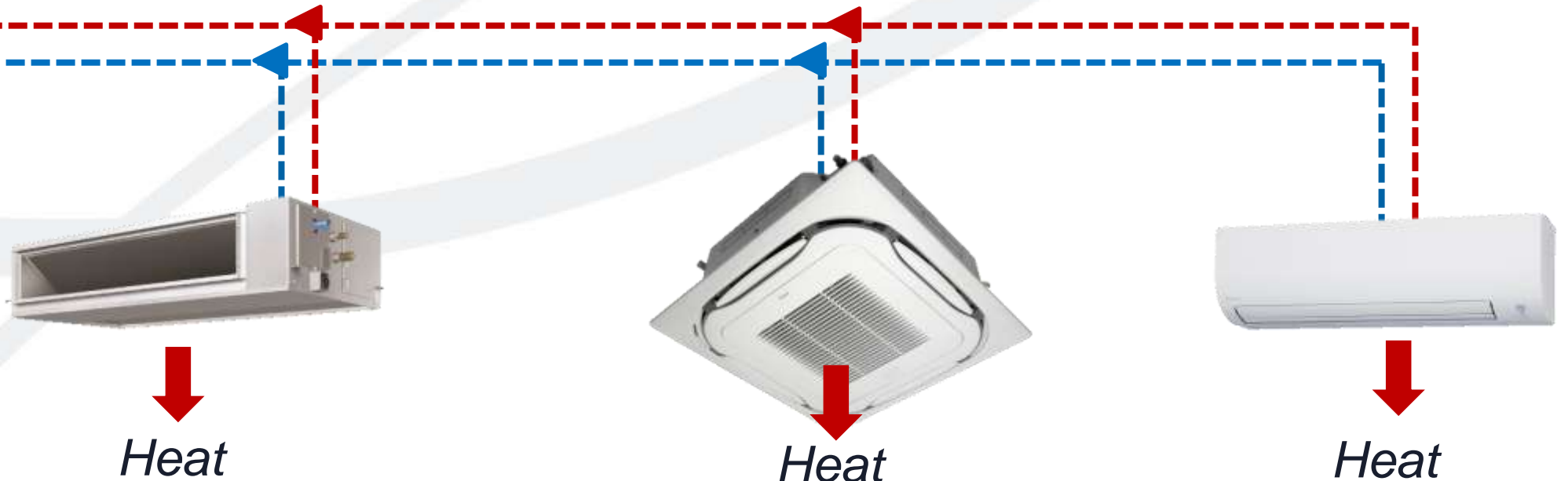


VRV Heat Pump vs Heat Recovery



HEAT PUMP

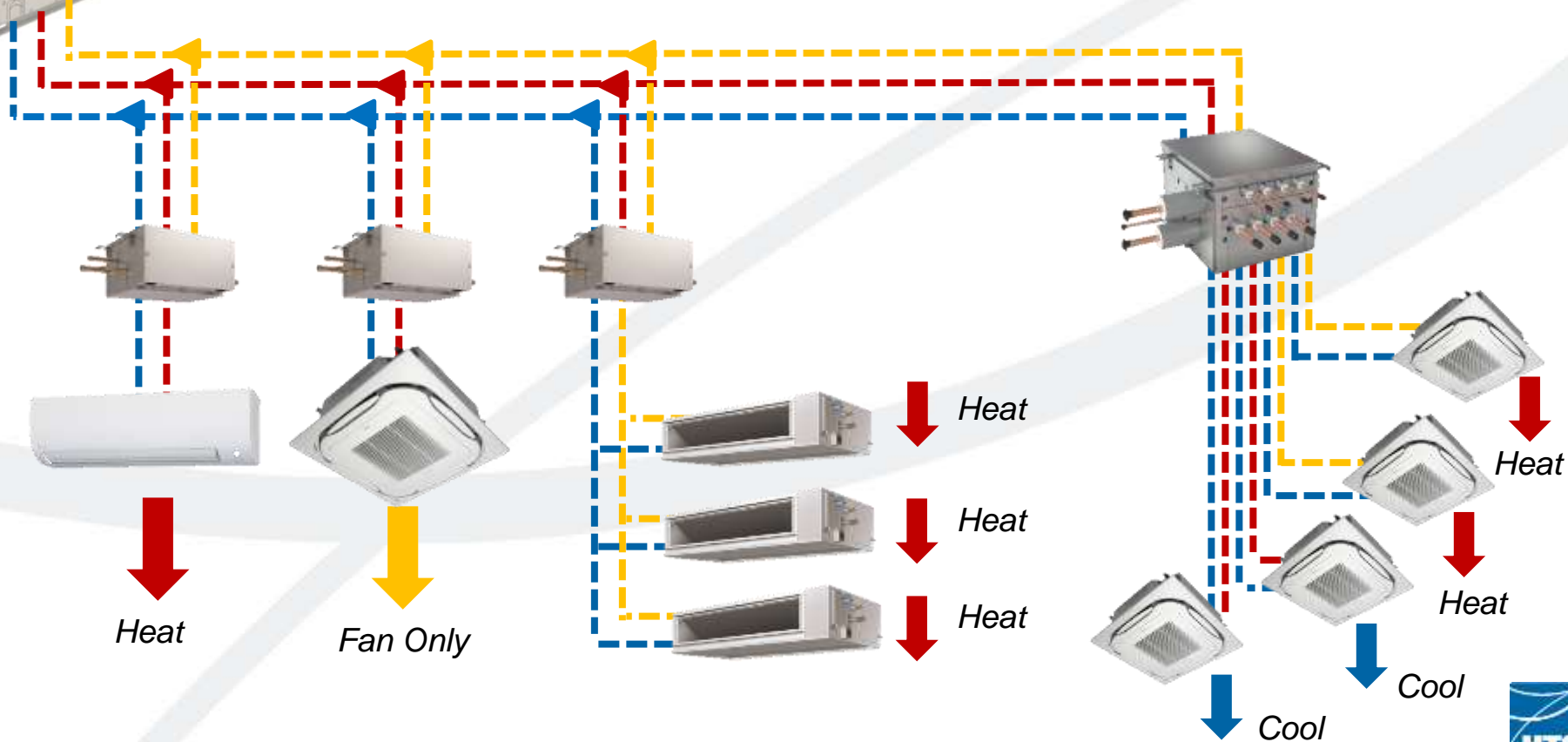
- Like a 2-pipe changeover system
- All indoor units are in either heating or cooling
- Automatic switchover within minutes, year round



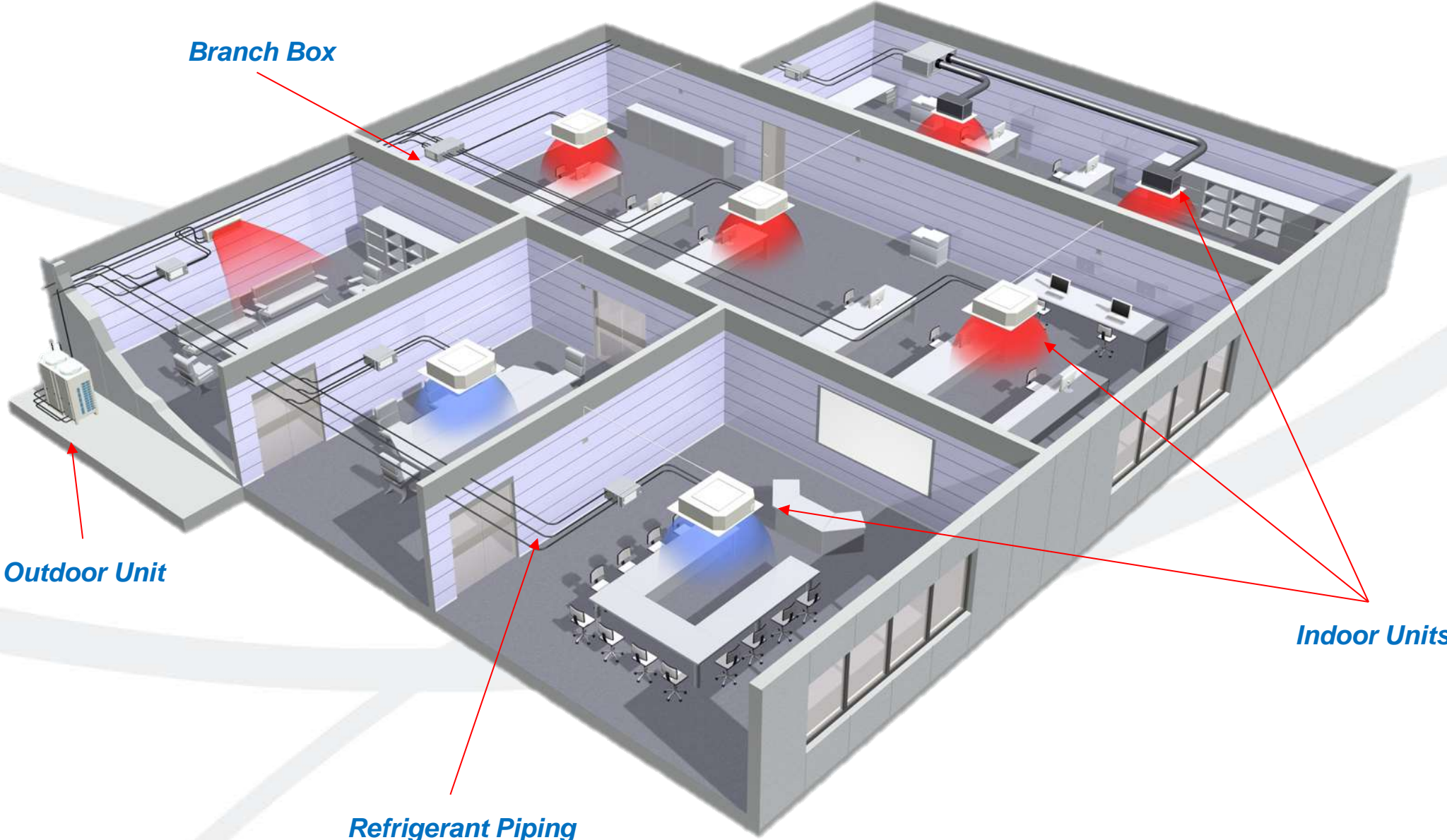
VRV Heat Pump vs Heat Recovery

HEAT RECOVERY

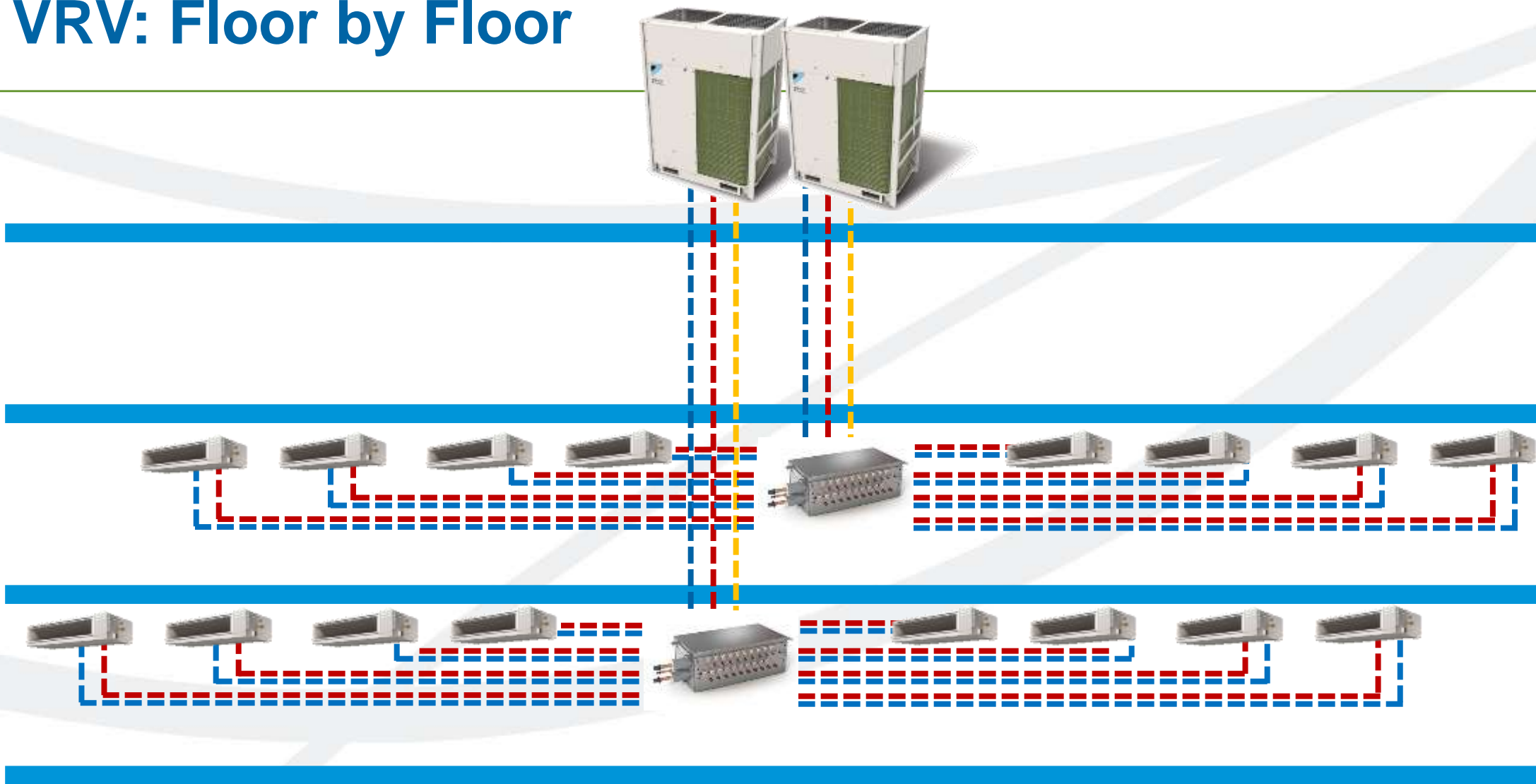
- Simultaneous heating and cooling
- Branch selector boxes



Heat Recovery Systems



VRV: Floor by Floor



Individual Split Systems

Condensing Unit Space



23'

5'

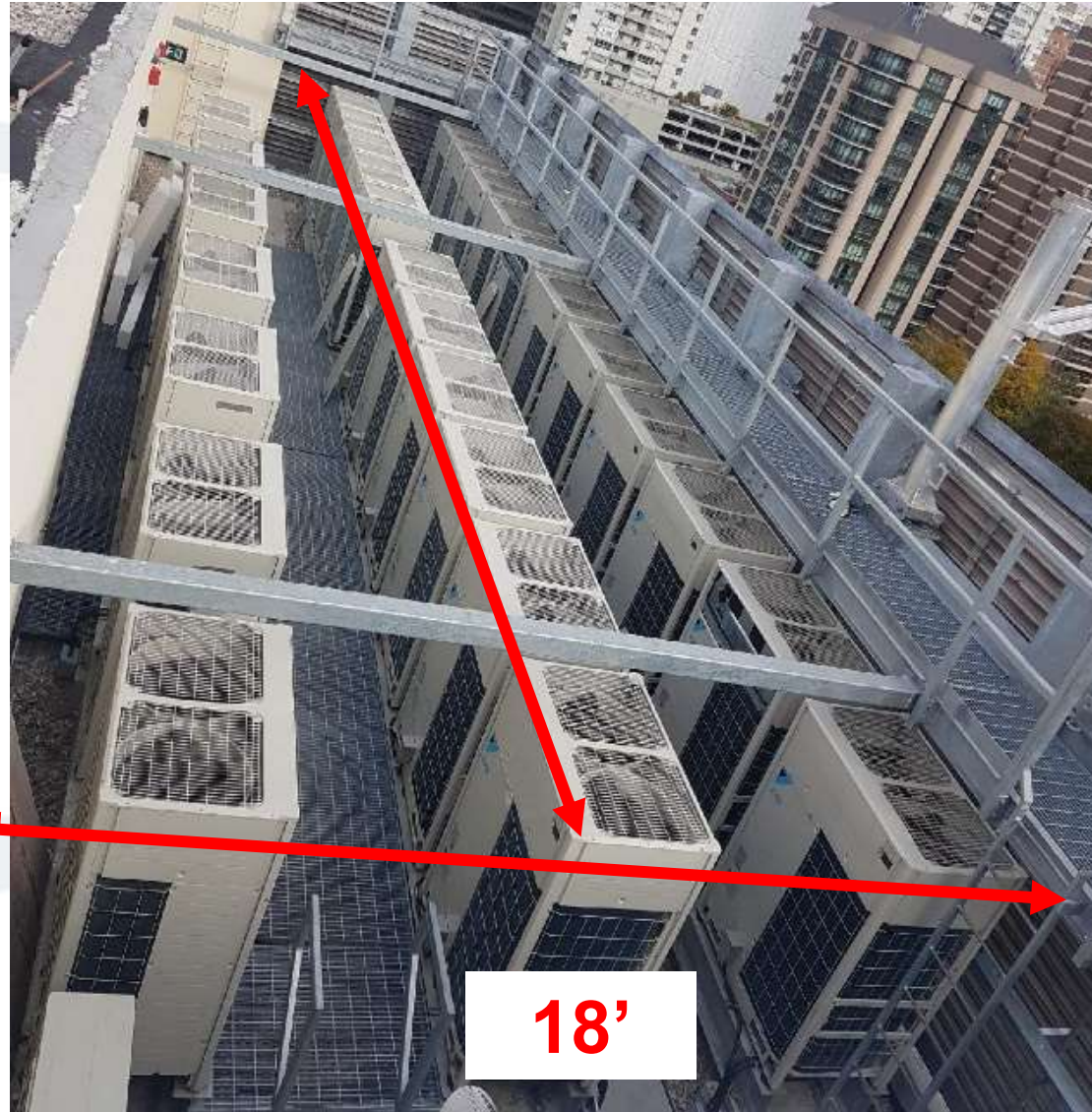


12 Suites

115 sq.ft.

~10 sq.ft. / suite

Central VRV Systems



54'

18'

330 Tons

220 Suites

972 sq.ft.

~4.4 sq.ft. / suite

330 Tons

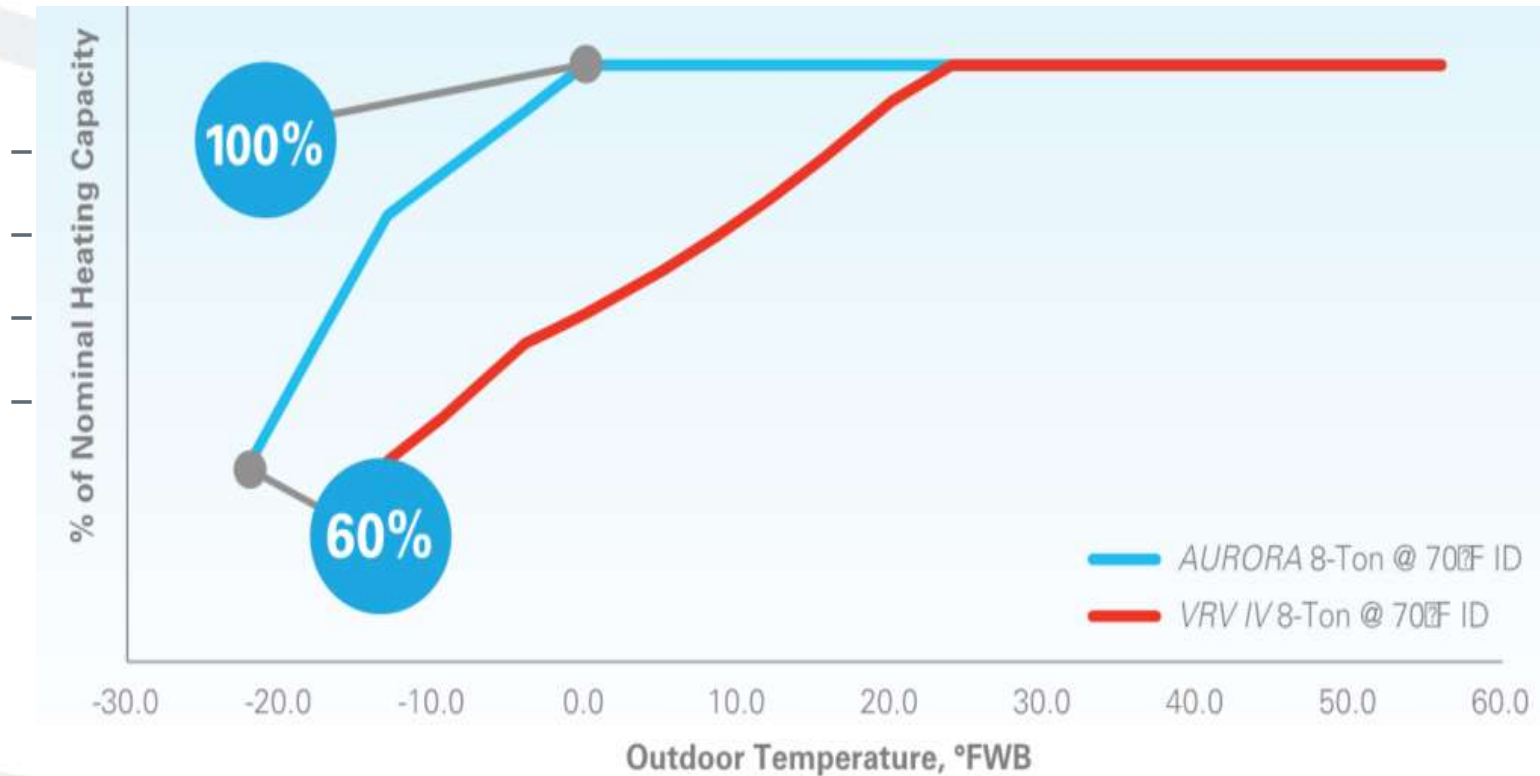
330 Suites

972 sq.ft.

~2.95 sq.ft. / suite



VRV – Standard vs Cold Climate



- Tested to lower temperatures
- Some components upgraded and rated to lower temperatures
- Holds heating capacity down to lower temperatures (100% @0F)
- Larger coil surface area (results in more modules, more space, more electrical)

When to use Cold Climate VRF?

Not always required in New England! Especially in New Construction and high-performance buildings. Use cold climate for:

- Design temperatures well below 0F (ME, NH, Canada)
- Retrofit of older buildings with high heating loads
 - *** Always recommend envelope upgrade first! ***
- Quick math:
 - **Cooling:** 350 sq.ft. / Ton = 34 BTUH / sq.ft.
 - VRF heating @ 0F
 - **Standard [70%]** = 24 BTUH / sq.ft.
 - **Cold Climate [100%]** = 34 BTUH / sq.ft.

When to use back-up / auxiliary heating

Electric resistance

- Redundancy (full or partial)
- ~~To downsize the VRV heat pump (with VRV, we recommend sizing for full load)~~

Fossil fuel

- To downsize the VRV heat pump (cost, power, space)
- To optimize for lower operational costs (short / medium term)
- Retrofits with existing auxiliary heating (if you already have it!)
- Simply looking for redundancy (full or partial)

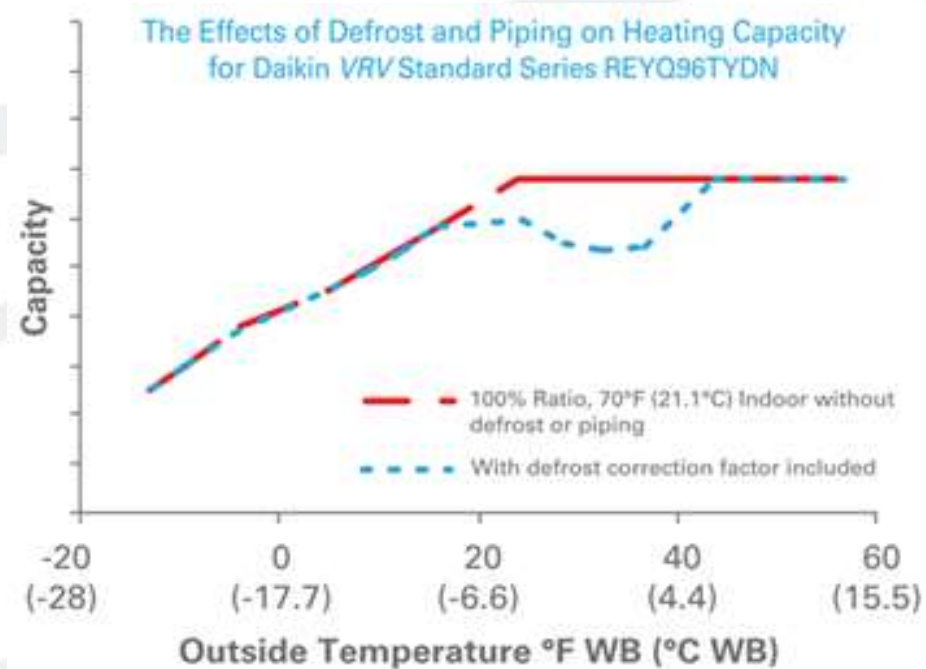
VRV - Defrost

Built-in Defrost Strategies

- Temperature / Pressure Coil Approach
- Outdoor heat exchanger temp

Continuous Heating through:

- Partial defrost within each module
- Full defrost on multi-module **heat recovery** systems.



Defrost

No Drain Pan Heaters Required

- Refrigerant cooled inverter board

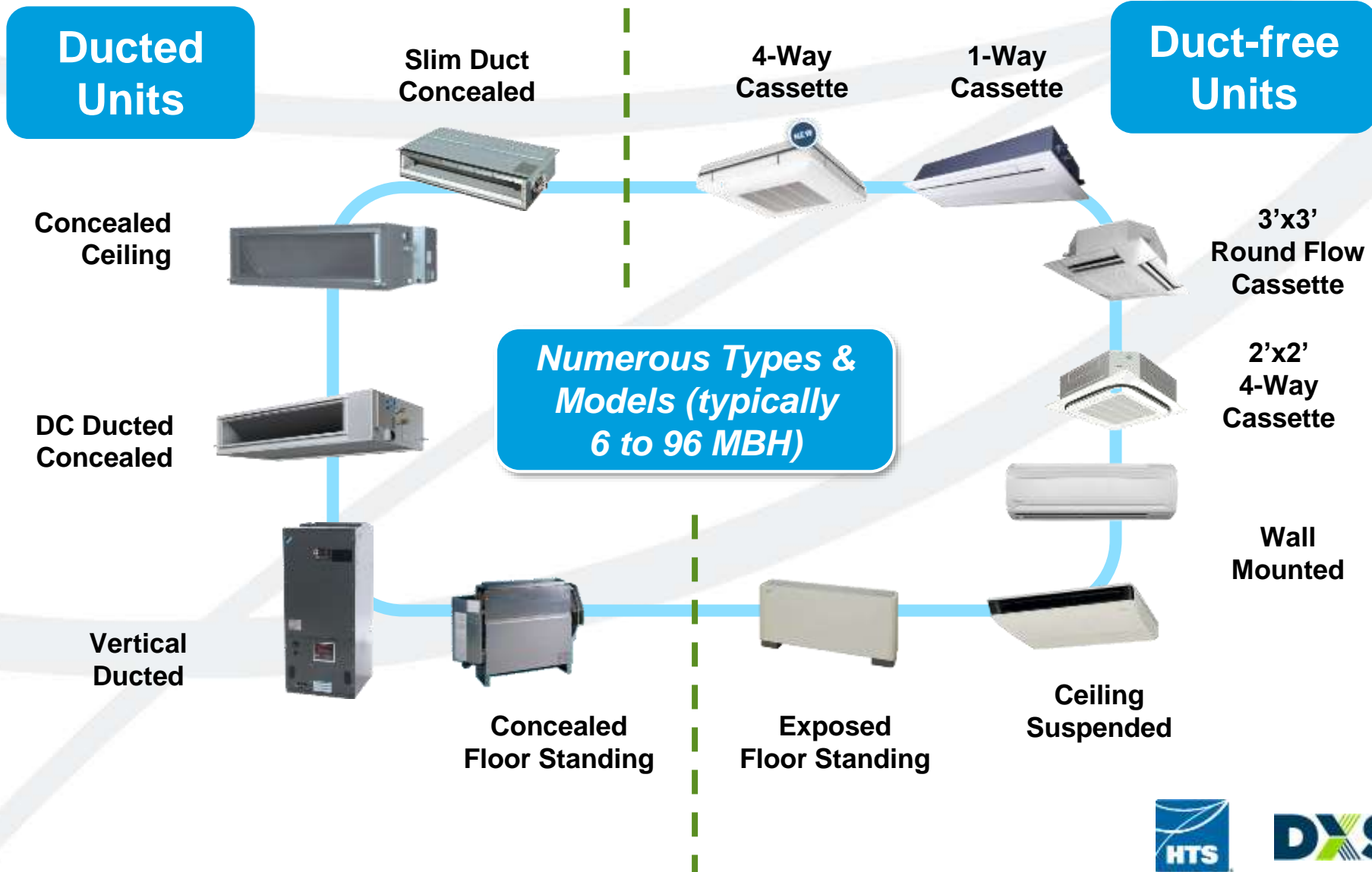


VRV – Water Source



Fundamentally same technology... but with a different heat source / sink.
Distribution to the occupied spaces is still with refrigerant

VRV – Indoor Units





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ASHP RTUs



Heat Pump Chillers



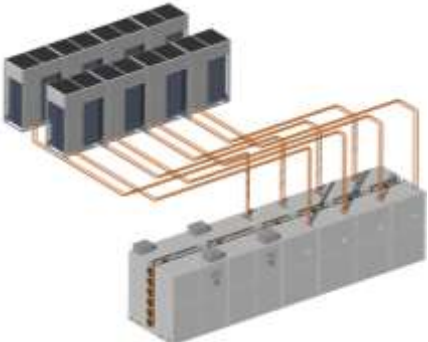
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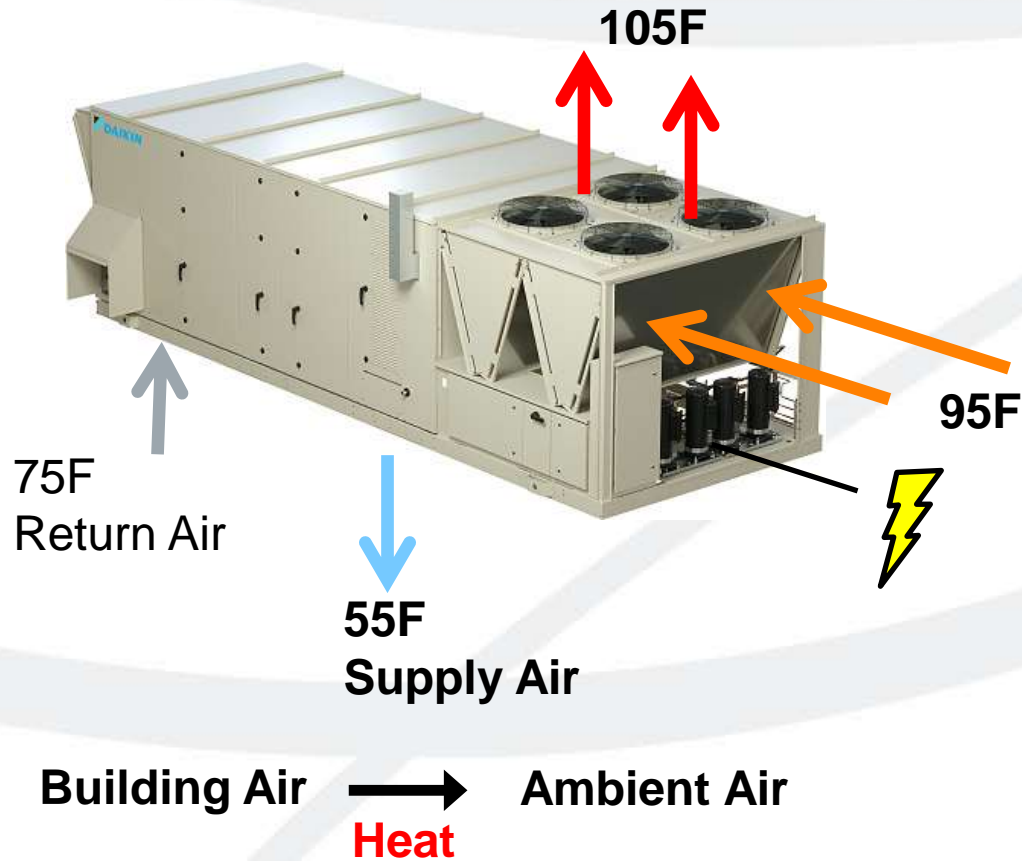


Waste-Water Recovery

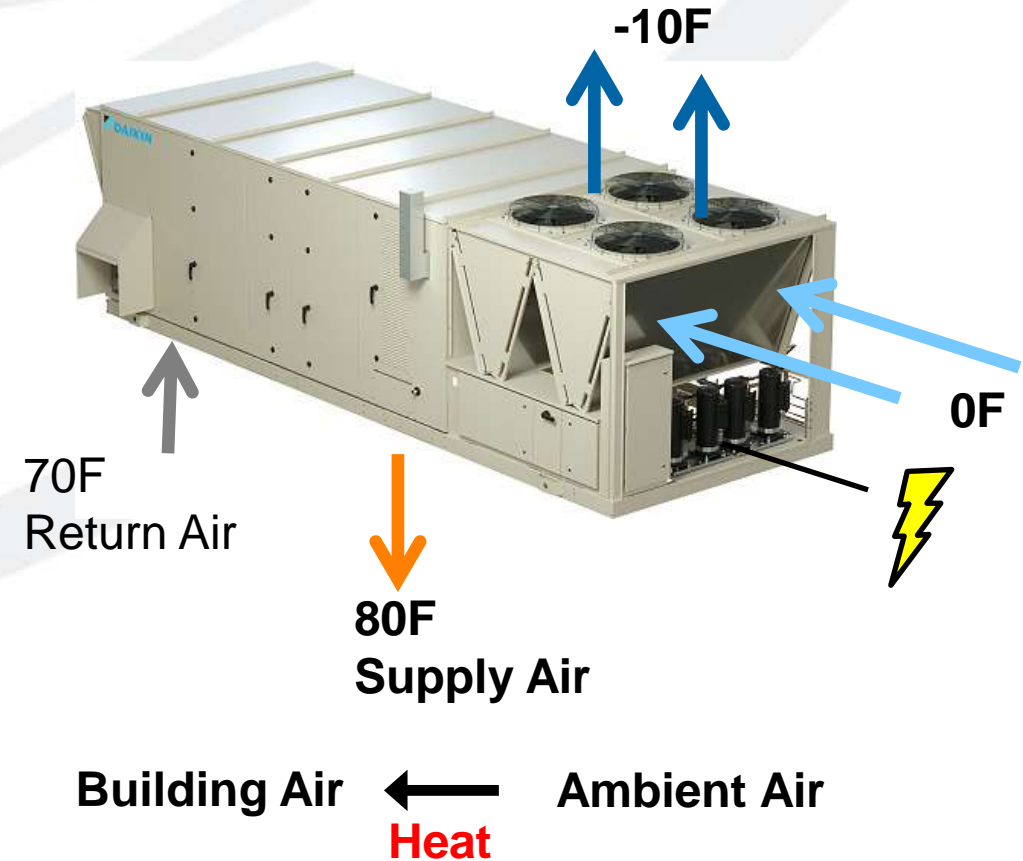


Packaged Heat Pump RTU's

Cooling Mode



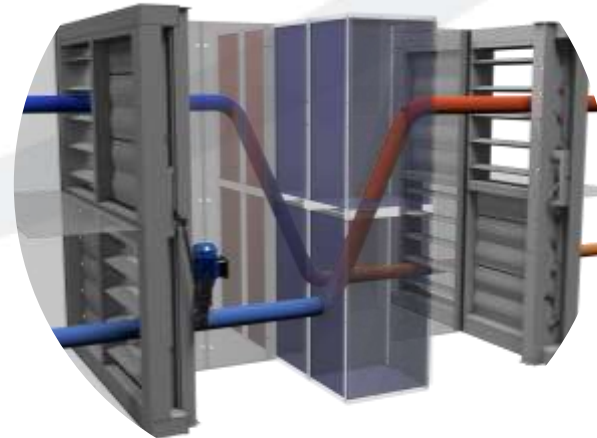
Heating Mode



Packaged Heat Pump *DOAS* RTU's

Variety of energy recovery options available

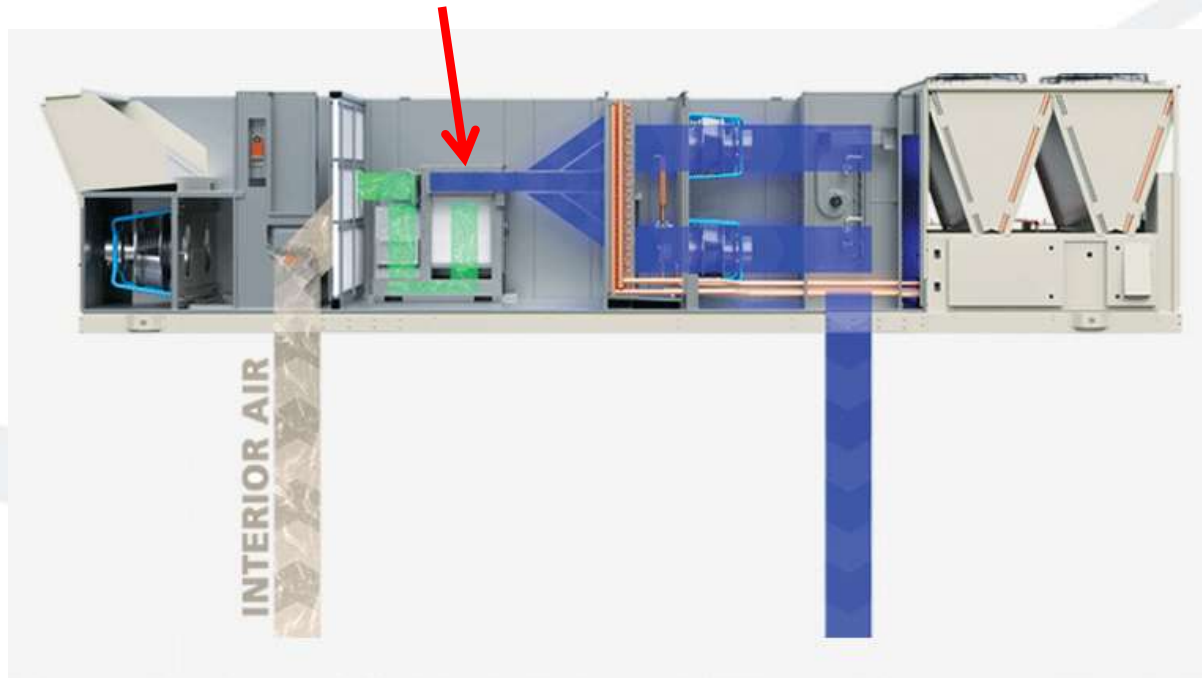
- Sensible and latent plate heat exchanger (50-60%)
- Enthalpy wheel (60-80%)
- **Regenerative core (85-95%)**



Packaged Heat Pump RTU's with SVT

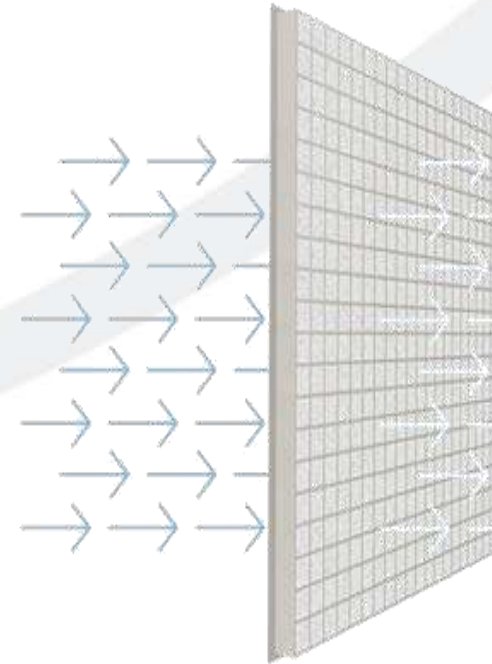
SVT = Sorbent Ventilation Technology

This device scrubs return air to reduce the required amount of ventilation air



Captures:

- Carbon Dioxide (CO₂)
- Formaldehyde
- VOC's
- Inorganic Compounds



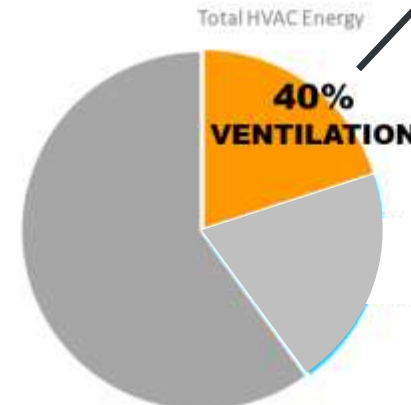
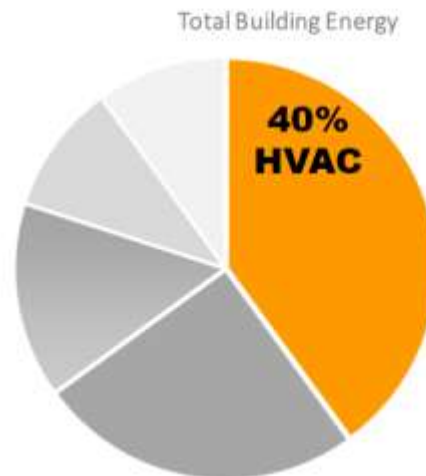
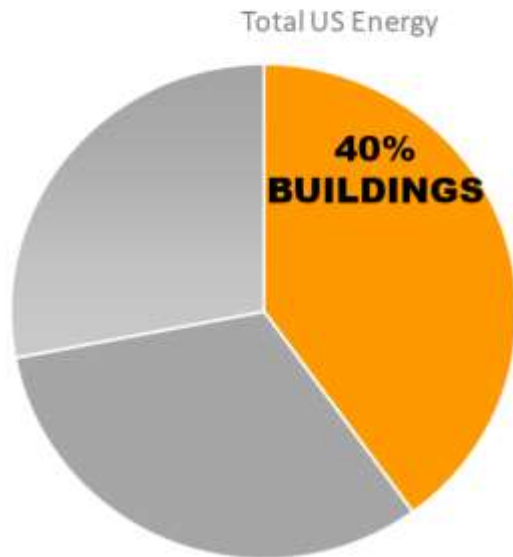
Passes Through:

- Nitrogen
- Oxygen
- Water (H₂O)

How does SVT relate to decarbonization?

The **40-40-40** Rule

Ventilation energy reduction is the lowest hanging fruit in building decarbonization



Ventilation air is 6.4% of US energy

SVT can reduce total US energy usage by 2% - 3%

Packaged Heat Pump RTU's

Let's get down to it...

- **Where were we?**
 - Heating down to about 10F ambient
 - Enthalpy wheel energy recovery
 - Limited electrical flexibility
 - Limited catalog product availability
- **Where are we?**
 - Heating down to 0F ambient
 - *All* energy recovery and energy reduction options
 - Configurable electrical design
 - › Simultaneous electric heat vs. backup
 - Available in many catalog *and* custom configurations



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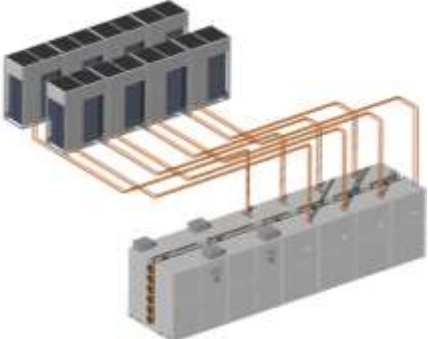
Ventilation / ERV Heat Pumps

A photograph of a Ventilation / Energy Recovery Ventilator (ERV) heat pump unit. It is a large, rectangular indoor unit designed for mechanical ventilation and energy recovery.

Air / Water Source DHW



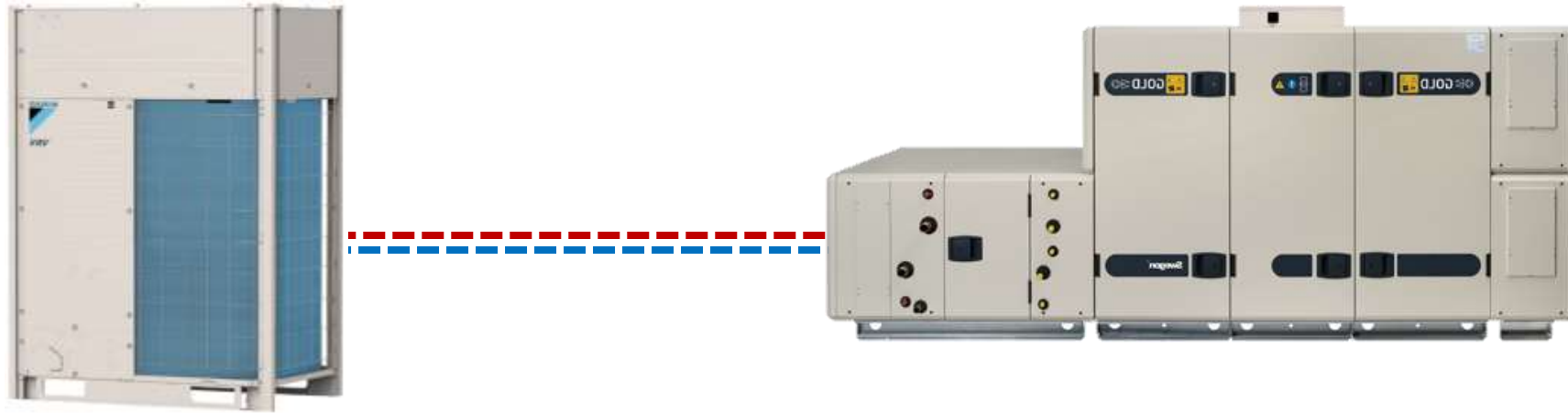
High Temp (180F) Air-to-Water



Waste-Water Recovery



Split (VRV driven) AHUs / ERVs

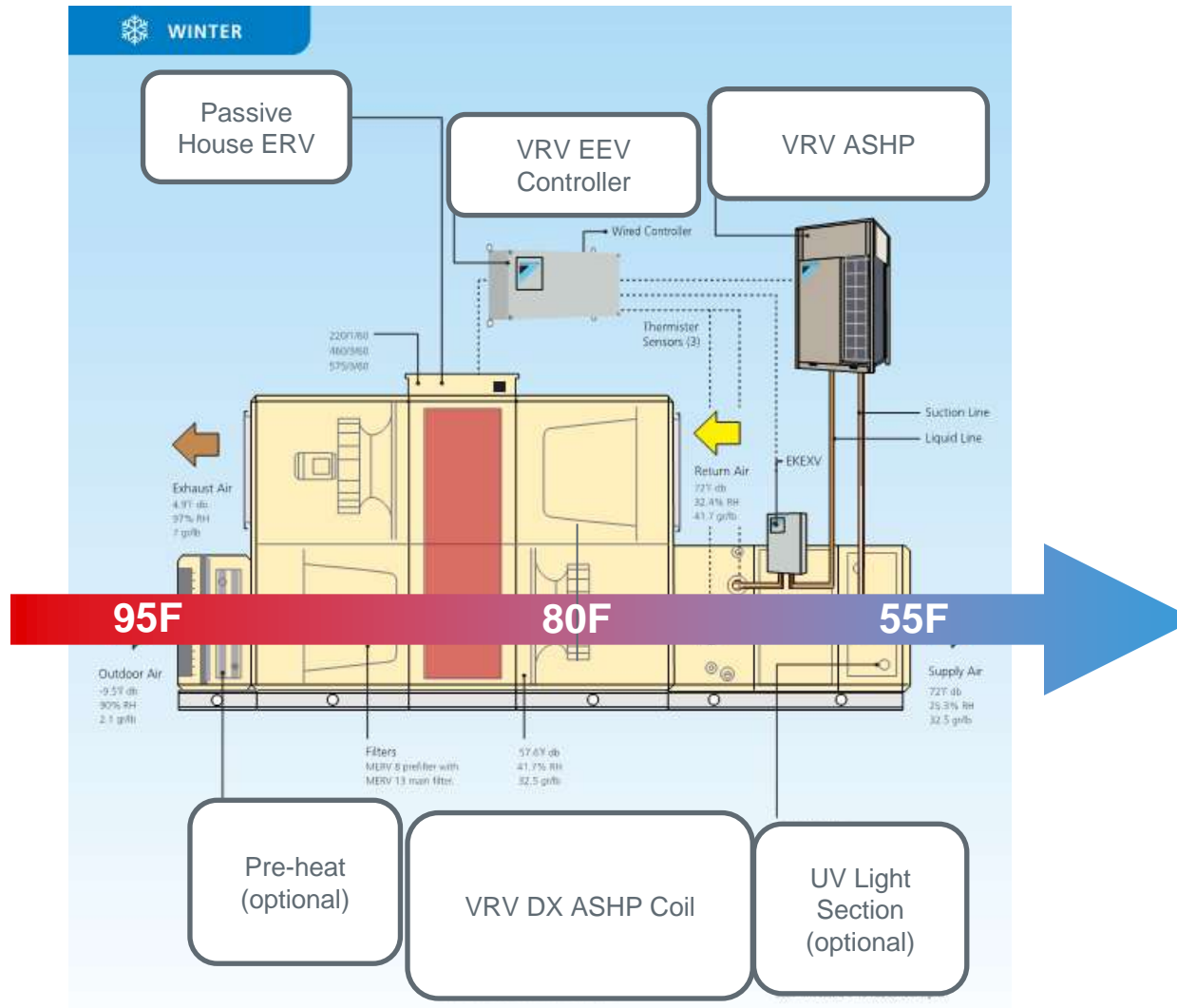


Why?

- Efficiency of the VRV outdoor units
- Low ambient heating capacity (no electric heat)
- Indoor AHUs (long piping)
- Size / weight of condensing section



VRV Driven ERV (Cooling)



Oxygen8 ERVs





Remote cased VRV DX Coil
section with factory VRV EEV,
EEV Controller
[Still controlled by O8 unit]

VRV EEV
Controller

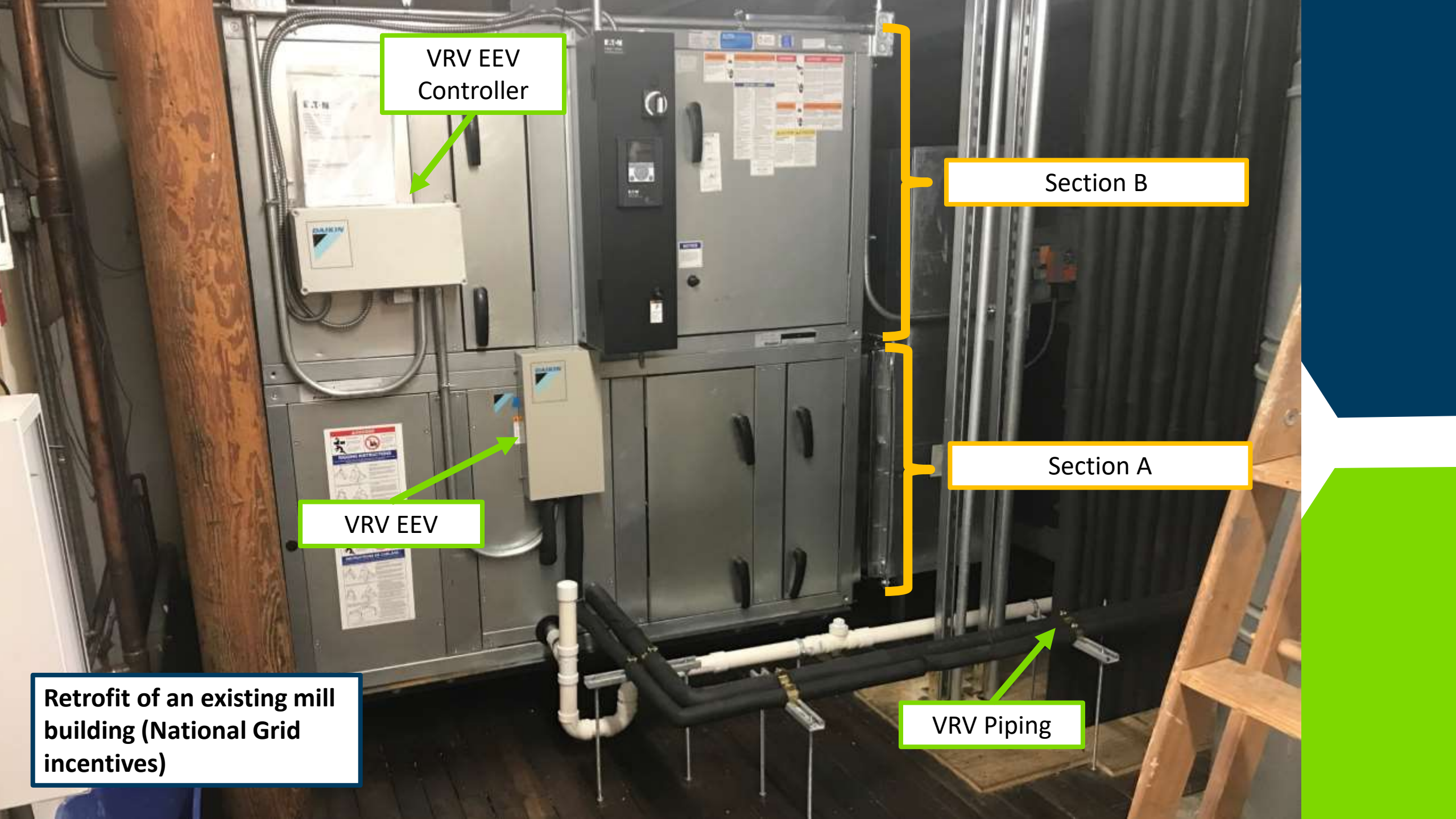
Section B

VRV EEV

Section A

Retrofit of an existing mill
building (National Grid
incentives)

VRV Piping



Types of heat pumps (2024 and beyond)

Mini/Multi Splits



Air / Water Source VRV/VRF



ASHP RTUs



Heat Pump Chillers



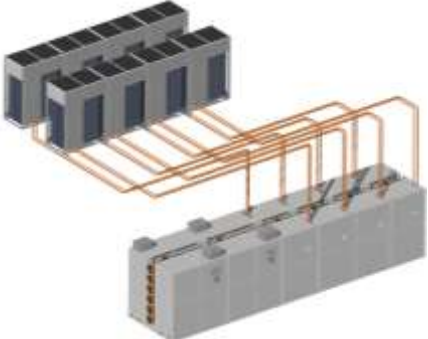
Ventilation / ERV Heat Pumps



Air / Water Source DHW



High Temp (180F) Air-to-Water

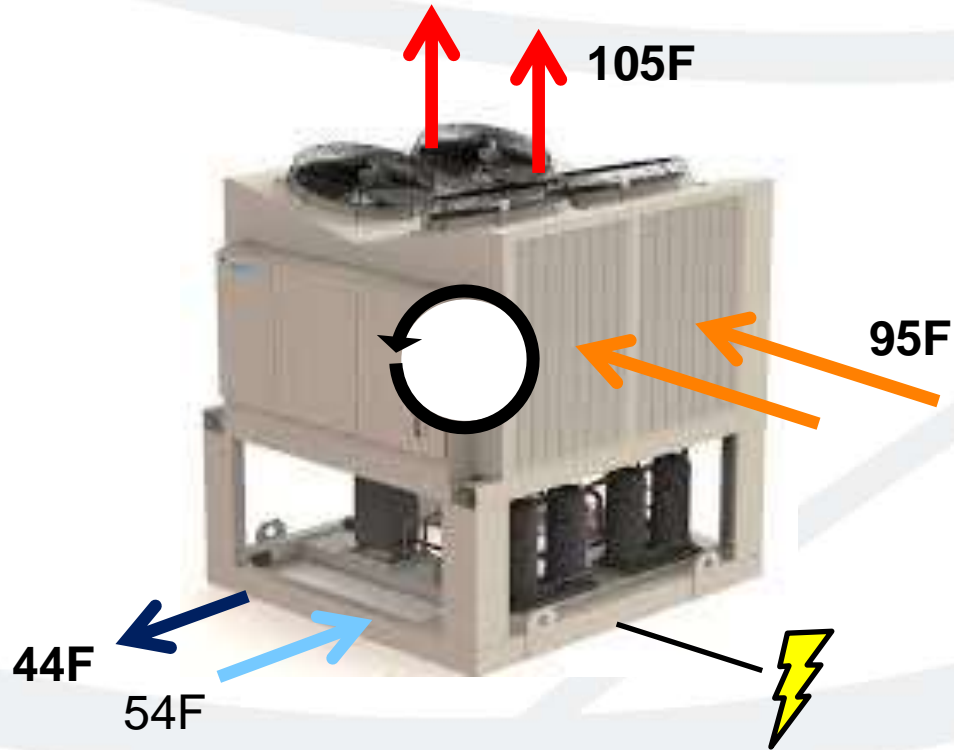


Waste-Water Recovery

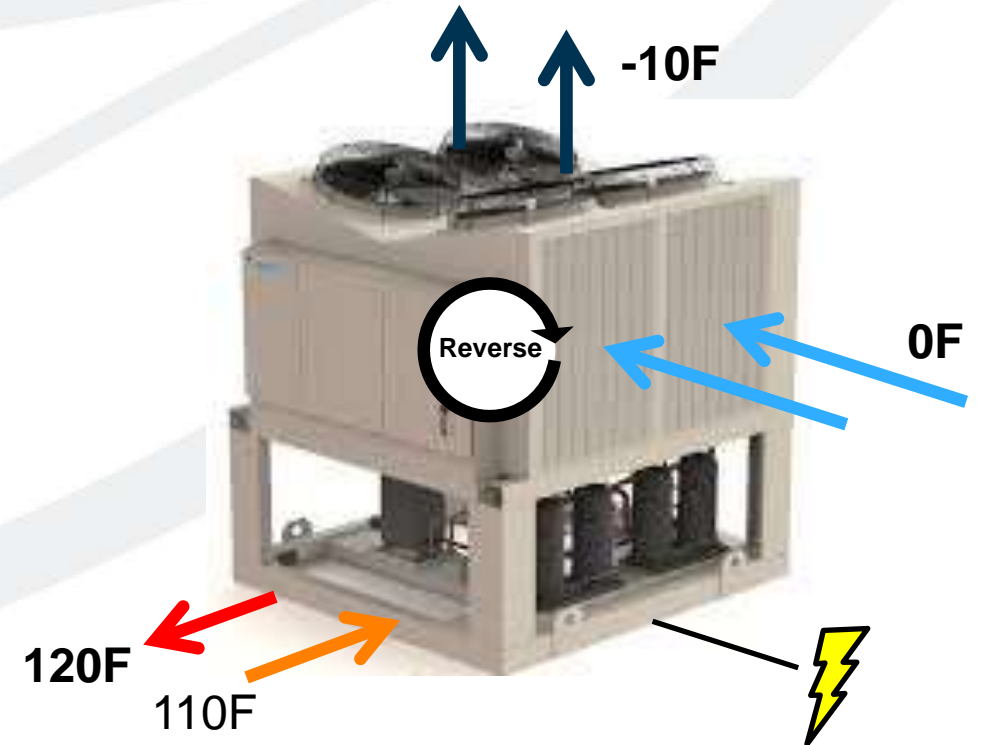


What is a heat pump?

Cooling Mode (Chiller)



Heating Mode (Heat Pump)



Air-to-Water Heat Pumps

Let's get down to it...

- **Where were we?**
 - **Modular:** 120F HW at -4F ambient
 - **Unitary:** 105F HW at 5F ambient
 - **Heat Recovery:** Limited by load matching

- **Where are we?**
 - **Modular:** 120F HW at -15F ambient
 - **Unitary:** 120F HW at -4F ambient
 - **Heat Recovery:** Load matching not required

Modular



Unitary

Modular vs. Unitary Air-to-Water Heat Pumps



Vs.



Who wins?

← **Cost**

Redundancy →

← **Reliability**



Medium Temp Unitary

- **120F HW down to -4F ambient**
- **Up to 135 tons in one unit (270 tons twinned)**
- **Lower equipment cost**
- **Lower installation cost**
- **Less parts**
- **True multi-function (heat recovery)**



Medium Temp Unitary

- 120F HW down to -4F ambient
- Up to 135 tons in one unit (270
- Lower e
- Lower i
- Less pa
- True mul (heat recovery)

**The modern solution for replacing
air-cooled chillers for electrified heating**



Water-to-Water Heat Pumps

- **How are these applied?**
 - **Geothermal**
 - › Heating + Cooling + Heat Recovery
 - **Heat recovery (heat-shift)**
 - › Moving heat from CHW to HW
 - **High-temp booster**
 - › 2nd stage (cascading) for high-temp



Types of heat pumps (2024 and beyond)

Mini/Multi Splits



Air / Water Source VRV/VRF



ASHP RTUs



Heat Pump Chillers



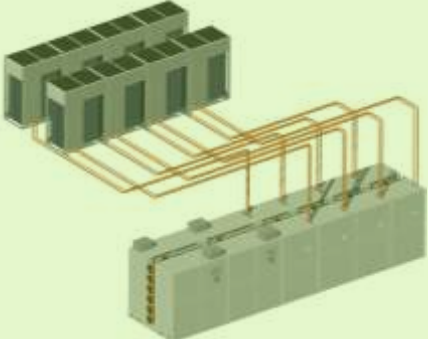
Ventilation / ERV Heat Pumps



Air / Water Source DHW



High Temp (180F) Air-to-Water



Waste-Water Recovery



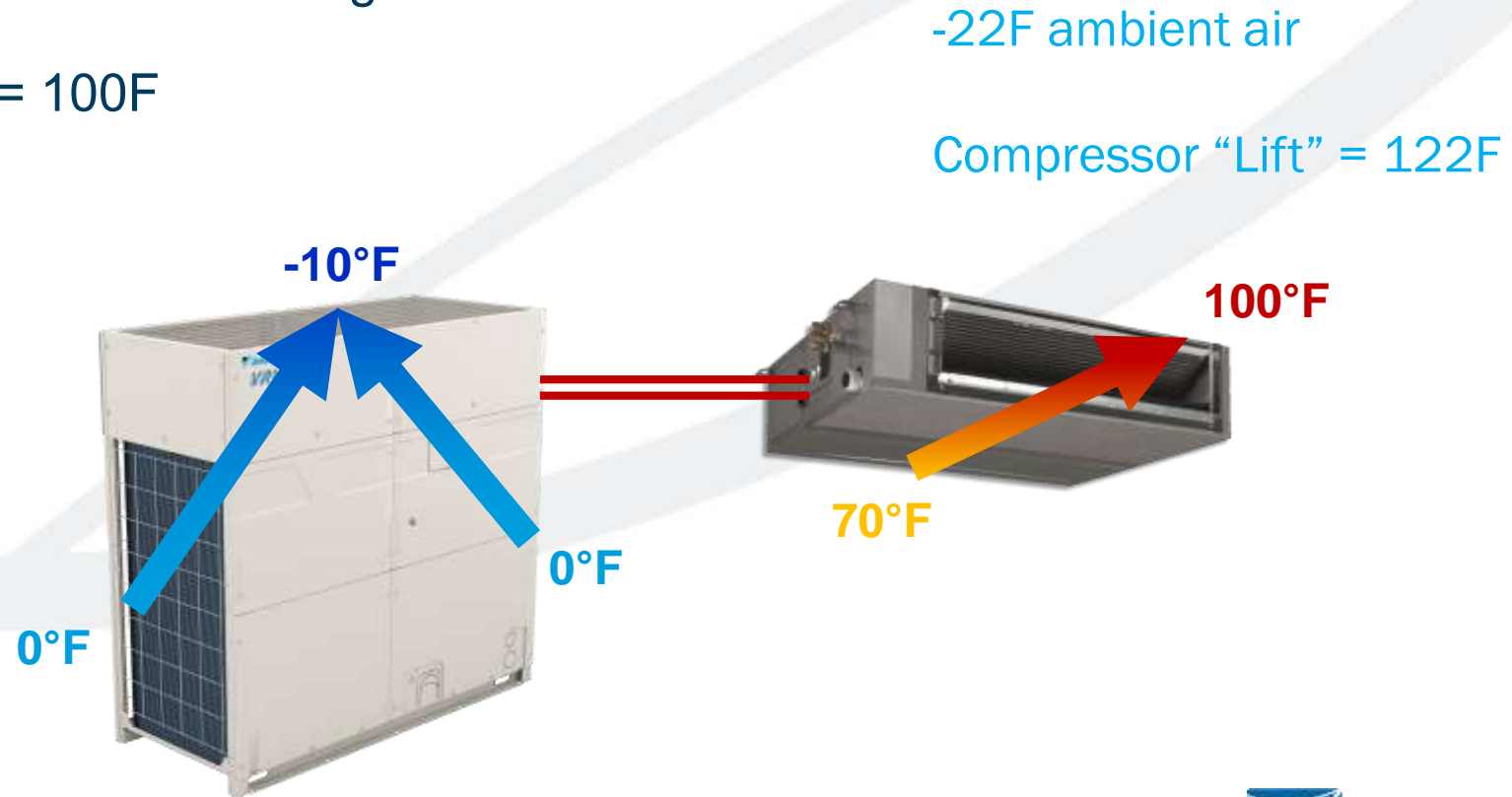
The Major Challenges with ASHP DHW

- **Compressor Lift**
- **Bringing water outdoors**
- **Peak Load vs. Recirculation Loads**



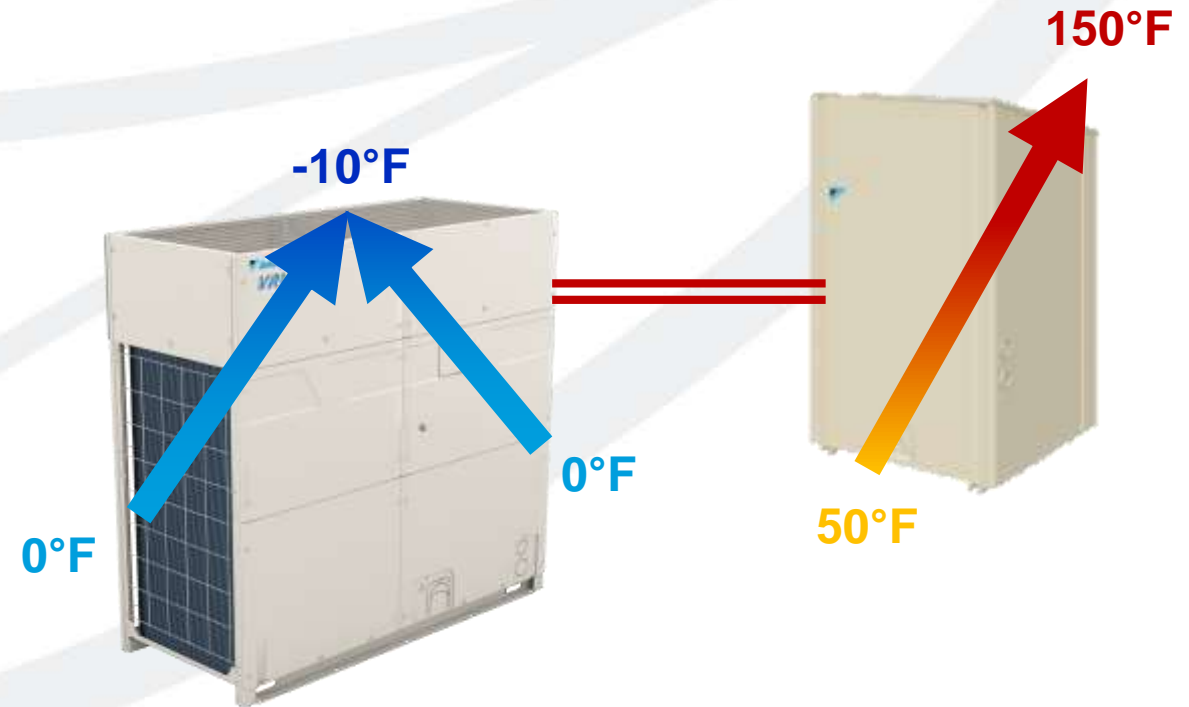
The Lift Challenge

- Conventional cold climate air source heat pumps (for space heating)
- Heat air from ~70F to ~100F using 0F ambient air
- Compressor “Lift” = 100F



The Lift Challenge

- Heat water from ~50F to ~150F using 0F ambient air
- Compressor “Lift” > 150F
- **Technology required:**
 - 2-stage
 - CO2
- Domestic water heating needs storage (not instant)
- Stored domestic hot water needs to be ~140F, which requires heating beyond 140F



VRV driven Domestic Hot Water

1



- High efficiency Inverter Air cooled VRV Heat Pump
- R410A Refrigerant (for now, allowed by EPA for DHW)

2



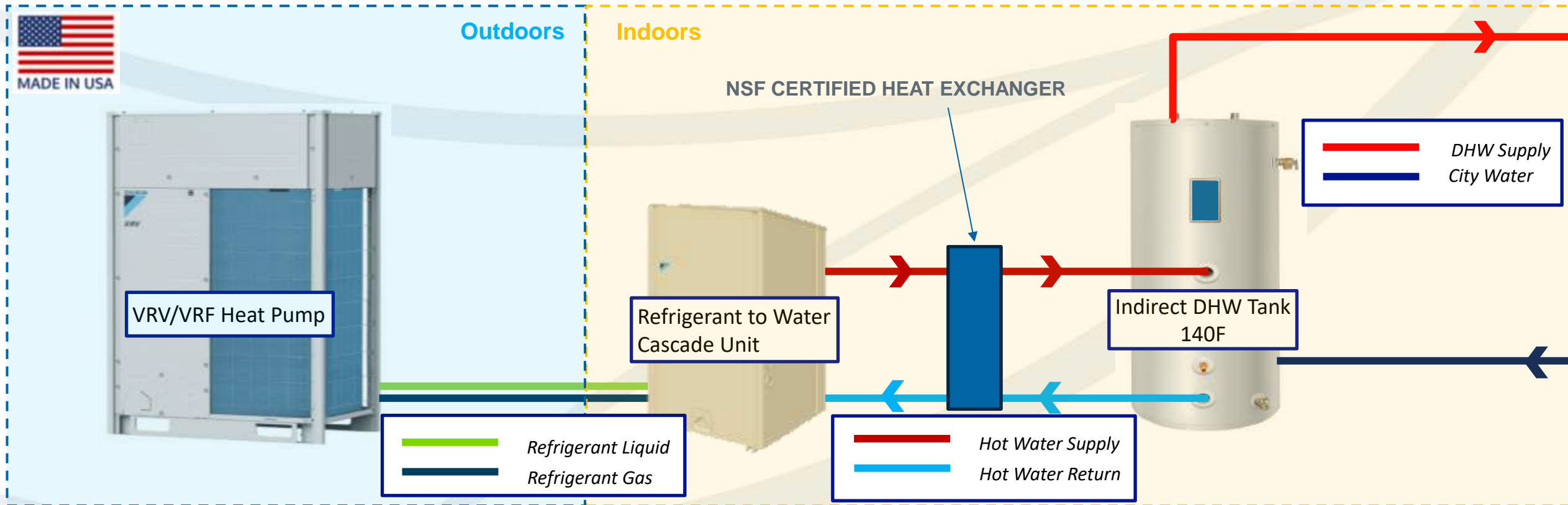
- Cascade Unit with inverter compressors
- Refrigerant to water HEX
- Built-in variable capacity water pump

3



- Tank control kit
- Connect up to 6 MEGA Q systems to 1 water loop.

Cold climate VRV split modular domestic hot water heater



- Split setup so all water can remain indoors (avoids the need for glycol)
- High temp: up to 194F hot water heating loops (via a cascade boost unit)

*Simplified schematics – for conceptual discussion only – components and accessories missing



Example Project

Cascade - Indoors

HP Source - Outdoor

Tank - Indoors



Refrigerant piping

Hydronic Piping



Types of heat pumps (2024 and beyond)

Mini/Multi Splits



Air / Water Source VRV/VRF



ASHP RTUs



Heat Pump Chillers



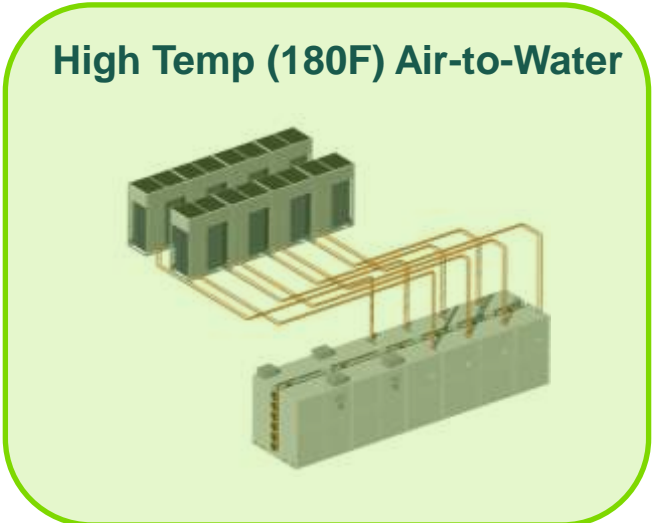
Ventilation / ERV Heat Pumps



Air / Water Source DHW



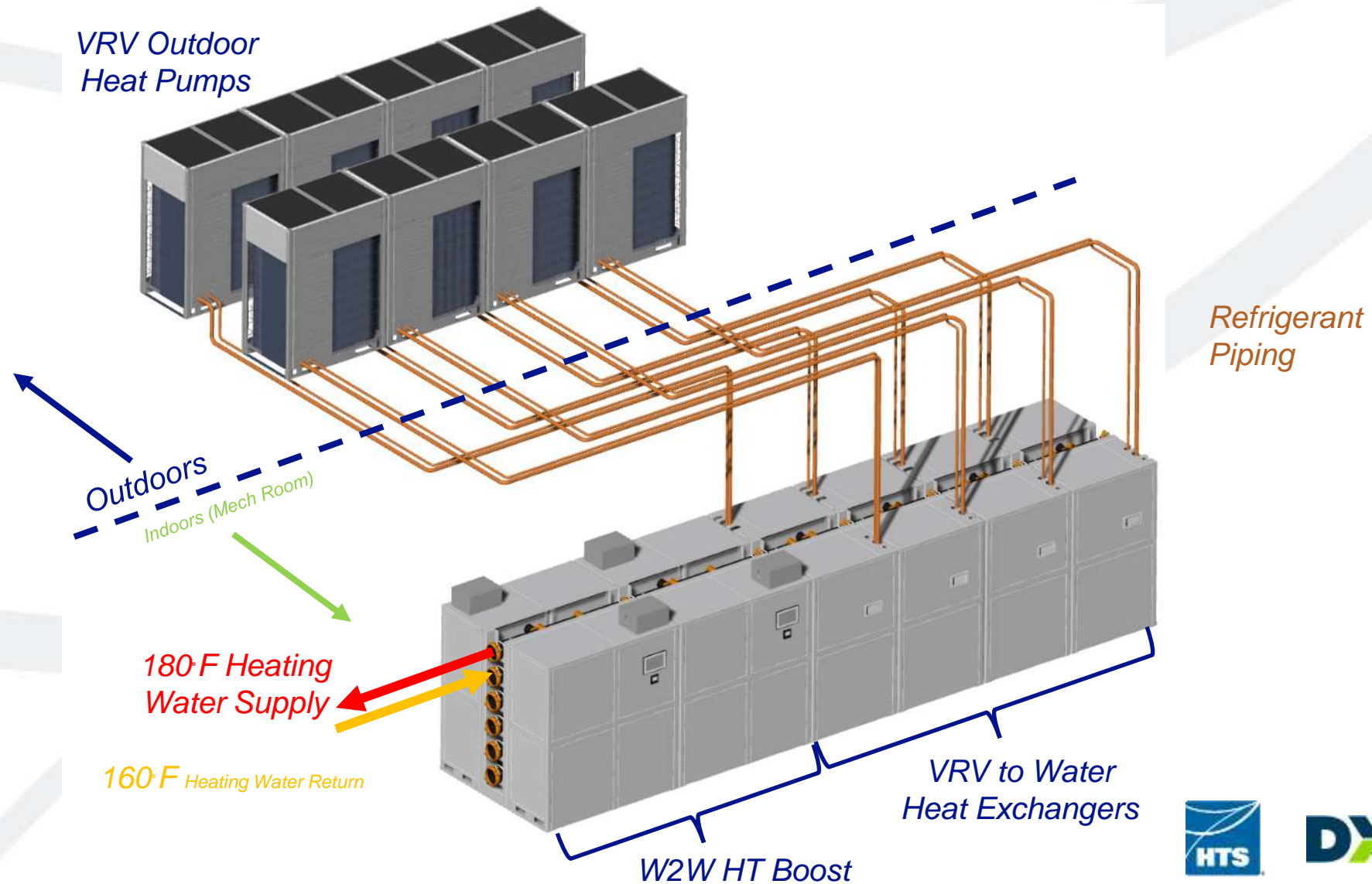
High Temp (180F) Air-to-Water



Waste-Water Recovery



VRV driven, split, modular cold climate heat pump chiller



Types of heat pumps (2024 and beyond)

Mini/Multi Splits



Air / Water Source VRV/VRF



ASHP RTUs



Heat Pump Chillers



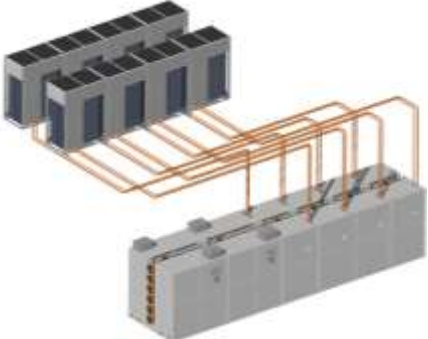
Ventilation / ERV Heat Pumps



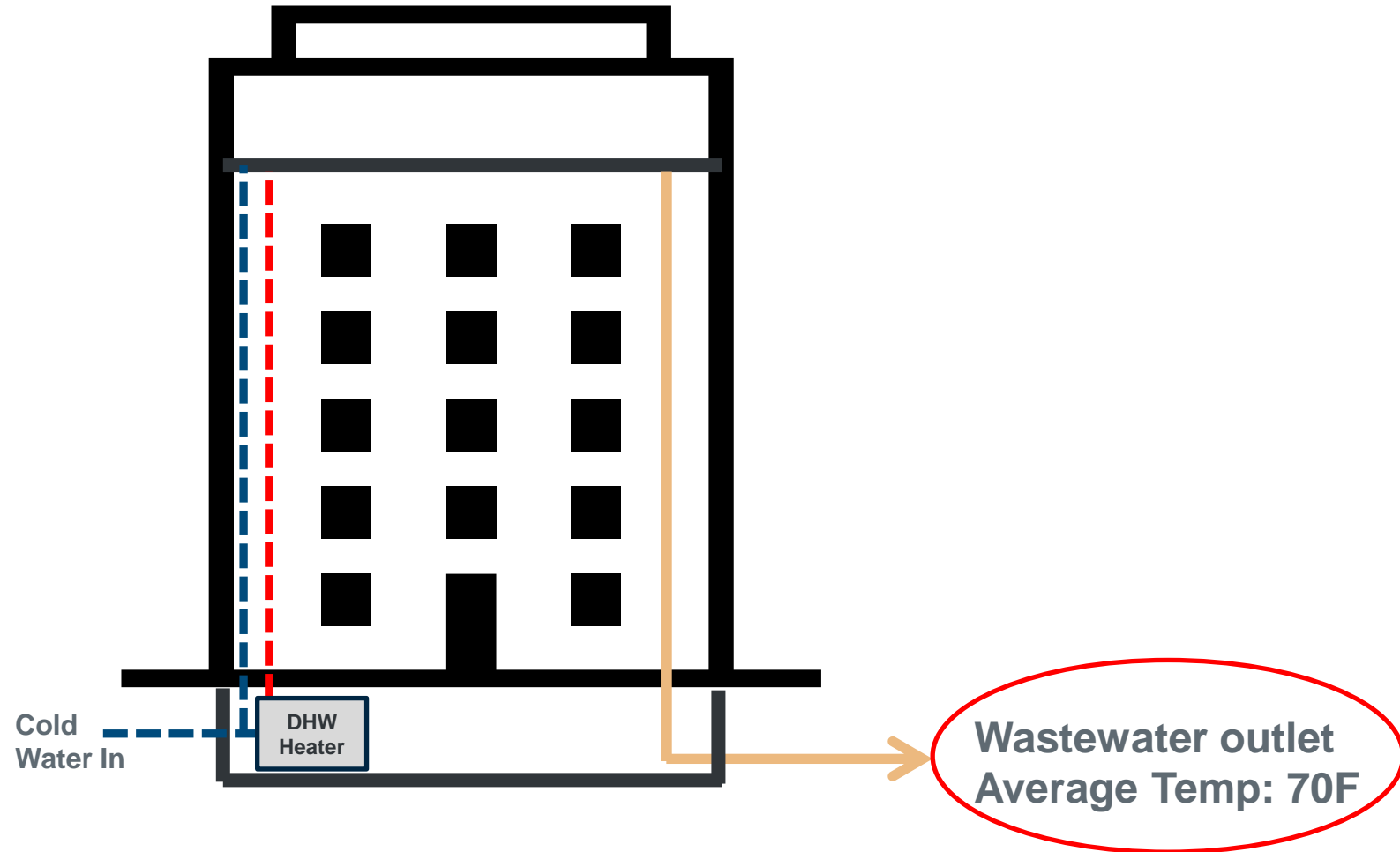
Air / Water Source DHW




High Temp (180F) Air-to-Water



Where else can we recover heat?





The Average Person Uses **24 Gallons** of **Hot Water** per Day at 140°F*

- Average Residential Wastewater Temperature is 70°F
- Commercial & Industrial Wastewater Temperature can reach 140°F or Higher

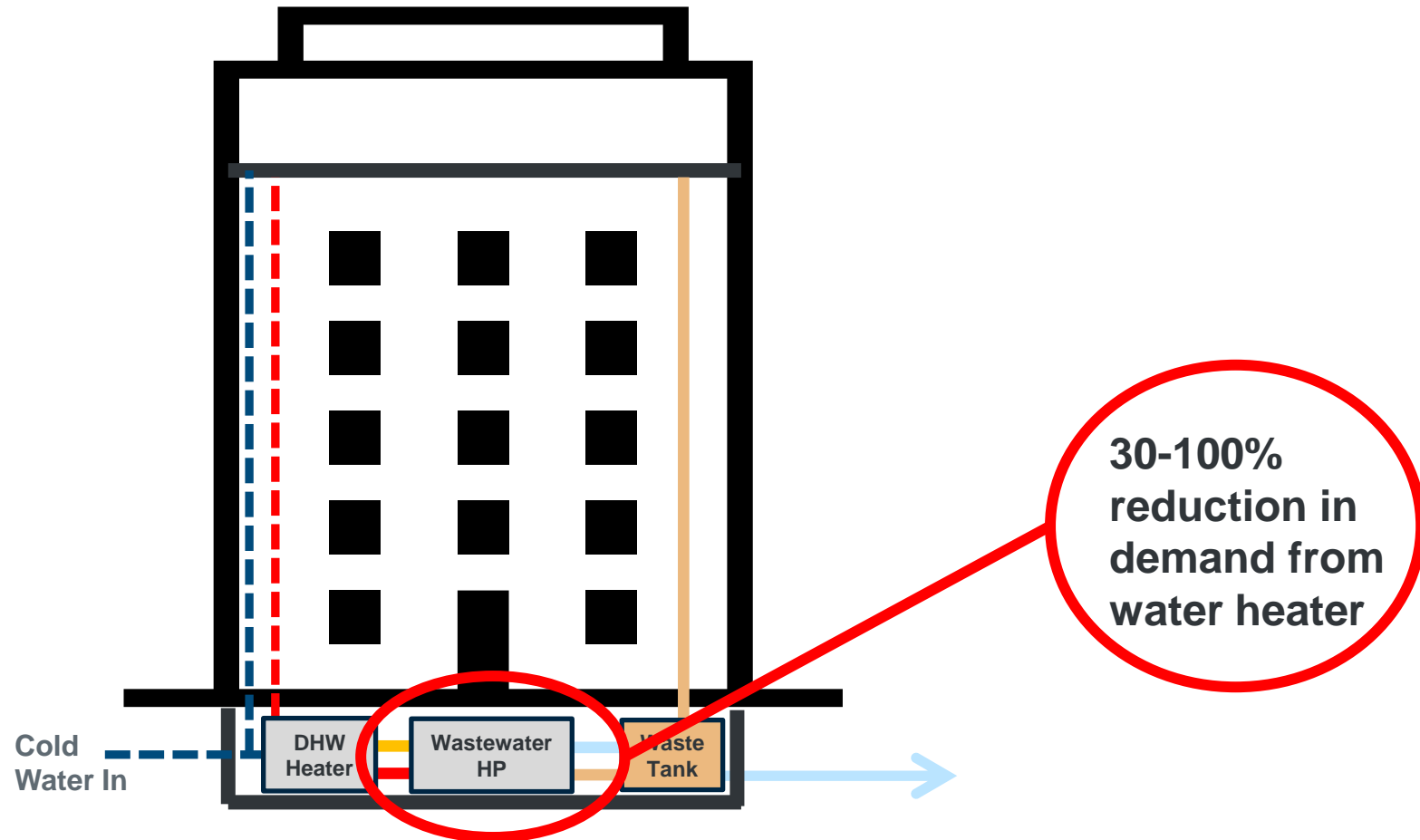
Wastewater sources:

- Black and Grey Water Within Buildings
- Sanitary Sewers
- Lift Stations/Treatment Centres

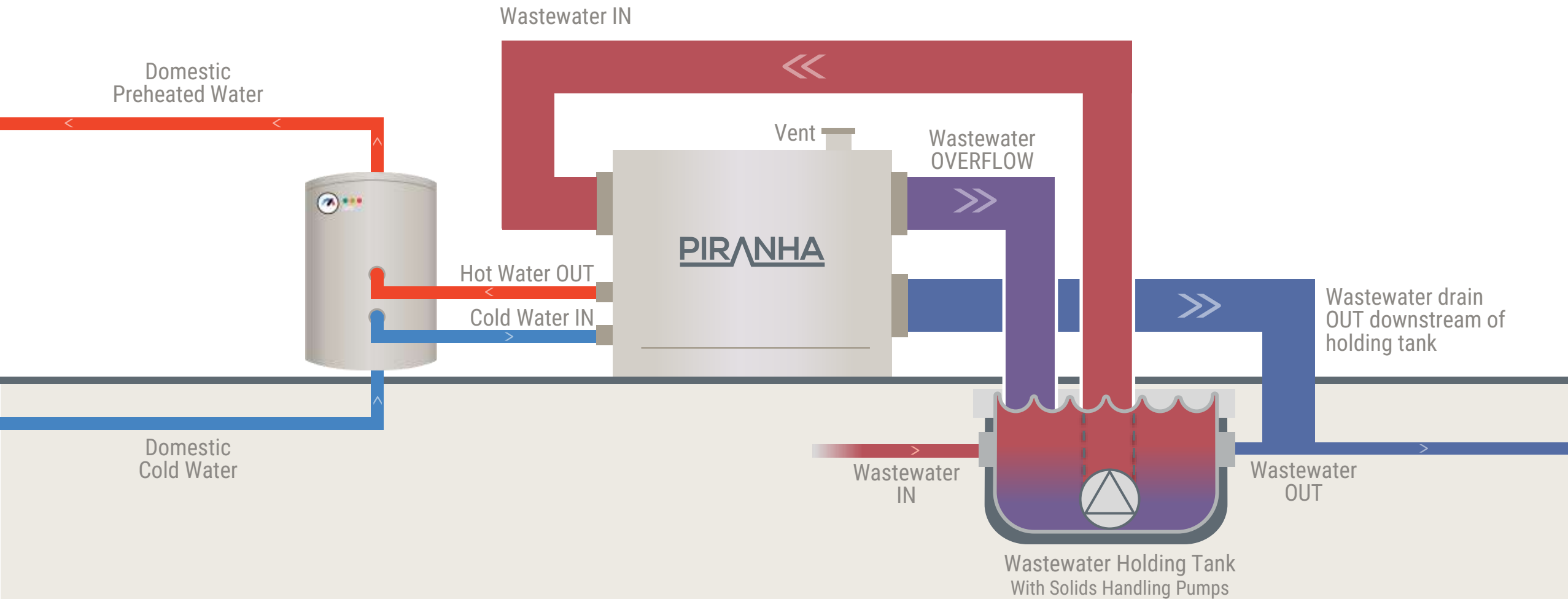
**estimated 60 gallons/day of wastewater*



Where else can we recover heat?



Wastewater Heat Recovery



Seven35

North Vancouver, BC

- The first multi-family LEED® for Homes Platinum building in Canada
- Certified BuiltGreen Gold
- 60 Residential Units
 - **PIRANHA T10** Commissioned Spring 2016
 - **9,350 Therms Natural Gas reduction**
 - **GHG Emission reductions of approximately 49.6 t CO₂e/year**
- PIRANHA system provides domestic hot water preheating
- Piranha contributed to LEED® Platinum certification of the building
- **Currently PIRANHA HC EPRI Challenge Site**





Hosted by: 

Technical Round Table: Heat Pump Technology

HTS New England
1 Corporation Way
Peabody, MA 01960



November 6, 2024
8:00am-12:00pm

Agenda:

- 8:00 – 8:10** Arrival, registration
- 8:10 – 9:00** Heating with lower temperature hot water (Joe Bliss, B2Q)
- 9:00 – 9:20** Refrigerants & Heat Pumps (JS Rancourt, DXS)
-
- 9:30 – 9:45** Heat Pumps & Decarb, overview of heat pumps and types (Mark Lafrance, HTS)
- 9:45 – 10:20** Distributed DX heat pumps (including training center tour) (JS)
-
- 10:30 – 11:00** ASHP RTUs, AHUs and Air-to-Water heat pumps (Mark)
- 11:00 – 11:20** DHW and high temp (JS)
-
- 11:30 – 12:00** Water Solutions (Chris Ouellette, Mitsubishi)