Decarbonizing with Heat Pumps (in a low GWP A2L World)

PART 2

Distributed Refrigerant Systems

Your Presenters

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Principal (HTS & DXS)

Mechanical Engineer, University of Waterloo (Ontario, Canada) 2011

Areas of expertise: ASHPs, VRF and refrigerants

North American Manufacturer's Representative Councils:

- *Daikin Comfort Technologies*
- *Oxygen8 Solutions*

Voting Council Member of MA's Grid Modernization Advisory Council!

- *Representing Building Electrification Sector*

Refrigerant Codes & Standards

- *SSPC 15 (ASHRAE 15 committee): long-term attendee*
- *780 CMR 10^{th} Edition A2L Code Change Proponent (BBRS)*

Your Presenters

Adam Camillo

Sales Engineer (DXS)

Mechanical Engineer, University of Rhode Island 2016

Areas of expertise: ASHPs, VRF and refrigerants

North American Manufacturer's Representative Councils:

- *Oxygen8 Solutions*

HVAC Manufacturer's Representatives & Building Automation contractor

AHUs, ERVs, Chillers, ASHP & WSHP Chillers, Fans, Lab exhaust, Lab energy recovery, pre-fab plants, terminal equipment, humidification, IAQ
www.hts.com

Specialized in Daikin VRV/VRF, Daikin ASHPs, VRV driven ERVs and AHUs, VRV controls
www.dxseng.com

Largest Daikin VRV rep in North America!

Building automation, energy and emissions monitoring and reporting, fault detection systems
www.controltechinc.com

Your Presenter's Biases…

- *We are born & raise ASHP & VRV/VRF…*
- *We are with the largest VRV rep firm in North America, representing the largest VRV manufacturer in the world, and the inventors of VRV…*
- *All we do is VRV, all day every day. Hundreds of units per year.*
- *Water scares us. People can drown.*
- *We've seen the good, the bad and the ugly when it comes to VRV, and we're still here.*
- *BUT, this is why we have competing presentations!*

AGENDA

- Distributed Refrigerant Systems 101
- Refrigerant transition
- Distributed Refrigerant Systems 102 (with A2Ls)
- Refrigerant vs Hydronic Distribution
- LCCP & Refrigerant emissions
- Reducing refrigerant emissions
- When VRV & Hydronics get married

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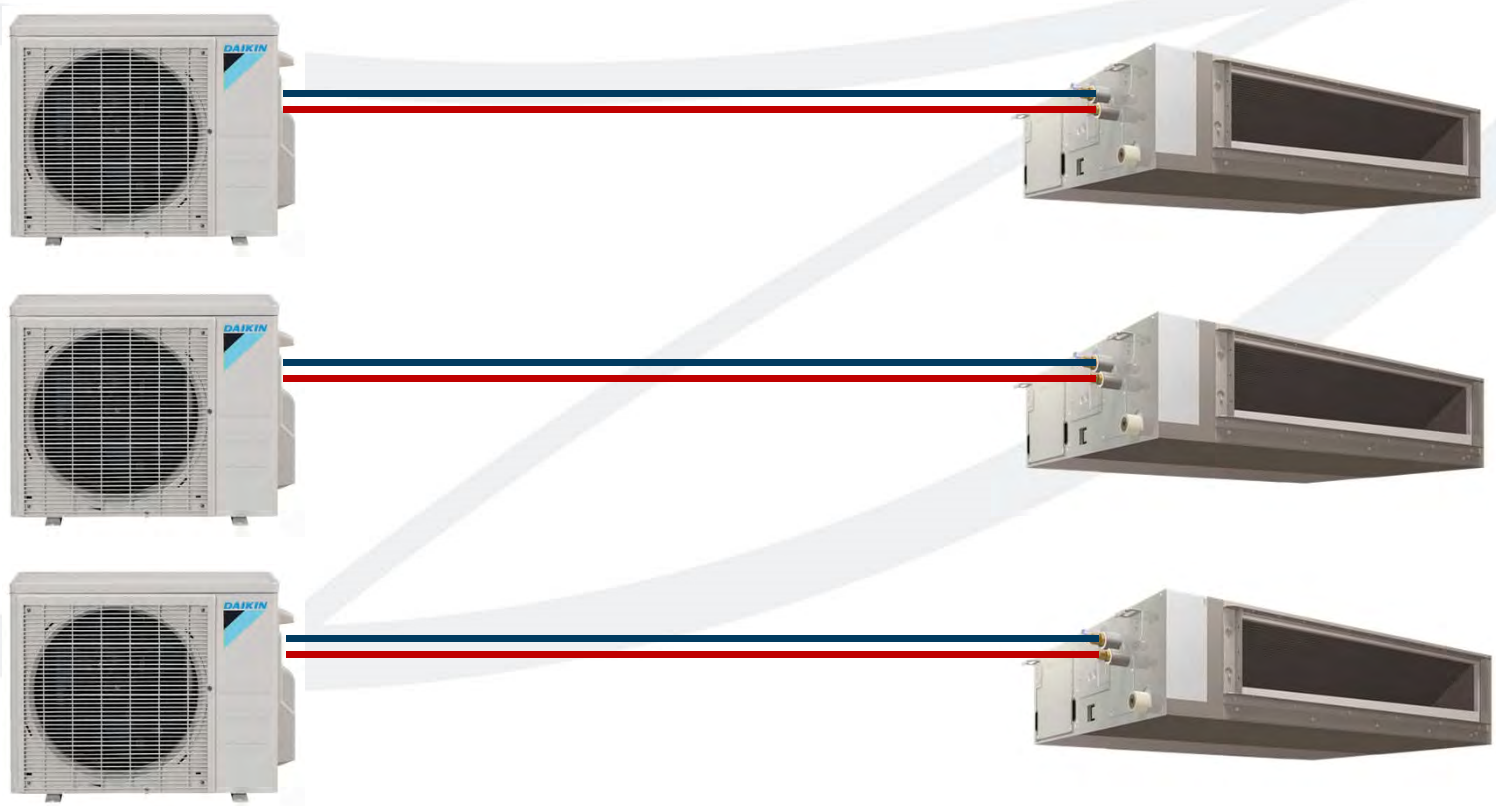
Mini-Splits

R-410A → R-32
(1/1/2025)

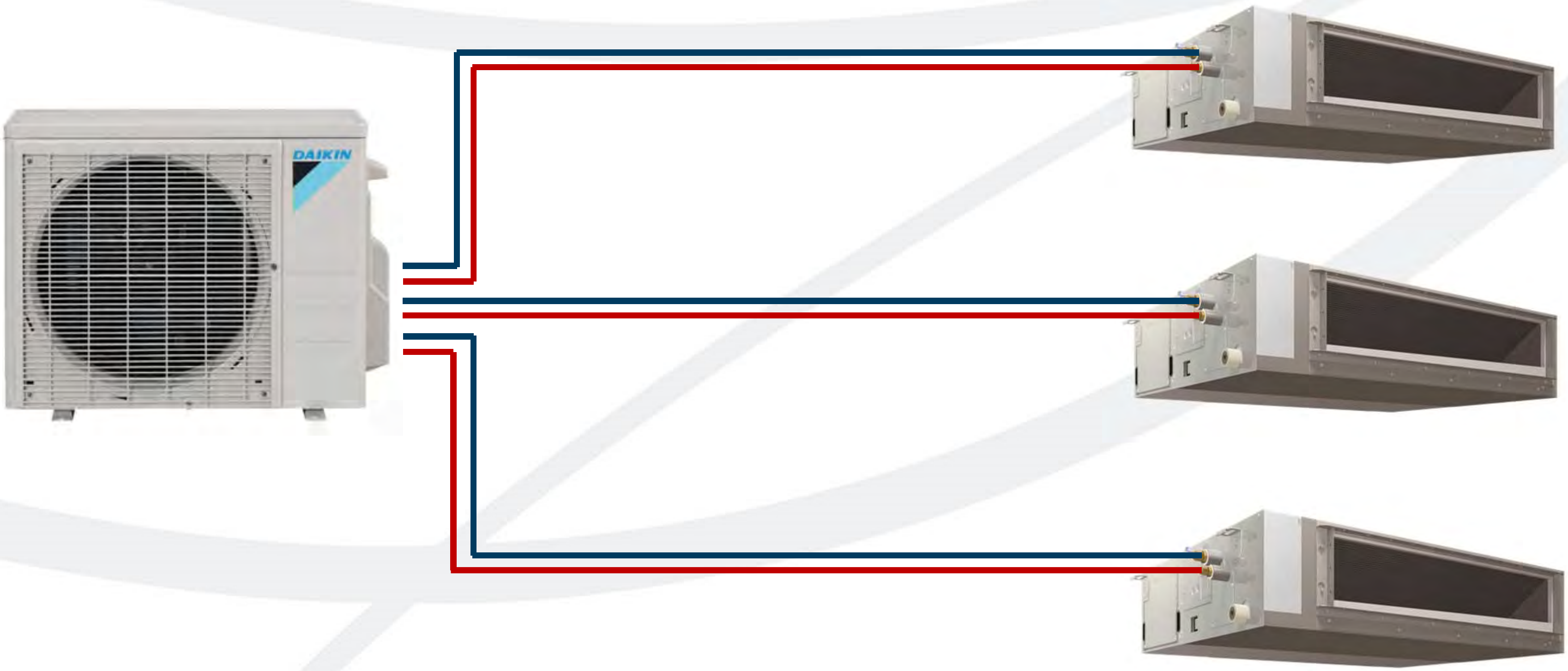


¾ Ton → 4 Tons

HTS DXS CONTROL TECHNOLOGIES

Multi-Splits

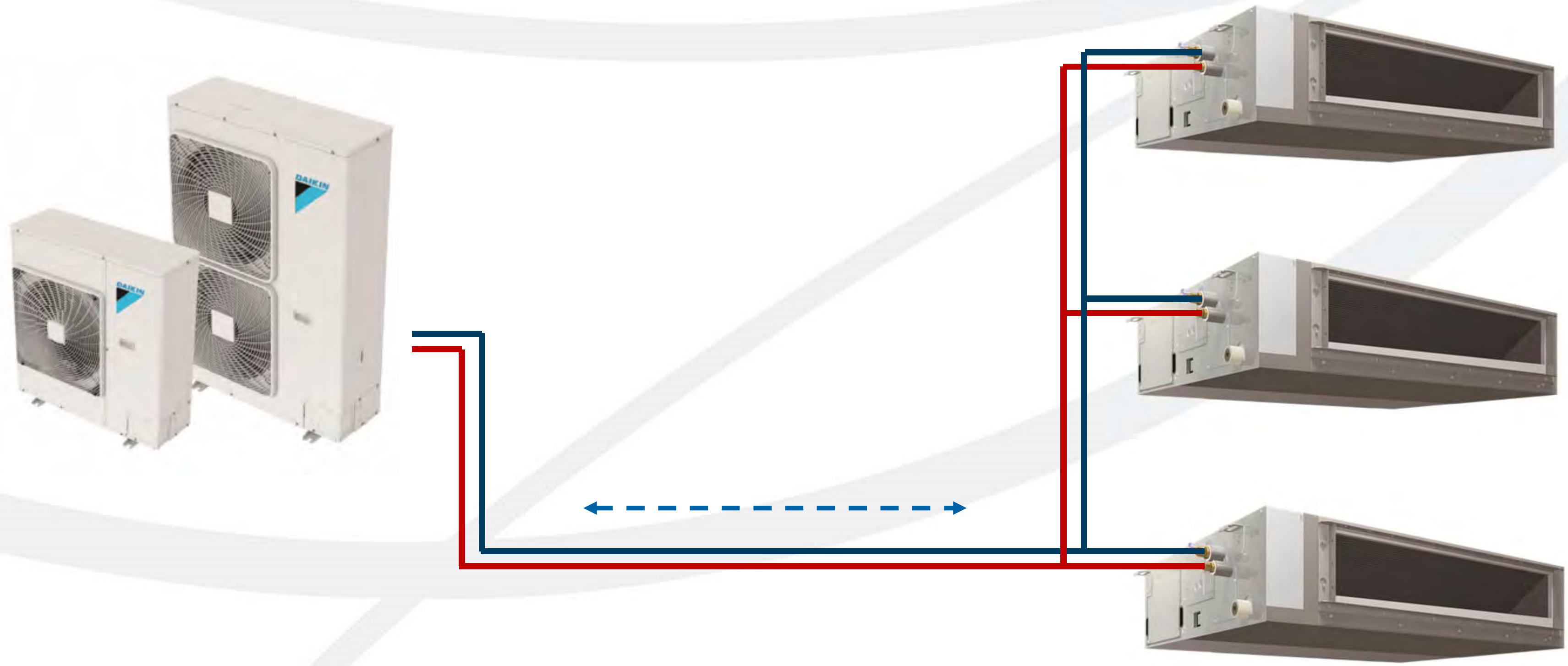
R-410A → R-32
(1/1/2025)



1.5 Ton → 4 Tons

VRV-S (Single Phase)

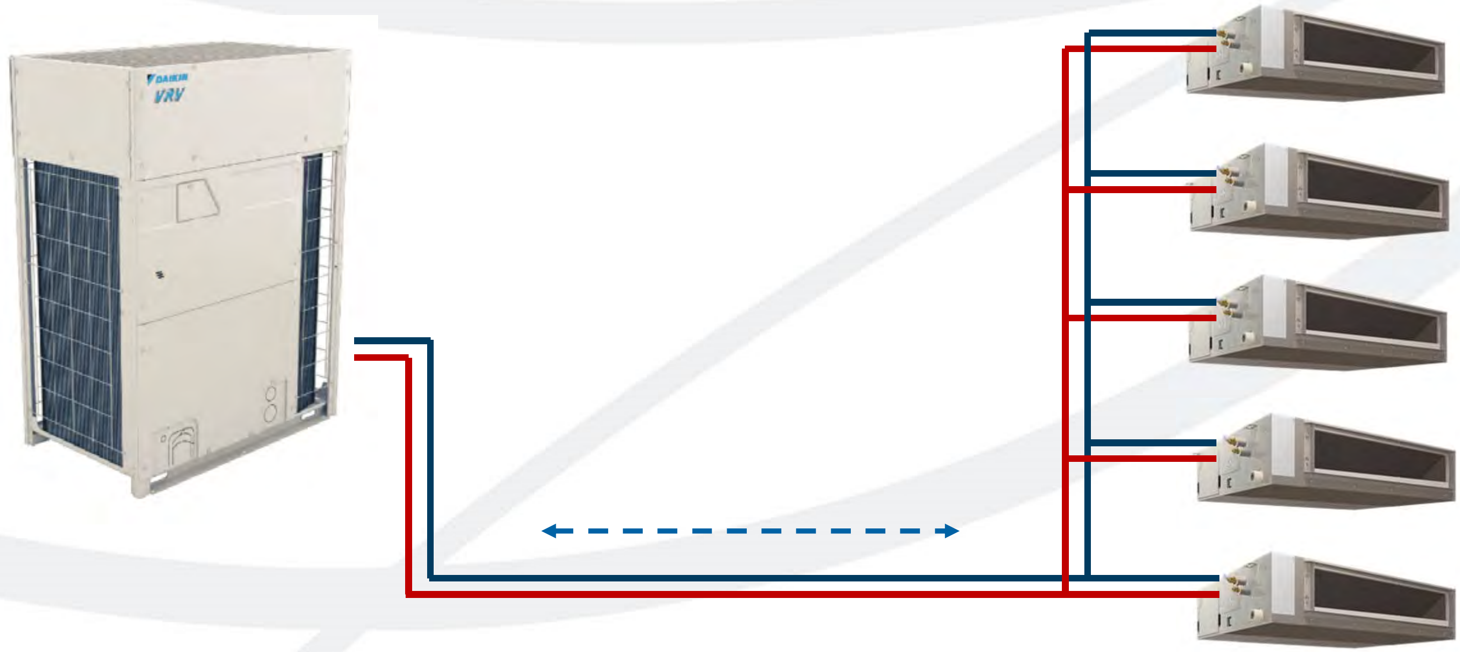
R-410A → R-32
(1/1/2025)



2 Ton → 5 Tons

VRV (Three Phase)

R-410A → R-32 (1/1/2026)



6 Ton → 40 Tons

Sidebar: VRV vs VRF

DAIKIN *Trademarked *VRV* in 1982

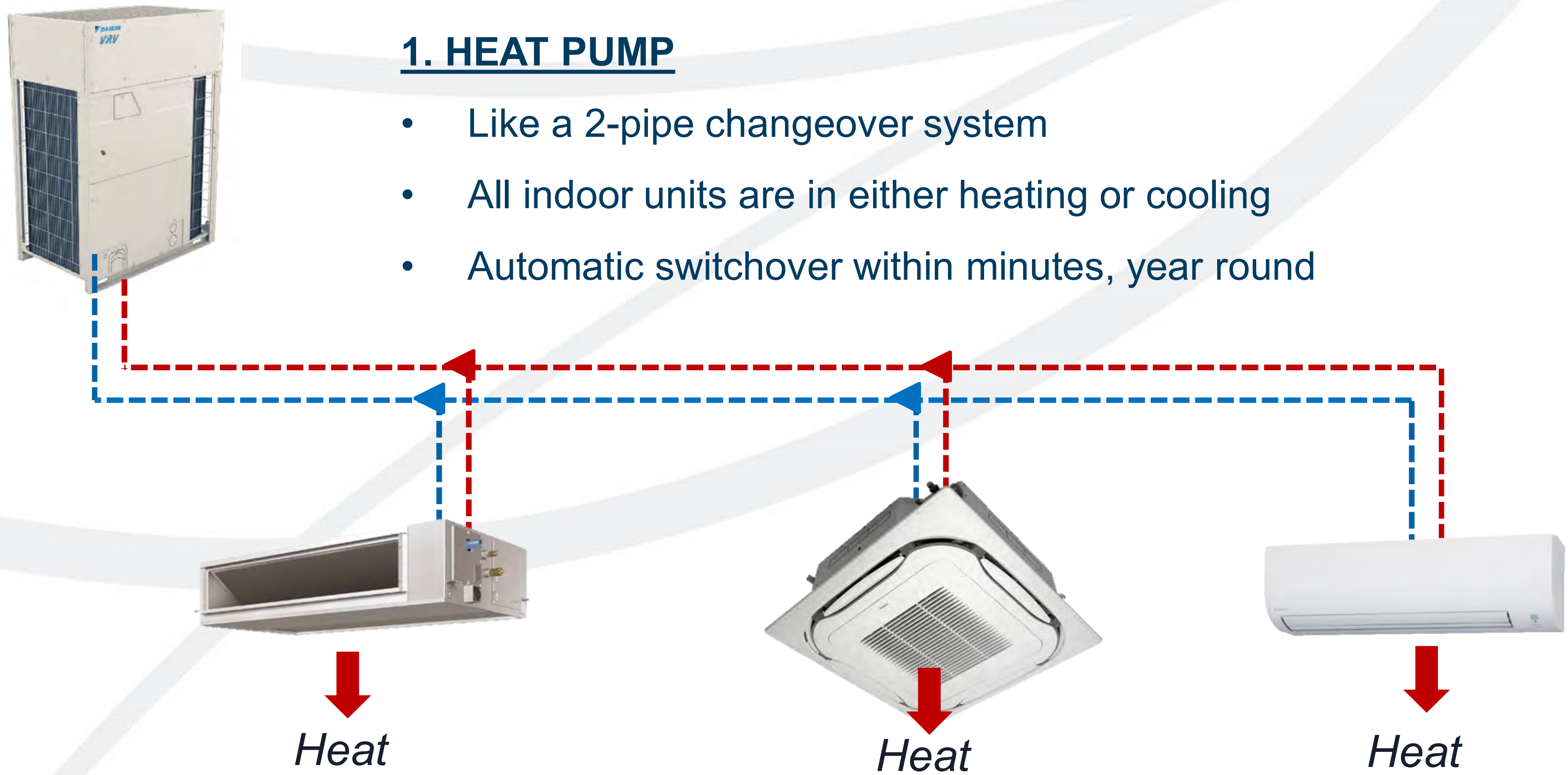
Variable - *System output depending on required load*
Refrigerant - *R-410A Direct Expansion System*
Volume - *Refrigerant flow regulated by EEV and variable speed compressor*

AHRI
Air-Conditioning, Heating, and Refrigeration Institute

Variable - *System output depending on required load*
Refrigerant - *R-410A Direct Expansion System*
Flow - *Refrigerant flow regulated by EEV and variable speed compressor*

HTS DXS Control Technologies

Two types of VRV/VRF Systems



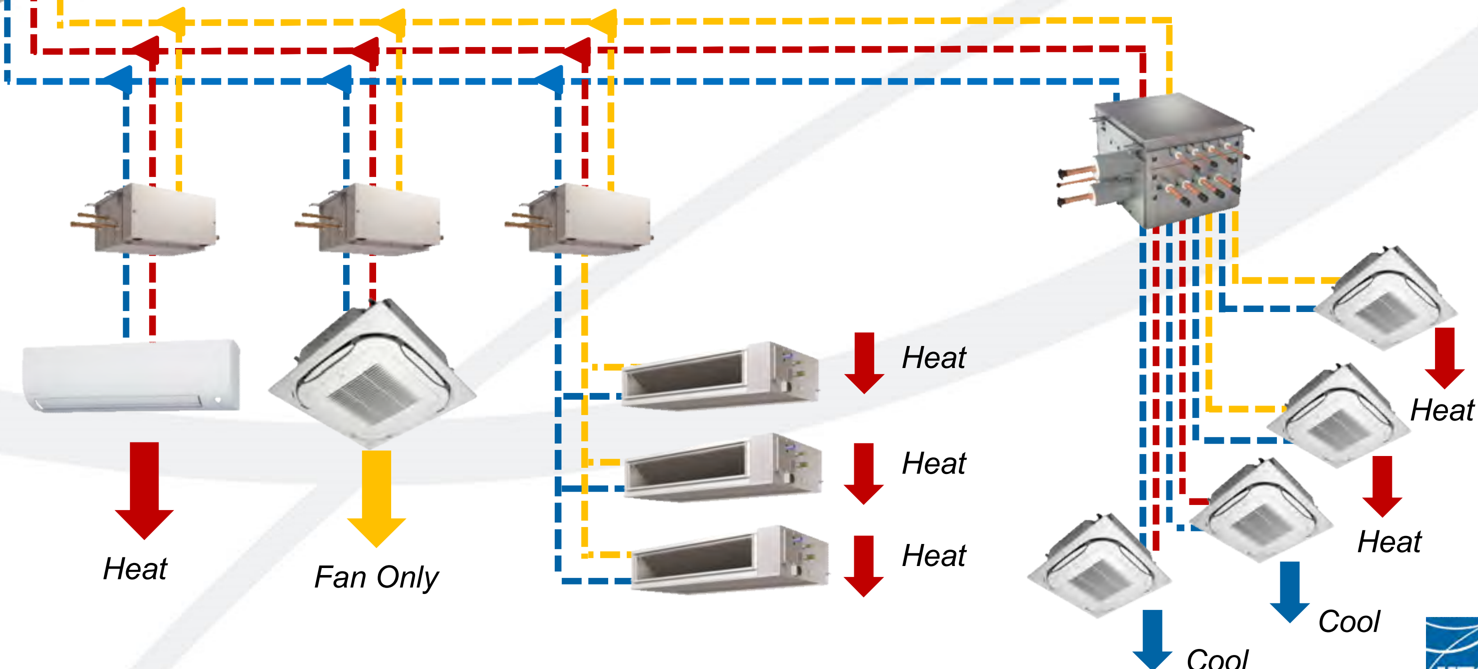
1. HEAT PUMP

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

Two types of VRV/VRF Systems

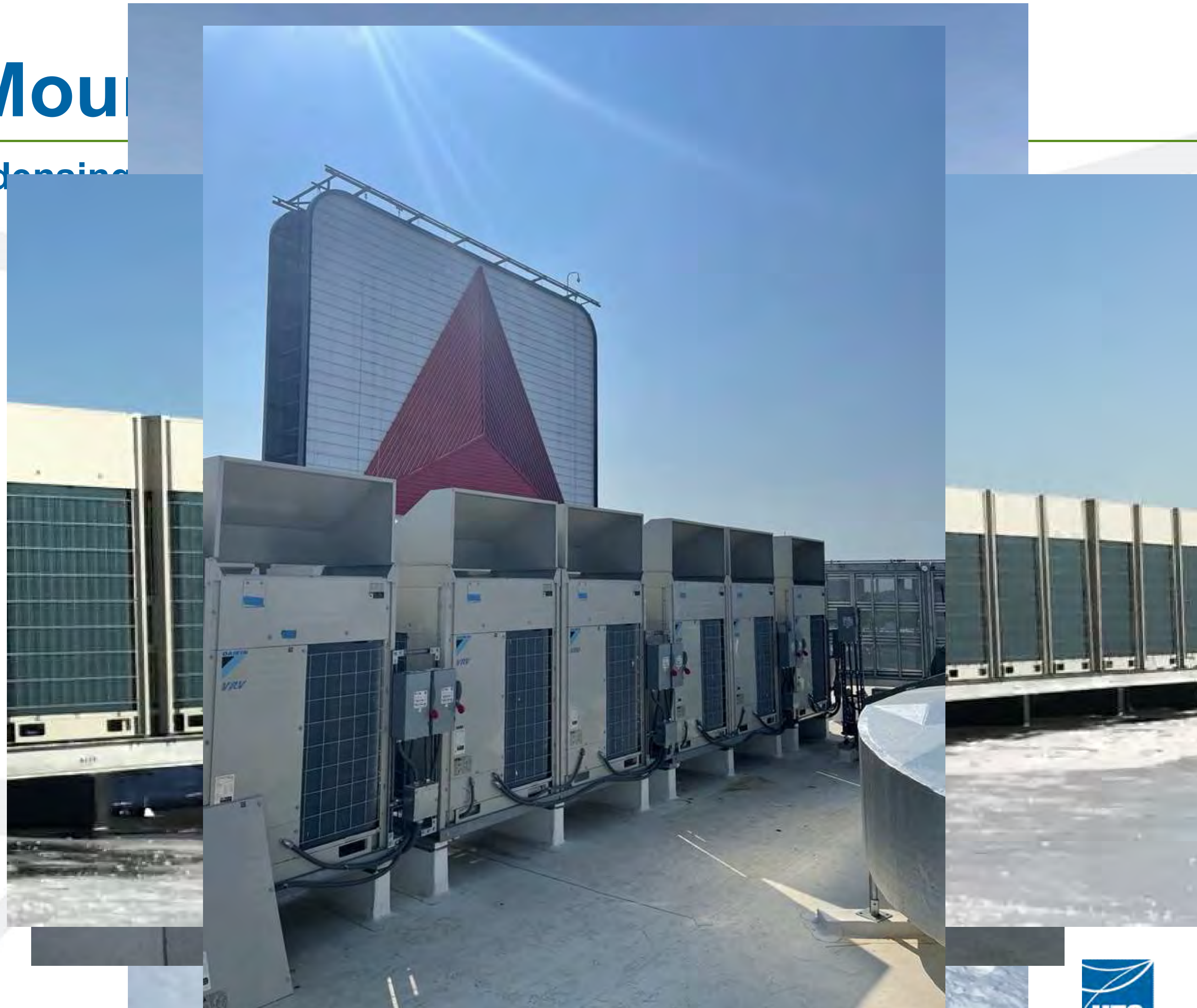
2. HEAT RECOVERY

- Simultaneous heating and cooling
- Branch selector boxes



VRV – Mou

Cond



Frost & Defrost

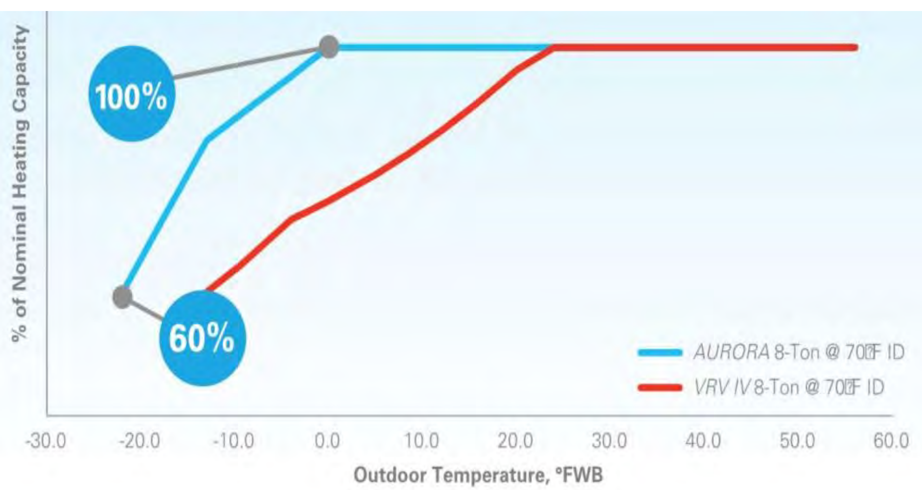
- All heat pump outdoor units will generate condensate on the coil while in heating mode, when the coil temp is below dew point
- This condensate will freeze / frost when the coil is below freezing.
- **Defrost:** Reverse the refrigerant cycle (cooling mode) and stop all fans in the system (accelerates defrost, reduces cooling impact)
- **Peak frost / defrost:** 20-40F ambient.
- **ccASHP Provisions:** elevation above snow levels…drain pan heaters (manufacturer dependent) & drainage management
- Daikin:
  - True continuous heating during full defrost (VRV dual modules)
  - Hot gas base pan circuit (No need for electric base pan heater)

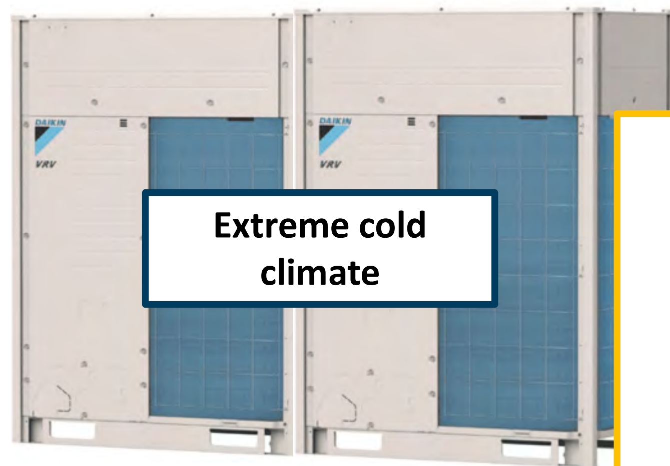
What makes VRV “cold climate”?

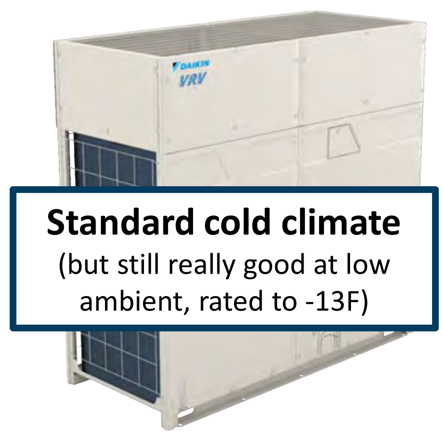
- Cold Climate is <u>not</u> a certified term

- Vapor injection compressors (now in std machines)
- All components certified to lower ambient (Daikin)
- Larger surface area (often more machines)
- **Electrical connection / feed sized for cold climate**

- Result: true capacity maintenance at low ambient







Which do you need? Depends on…

True heating load
True design temp
Safety factor desired

<u>Cost implications</u>

*** Common VE ***

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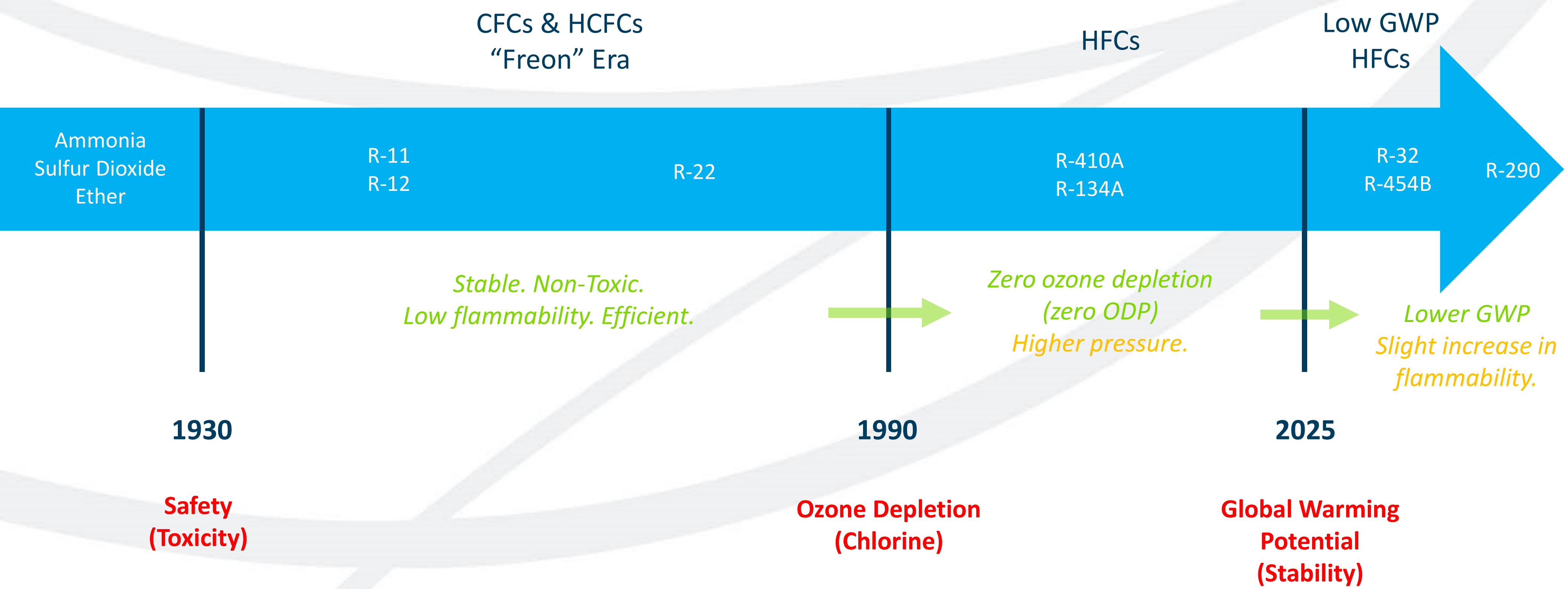
Quick History of HVAC refrigerants…



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

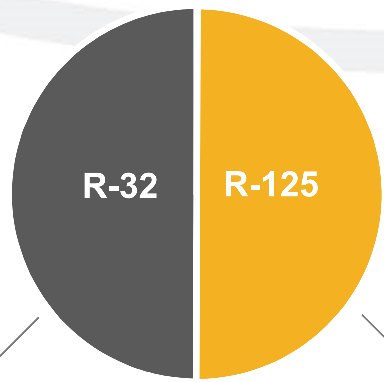
- Most refrigerants can and will combust when put into a high-energy situation such as a fire (ie. R-410a)
- There are (4) flammability classes, and no class called “non-flammable”

- 1: Flame propagation Test (at testing standard of 140F)

- 2: How much (needed to ignite), how hot, how fast
  - *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 refrigerant[1]

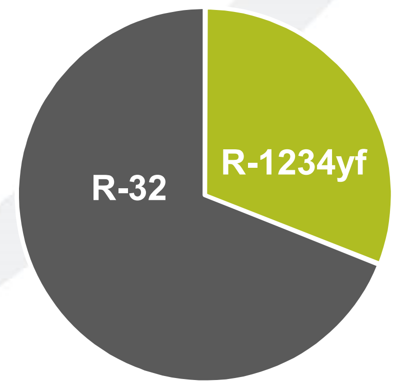
Not so awesome refrigerant.
High fluorine content refrigerant with low performance but high stability resulting in the A1 classification

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 refrigerants[1]

R-454B
(proprietary)



Class: A2L

R-32 mixed with HFO R-1234yf further 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

EPA Phase Out Ruling (on high GWP HFCs)

- EPA's final rule restricting certain HFCs in most new HVACR systems was signed Oct 2023 (Clarified Dec 2023 & Dec 2024). Key products, Global Warming Potential [GWP] limits and dates:

Refrigeration, Air Conditioning, and Heat Pump Systems*			
Subsector	Systems	Global Warming Potential Limit or Prohibited Substances	Installation Compliance Date[5]
Stationary air conditioning and heat pumps	Residential and light commercial air conditioning and heat pump systems	700	January 1, 2025[6]
	Variable refrigerant flow systems	700	January 1, 2026

DXS Notes
Includes all mini/multi split systems and single phase VRF systems; 5 Tons and under
VRF systems 6 Tons and above (usually 3 phase)

- **Deadlines pertain to the manufacture or import of new equipment:** Equipment using refrigerants with GWP's above 700 cannot be manufactured OR imported into the United States after these dates, unless they are for service or replacement.

- **Residential AC and HP (ie. split systems):** R-410A equipment manufactured or imported prior to 1/1/2025 can be installed until 1/1/2026 (ie. there is a 1-year sell-through of any remaining R-410A inventory)

- **VRV/VRF:** R-410A equipment manufactured or imported prior to 1/1/2026 can be installed until 1/1/2027.

Code Adoption for A2L refrigerants – MA & 10th Edition Code

- 10th Edition code carries 2021 I-Codes (IMC 2021) which does not have the latest language surrounding A2Ls.
- HTS/DXS lead the MA 10th code change proposals for A2Ls (testified, submitted 8 proposals, defended etc.)

- Code change progress
  - MARCH 27 2024 : BBRS voted to adopt the first 2 of 8 proposals, updating the ASHRAE 15/34 referenced standard to 2022 and UL 60335-2-40
  - JULY 9 2024 : BBRS voted to adopt the remaining 6 of 8. These are still going through the process.
  - NOV 12 2024 : BBRS issues advisory document allowing the use of ASHRAE 15 2022 to comply with 10th edition code

    *** Solves pipe shaft requirement issues, R-32 & R-454B cl er formulas for volume calculations, use of safety shut off valves etc.***

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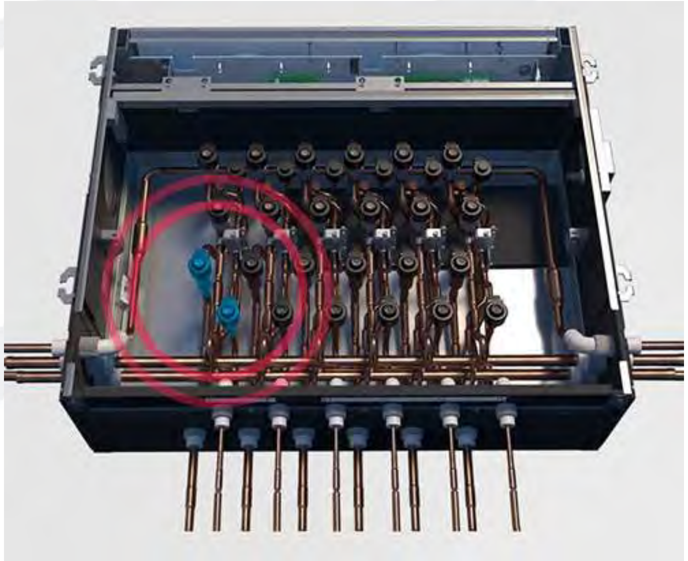
ASHRAE Standard 15 - 2022 & A2L's – VRV/VRF

- All A2L VRV/VRF will need refrigerant detection in all spaces
  - Daikin: factory mounted detectors in fan coils
  - Result:
    - Increased safety (R410a had no detection)
    - Increased RCL from 4.8 (R-32) to 9.6 lbs / 1000ft^3
      - *R-32 also has ~30% less charge than R-410a*



- Safety Shut Off Valves (SSOVs) can be used to reduce the "releasable charge" of the system
  - Daikin: factory mounted safety shut off valves
  - Result:
    - Reduced safety risks (upon a leakage event)
    - Reduced emissions (upon a leakage event)
    - Simplification of R410a to R32 VRV retrofits

https://www.ashrae.org/technical-resources/bookstore/ashrae-refrigeration-resources

ASHRAE Standard 15 – 2022 – SUMMARY (for A2Ls)

- ASHRAE 15 2022 includes all positive improvements when applying A2Ls to distributed refrigerant systems
  - Making the systems safer to use
  - Making the systems easier to design and comply with refrigerant concentration limits.
  - Major Reduction in leakage quantity in the event of a leak (reducing emission potential)
    - Identifying and locating leaks quicker and easier
  - Removes requirements for fire rated and ventilated shafts.
    - ASHRAE 15 2024 is further clarifying this, including the removal of ventilation requirements if you DO volunteer to use a shaft.

The VRV/VRF and mini/multi-split industry welcomes and embraces A2Ls, including the improved performance and management of the systems!

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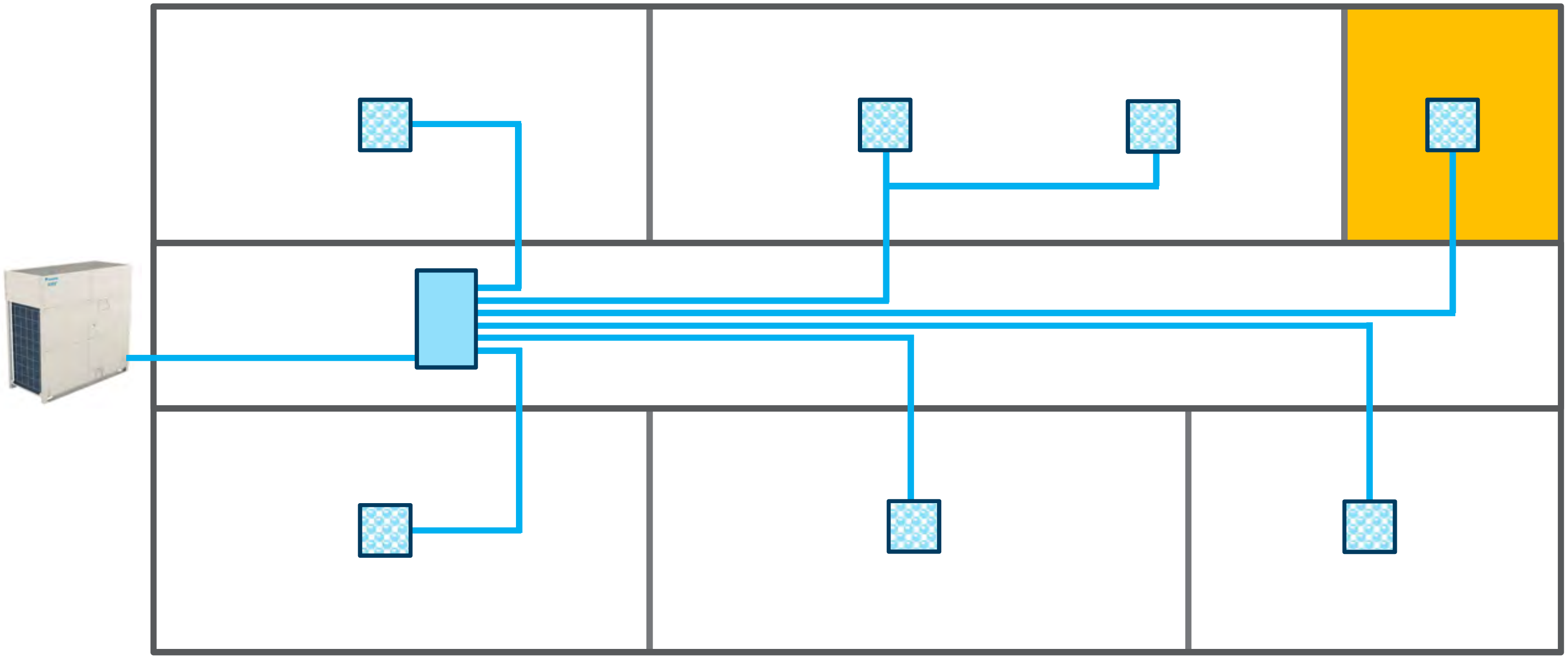
ASHRAE Std 15 – 2022 (Example)

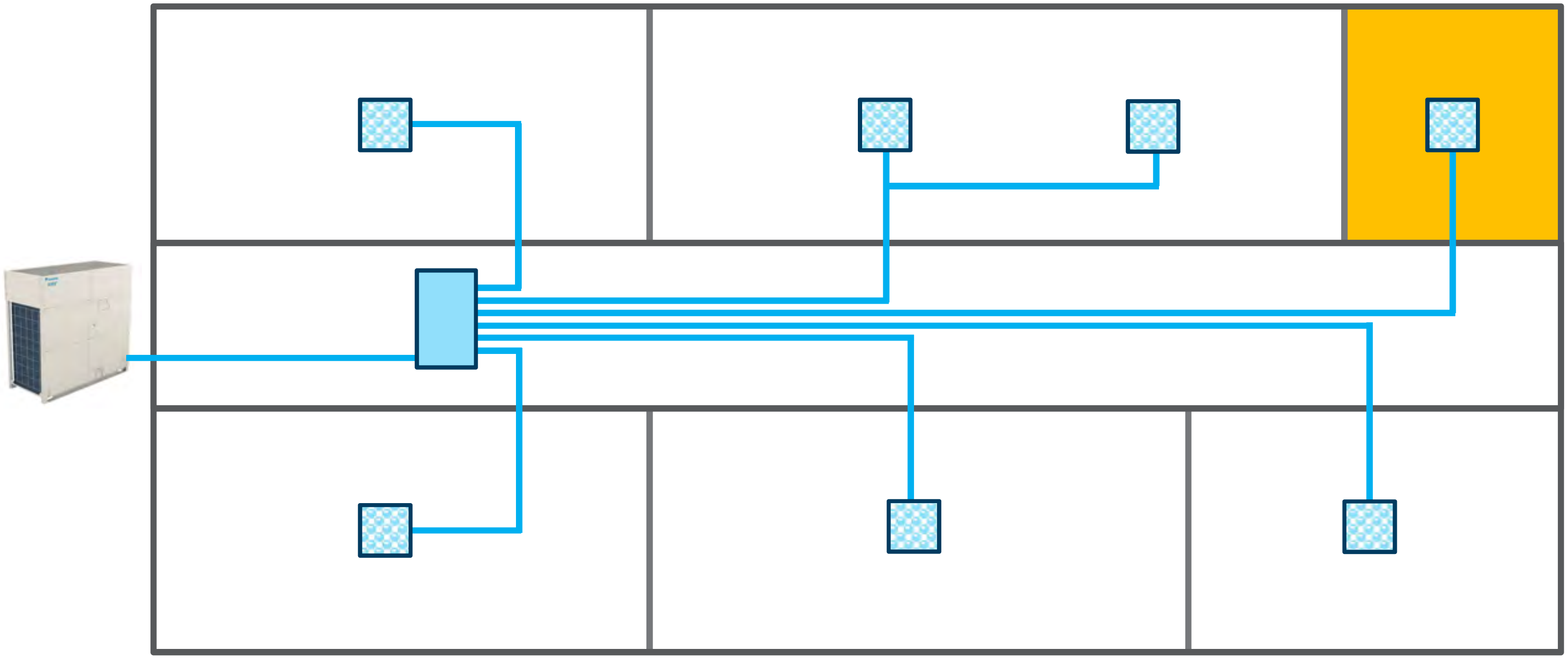
R-410A



1. Smallest room: 15' x 15' x 8' = 1,800 cubic feet
2. Allowable charge = volume x RCL = 1,800 x **26** / 1000 = 46.8 lbs or R-410A
3. Releasable charge = full system charge = 40 lbs
4. 40 < 46.8 system in compliance

ASHRAE Std 15 – 2022 (Example)

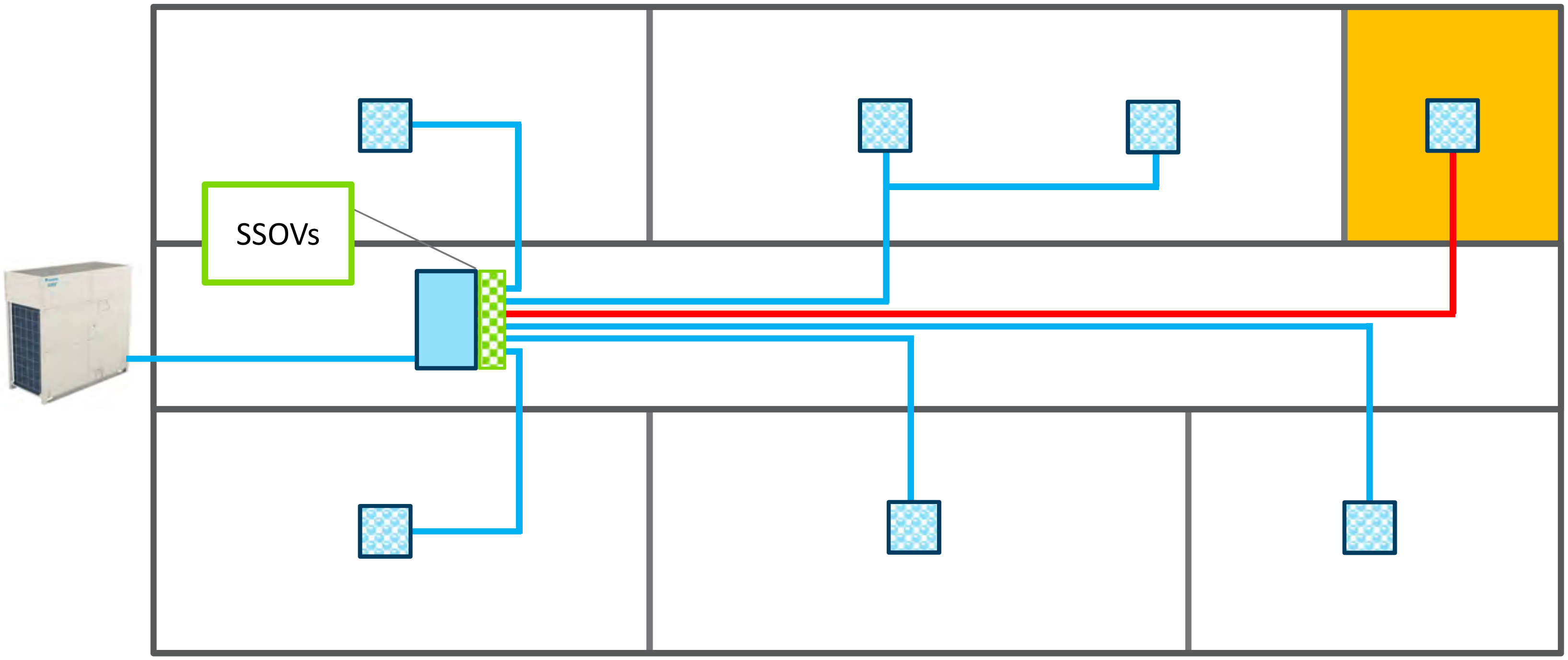
R-32



1. Smallest room: 15’ x 15’ x 8’ = 1,800 cubic feet
2. Allowable charge (with air circulation) = volume x RCL = 1,800 x **9.6** / 1000 = 17.28 lbs or R32
3. Releasable charge (no SSOVs) = full system charge = 30 lbs
4. 30 > 17.28 system not in compliance

ASHRAE Std 15 – 2022 (Example)

R-32



1. Smallest room: 15’ x 15’ x 8’ = 1,800 cubic feet
2. Allowable charge (with air circulation) = volume x RCL = 1,800 x 9.6 / 1000 = 17.28 lbs or R32
3. Releasable charge (beyond SSOV) = 12 lbs
4. 12 < 17.28 system in compliance

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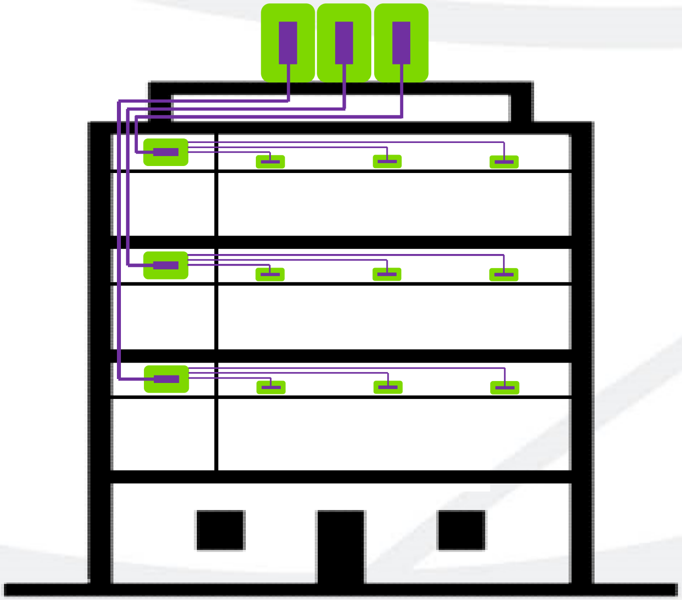
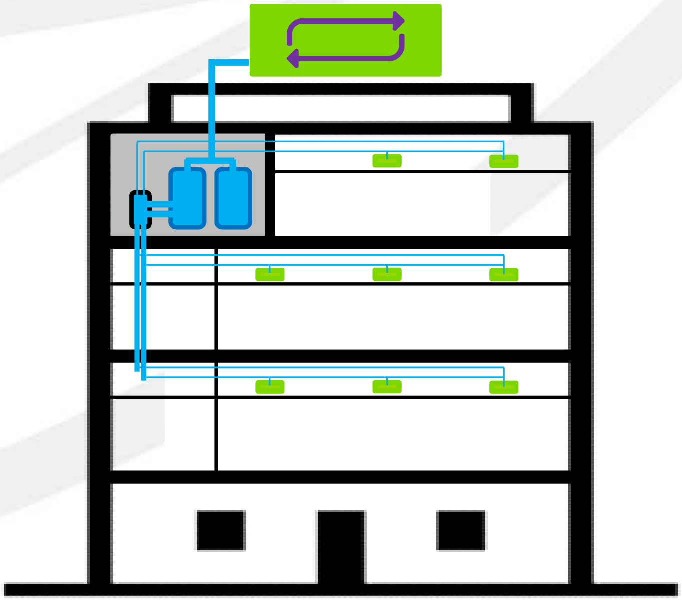
Refrigerant Distribution vs Hydronic Distribution



VRV / VRF



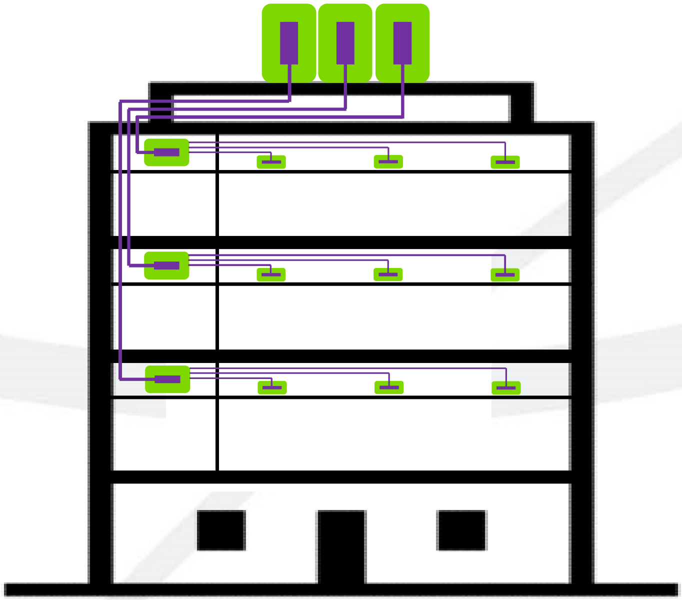
Air Source Heat Pump Chillers

Green before green was cool!

Comparison: Distributed Refrigerant Systems (vs Hydronic)

Advantages

- Capital costs (for an all-electric solution)
- Low ambient performance
- Space & Architectural flexibility
- Tenant billing & independent ownership
- Factory central / remote control options



VRV / VRF

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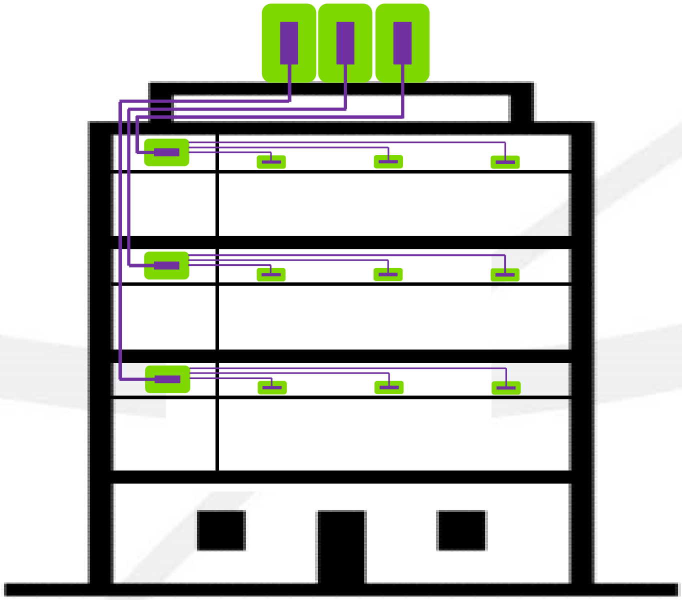

VRV / VRF

- **$2,500 - $4,500 / Ton (R-32)**
  - Includes outdoor heat pump, indoor fan coils, thermostats, central controls etc.
  - Flat economy of scale
  - Install cost: small refrigerant pipes vs larger hydronics, however, NEED qualified contractor
- **A2W outdoor heat pump: $2,000 - $4,000**
  - **Add**: tanks, HX, backup, fan coils, thermostats, central controls etc.
  - Install cost: mechanical room, large piping, tanks and pumps and glycol mgmt.
  - Economy of scale, price competitive in larger buildings and complexes
  - Pricing is coming down (unitary, competition)
- **Existing buildings**
  - With / without re-usable hydronics distribution
  - Temperature of terminal units

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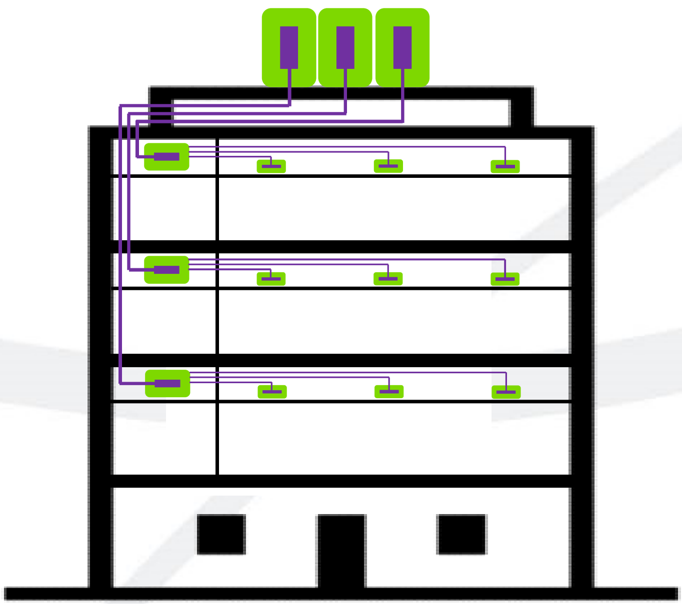

VRV / VRF

- **Low ambient heating range & capacity**
  - -13F standard on most, -22F on some
  - 100% heating capacity at 0F on some
    - While maintaining condensing temp
- **Low ambient heating efficiency**
  - 40 years of experience in ASHP, 10 years of vapor injection
  - Modular setup, defrost technology, etc.
  - Efficiency metrics (COP) take indoor unit fan power into account
  - No added power for pumps
- **No need for back-up heating (gas or electric)**
  - Still an option for resiliency
  - Key for new stretch code C406 (no electric resistance allowed)
- **Operational costs and emissions**
  - Grid emissions over the next 10-20 years
  - Cost of electricity

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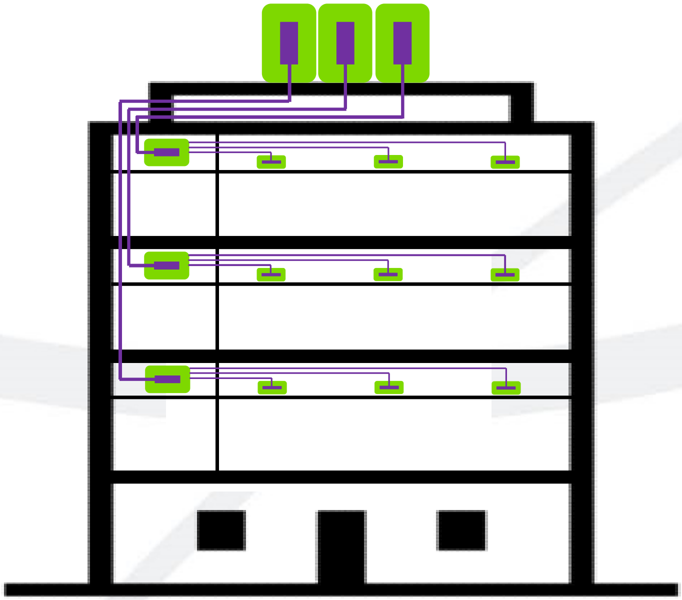

VRV / VRF

- **No mechanical room needed for hydronics**
  - Refrigerant lines distributed right to terminal units and / or branch boxes
  - Maximizes indoor leasable space
  - Roof space similar to equivalent ASHP chillers sized for similar heating capacity
  - **Note**: mech room possibly still needed for central DHW
- **Small piping easy to route through buildings**
  - Hard copper risers, soft copper to fan coils
  - Fit 20 Tons through 1-1/8 x 7/8 pipes

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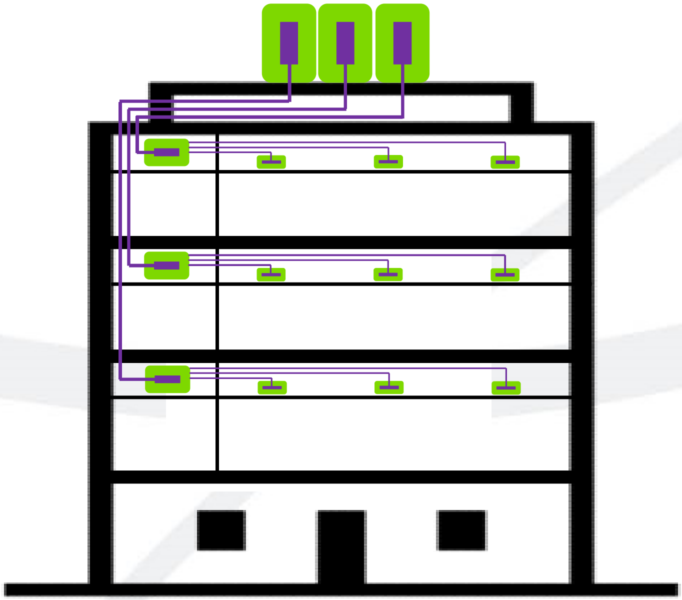
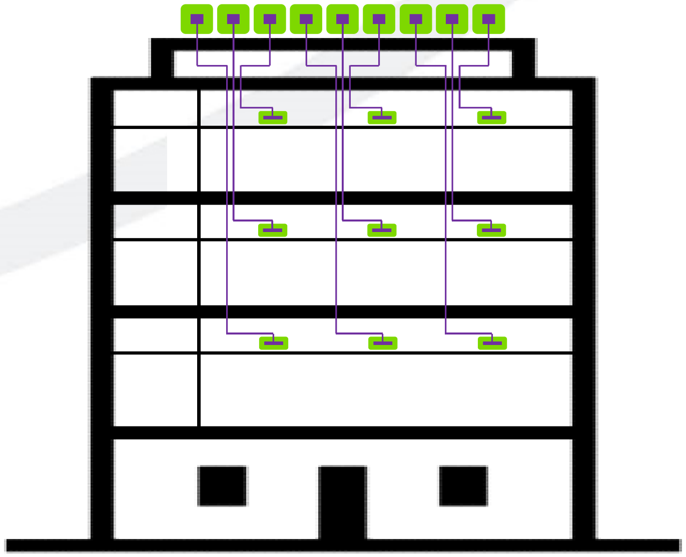
- **Unitized split systems**
  - Full individual ownership and / or operational cost responsibility
  - No interdependence on any central system



VRV / VRF



Mini / Multi Splits

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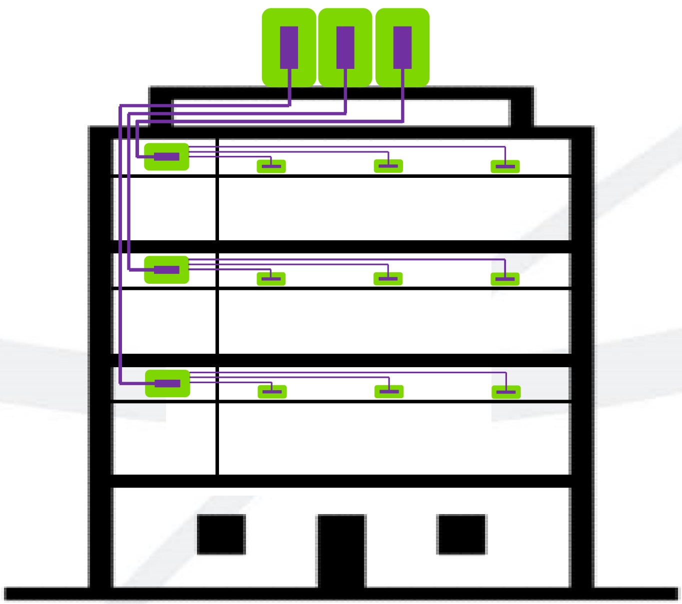


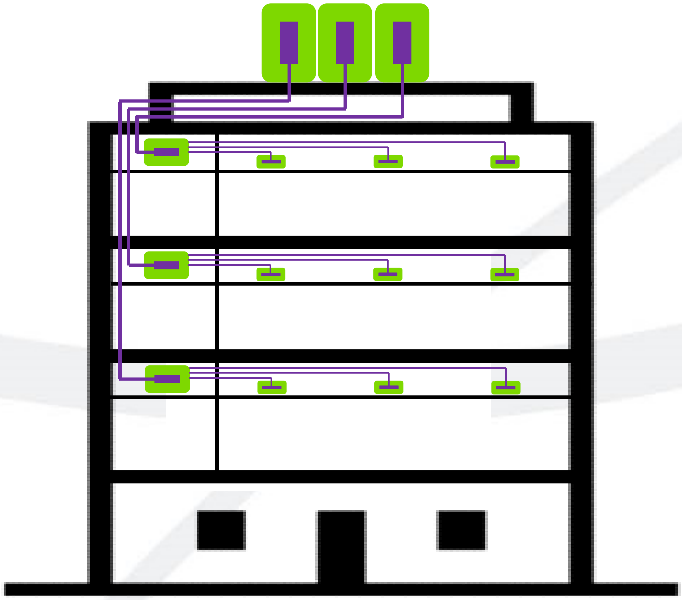
VRV / VRF

- **VRV/VRF systems are already wired back to outdoor heat pump**
  - Touch screen central controls for very small incremental costs, remote access
  - Growing IOT remote devices and service tools being released
    - Predictive errors, early refrigerant leak detection, failure forensics etc.

Comparison: Distributed Refrigerant Systems (vs Hydronic)

Disadvantages

- Higher refrigerant charge & leak risk
- Reduced flexibility for future HVAC systems
- Heat recovery only within individual systems
- No thermal battery
- Current lack of understand of A2L codes



VRV / VRF

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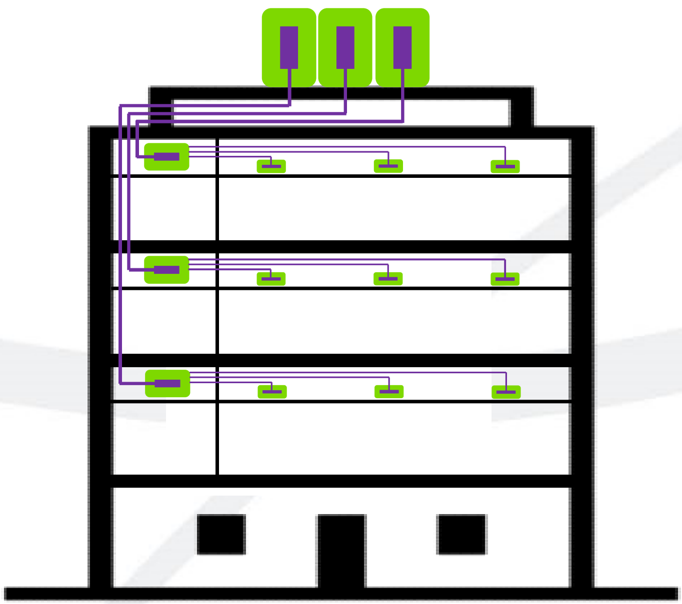

VRV / VRF

- **More refrigerant / ton**
  - Charge dependant on piping lengths, but generally more # / Ton (3-6 vs 1.5)
  - Note: ~20% reduction in VRF charge for manufacturers going with R-32 vs R-410A
- **Higher leak risk**
  - Field installed system with field connections
  - Field pressure test
  - Pressure test requirements (by manufacturers & ASHRAE / IMC) designed to ensure systems never leaks. Needs to be done properly.
  - Field piping & connections exposed to disturbances, renovations etc.
- **R-32 improvements**
  - Addition of leak sensors in ALL indoor units
  - Addition of automatic isolation valves
  - Improved alarming and leak reduction

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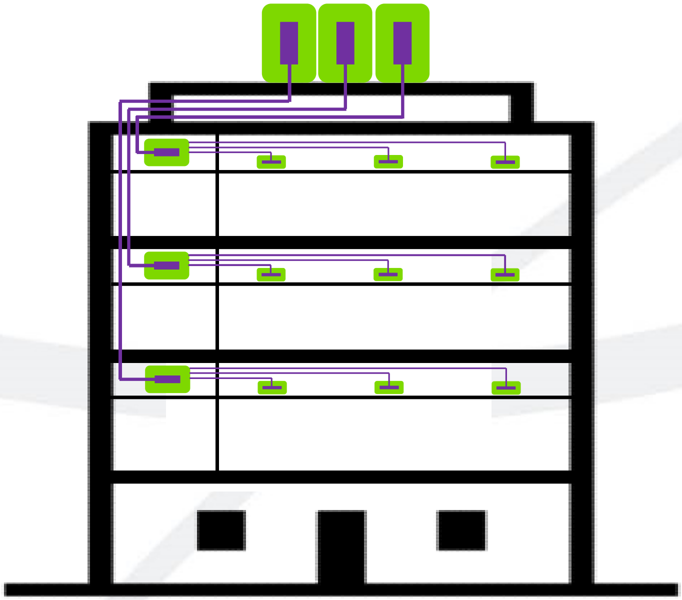


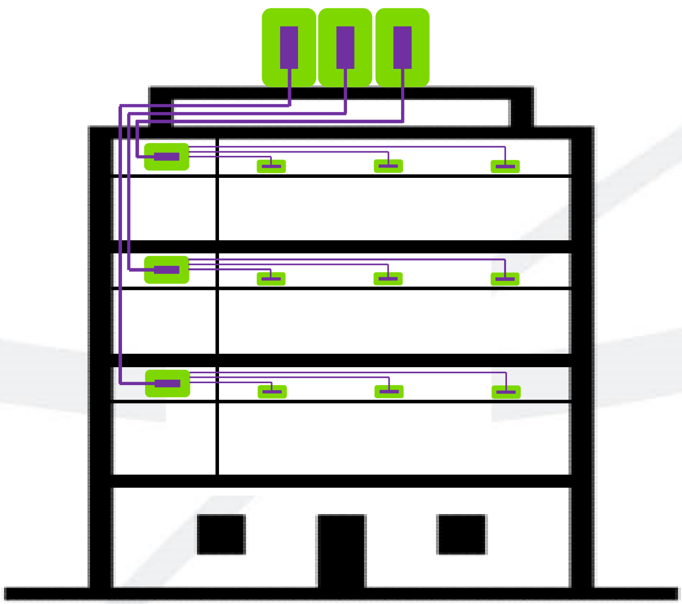
VRV / VRF

- **VRF piping networks can only be used for VRF**
  - Piping CAN be re-used, but limited to certain manufacturers (ie. 2-pipe vs 3-pipe)
  - Limited to distributed refrigerant, always
  - Cannot move to R-290 or other
- **Longevity of refrigerant copper piping vs Hydronic piping**
  - Steel hydronic piping known to last longer
- **Mitigation**
  - R-410A / R-32 systems can continue to be repaired and components replaced as needed
  - Most manufacturers have multiple distribution outlets for parts / replacement units

Comparison: Distributed Refrigerant Systems (vs Hydronic)

Disadvantages

- Higher refrigerant charge & leak risk
- Reduced flexibility for future HVAC systems
- Heat recovery only within individual systems
- No thermal battery
- Current lack of understand of A2L codes



VRV / VRF

- **VRF systems only recover heat within individual systems**
  - Hydronic systems can benefit from full building heat recovery between all zones, and with other components (ERVs, DHW)
    - Highly recommend / required to compete or beat VRF efficiency
  - DHW can be a big factor, especially in the Summer.
    - DHW off central ASHP chillers requires proper ASHP chiller sizing

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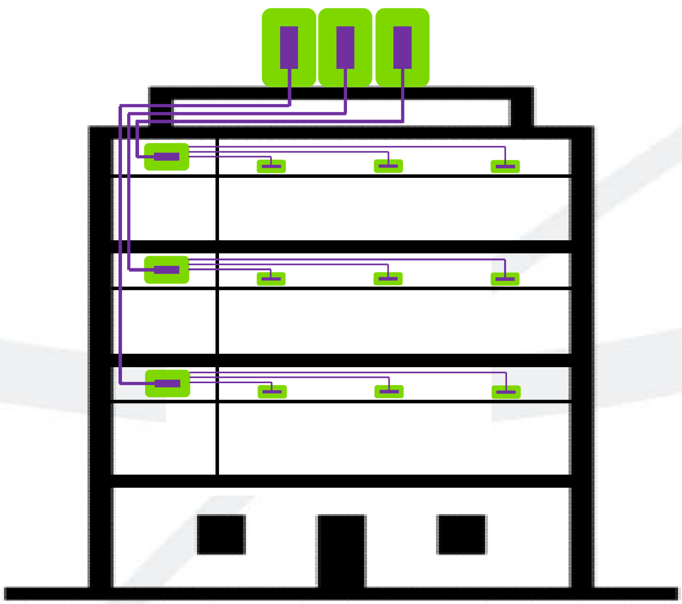
- **Hydronic systems with large storage create thermal battery**
  - Requires large tanks and storage, often already required for defrost
  - This creates a thermal battery in the building, for resiliency and / or for peak load shedding, power outages, time of use rates, improved day / night energy recovery



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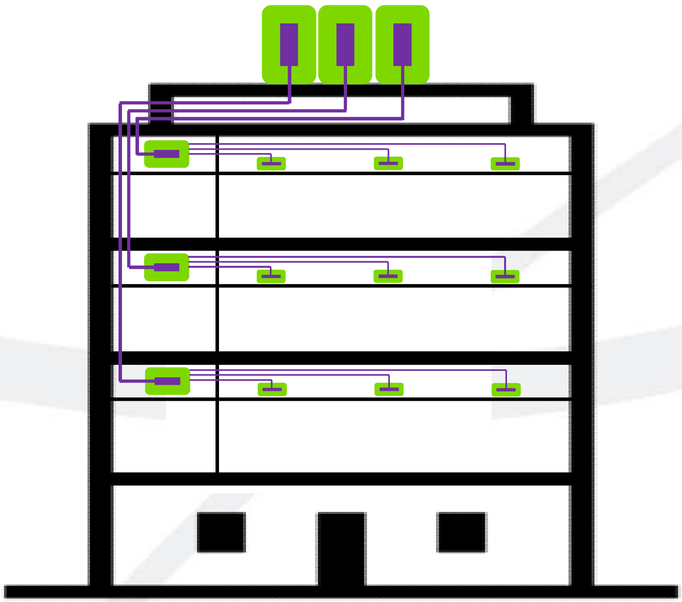


VRV / VRF

- **Current fear and lack of understanding of A2Ls**
  - EPA phase-out was VERY fast, create code language lags and conflicts, and fear
  - Europe and other parts of the world have been using R-32 for 5+ years (250M installs)
  - Jurisdictions that can use ASHRAE 15 2022 are in a good place, as most questions / concerns have been addressed
    - Main "ventilated shaft" issue finally solved
  - Some fear surrounding flammability still remain, though getting understood
  - Lots of false information out there!
- **Temporary issue**

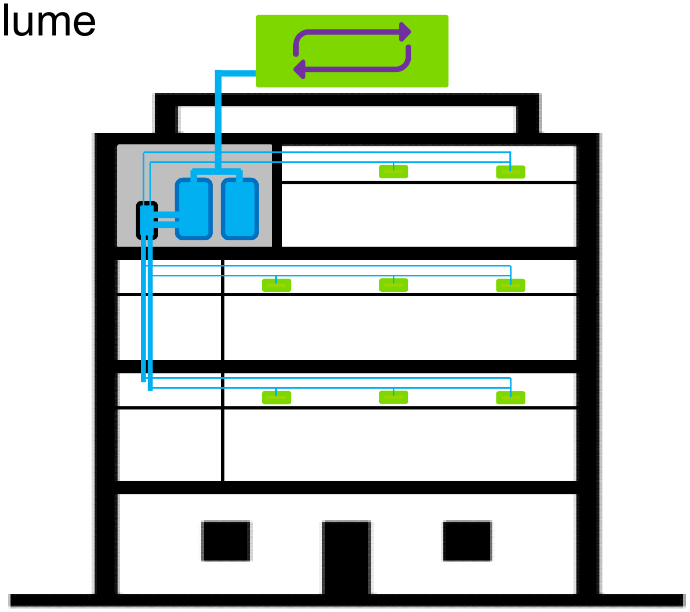
In reverse! A view of hydronic systems

Advantages

- Less refrigerant, factory sealed, outdoors
- Longevity & future flexibility of hydronic distribution network
- Integration & heat recovery with other HVAC and DHW components
- Thermal battery of hydronic volume

Disadvantages

- Install costs (with 4-pipe fan coils, heat recovery etc.)
- Mechanical room space for tanks, HX, pumps
- Glycol requirements (maintenance & risks)*
- Potential need for electric resistance backup*



Air Source Heat Pump Chillers

AGENDA

- Distributed Refrigerant Systems 101
- Refrigerant transition
- Distributed Refrigerant Systems 102 (with A2Ls)
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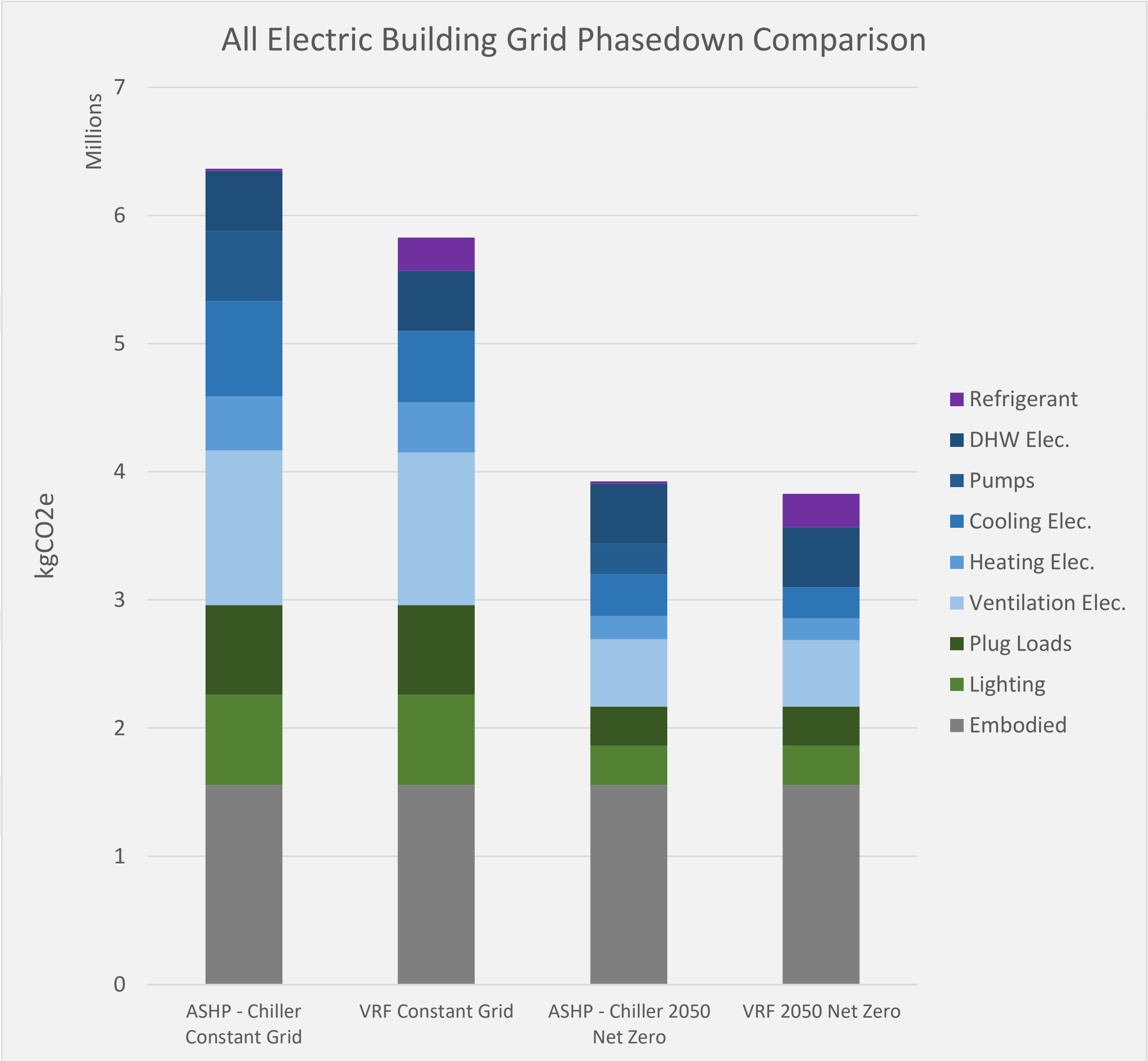
- When VRV & Hydronics get married

Life Cycle Climate Performance

- Building LCCP Study using 3rd party energy model
- 8 Story multi-rez building (Boston)
- All-Electric HVAC systems
  - VRF vs ASHP Chiller
  - ASHP DHW
  - VRF driven ERVs
- Deep analysis of grid emissions
  - Correlations to time-of-day & year
  - Correlations to weather
  - Overlaid onto TMY3
  - Multiple Grid phasedown scenarios
- Multiple refrigerant leak rates and emission scenarios



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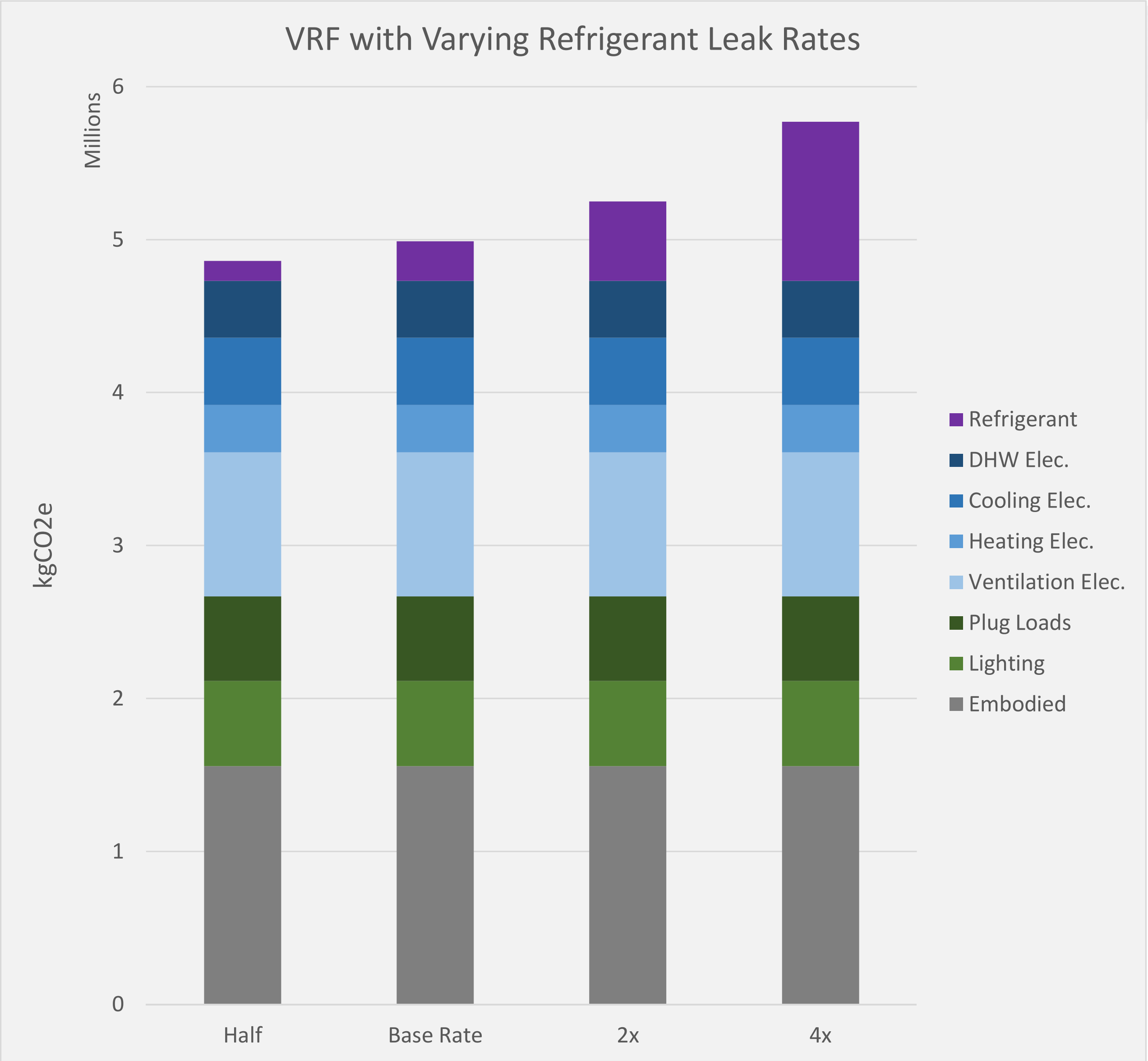

VRF systems under ASHRAE 15 2022

(regarding potential refrigerant emissions)

System A (R-410A)

- 30 Tons
- 100 lbs R-410a

- Potential leakage event:
  - Technically, up to 100% of charge
  - Realistically, alarms and impacts well before 50% is lost, but let's use 50%

- 50 lbs lost @ 2,088 GWP = ~**52 Tons CO_2**

System B (R-32) *Catastrophic central leak*

- 30 Tons
- 80 lbs R-32

- Potential leakage event:
  - Once again technically up to 100% of charge, but with improved IOT monitoring and alarming, assume 25%

- 20 lbs lost @ 675 GWP = ~**6.75 Tons CO_2**

Conceptual Only. Based on Daikin estimates for R32 refrigerant charge vs R410a, and on European systems.

VRF systems under ASHRAE 15 2022

(regarding potential refrigerant emissions)

System A (R-410A)

- 30 Tons
- 100 lbs R-410a

- Potential leakage event:
  - Technically, up to 100% of charge
  - Realistically, alarms and impacts well before 50% is lost, but let's use 50%

- 50 lbs lost @ 2,088 GWP = ~**52 Tons CO_2**

System B (R-32) *Indoor unit leak*

- 30 Tons
- 80 lbs R-32
- SSOVs and leak detection (ASHRAE 15 2022)

- Potential leakage event:
  - Largest leak possible, assume 5 lbs
  - Alarms, shut down and automatic refrigerant recovery upon detection of leak

- 5 lbs lost @ 675 GWP = ~**1.7 Tons CO_2**

Conceptual Only. Based on Daikin estimates for R32 refrigerant charge vs R410a, and on European systems.

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Other ways of reducing refrigerant emissions

- Pay attention to refrigerant charge (reduce where possible)
- Keep. Refrigerant. In. Systems. (reduce the risk of leaks)
  - Who is installing the systems? *(Certifications, not just of the contractor, but of who on site is physically doing the work)*
  - Who is (truly) witnessing the pressure test? Who is inspecting the install?
  - Where is the equipment being procured from? *(Engineering rep firms with training, experience, service instead of wholesalers)*
  - Advanced on-going monitoring systems***
  - Refrigerant accounting system***

Also a major contributor to reduced failures and down time, and overall project success

**** New / still in dev, reach out for more information! ****

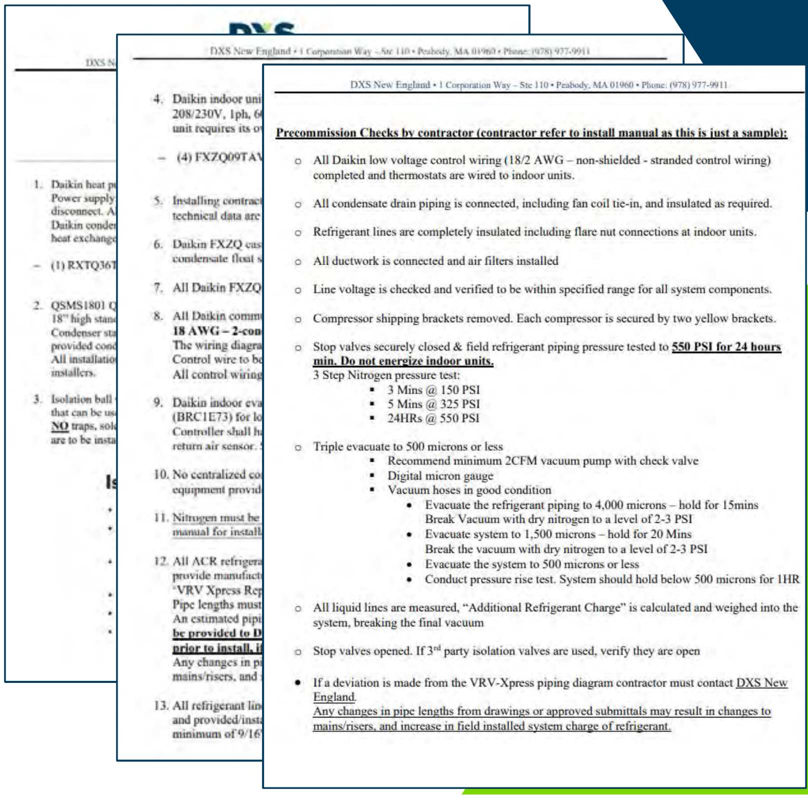
Suggestions

- Pre-install meetings between the VRV rep, mechanical contractor, general contractor, electrical contractor, controls vendor.
- QC site walkthrough visits with the VRV rep throughout the install (with GC)
- Witnessing and photos of specific VRV install requirements (nitrogen purging, pressure testing, evac process, etc.) by owner / GC / Commissioning agent
- All installers touching the VRV equipment must have attended the specific manufacturer's training (otherwise warranty can be voided)
- Identify early who from facilities will be responsible for the system. Get them in touch with VRV rep.

Where is the equipment coming from?

- Wholesalers vs engineered reps with engineering support, contractor support, service teams, parts group

DXS



DXS New England • 1 Corporation Way – Ste 110 • Peabody, MA 01960 • Phone: (978) 977-9911

Precommission Checks by contractor (contractor refer to install manual as this is just a sample):

- All Daikin low voltage control wiring (18/2 AWG – non-shielded - stranded control wiring) completed and thermostats are wired to indoor units.
- All condensate drain piping is connected, including fan coil tie-in, and insulated as required.
- Refrigerant lines are completely insulated including flare nut connections at indoor units.
- All ductwork is connected and air filters installed
- Line voltage is checked and verified to be within specified range for all system components.
- Compressor shipping brackets removed. Each compressor is secured by two yellow brackets.
- Stop valves securely closed & field refrigerant piping pressure tested to **550 PSI for 24 hours min. Do not energize indoor units.**
  3 Step Nitrogen pressure test:
    - 3 Mins @ 150 PSI
    - 5 Mins @ 325 PSI
    - 24HRs @ 550 PSI
- Triple evacuate to 500 microns or less
    - Recommend minimum 2CFM vacuum pump with check valve
    - Digital micron gauge
    - Vacuum hoses in good condition
        - Evacuate the refrigerant piping to 4,000 microns – hold for 15mins
          Break Vacuum with dry nitrogen to a level of 2-3 PSI
        - Evacuate system to 1,500 microns – hold for 20 Mins
          Break the vacuum with dry nitrogen to a level of 2-3 PSI
        - Evacuate the system to 500 microns or less
        - Conduct pressure rise test. System should hold below 500 microns for 1HR
- All liquid lines are measured, "Additional Refrigerant Charge" is calculated and weighed into the system, breaking the final vacuum
- Stop valves opened. If 3rd party isolation valves are used, verify they are open
- If a deviation is made from the VRV-Xpress piping diagram contractor must contact DXS New England.
  Any changes in pipe lengths from drawings or approved submittals may result in changes to mains/risers, and increase in field installed system charge of refrigerant.

Inspections & Supervision

Photo(s) of Main Front Full View of unit):

Photo(s) of Left Side:

General Visual

Visible physical damage of the c
☐ Yes ☑ No ☐ Cannot confirr

Description of Mounting Method
☐ Big Foot ☑ Quicksling ☐ Di

Confirmation of 6 points of cont
☑ Yes ☐ No

Location of ODU(s):
☑ Outdoors ☐ Indoors

Proper elevation of units above l
☑ Yes ☐ No

Measured elevation in inches:
29"

Presence of wind baffles:
☐ Wind baffles installed. ☑ No v

Comments:
On a roof in Boston. I'd recommend

Snow hoods:
☐ Snow hoods installed ☑ No s

Comments:
On a roof in Boston. I'd recommend

Adequate service and airflow cle
☑ Yes ☐ Yes, with comments ☐

Refi

Piping connection locations:
☑ Front ☐ Under ☐ Above

Additional photo(s):

Confirmation that piping between t rules (straight distances, proper su
☑ Yes

Confirmation that visible pipes are
☐ Yes ☑ No

Warning: The selected answer doe
This item must be addressed and f

Description of issue(s):
Suction not insulated

Measured thickness and type of in
Needs to be done

Interna

General photo(s) of the open unit:

Confirmation that access panels are
☑ Yes ☐ No

Confirmation that compressor brack
☑ Yes ☐ No

Confirmation of proper refrigerant pi
☑ Yes ☐ No

Confirmation that all piping within th and free from rubbing against any ot
☑ Yes ☐ No

Confirmation that all components, in
☑ Yes ☐ No

Power

Confirmation that high voltage powe the front of the unit:
☑ Yes ☐ No ☐ Not yet installed

Confirmation that low voltage contro the front of the unit
☑ Yes ☐ No ☐ Not yet installed

Confirmation that conduits that are r the panels and sealed from the insid
☑ Yes ☐ No

Confirmation that conduits that are r unit on a horizontal/upwards plane (
☐ Yes ☑ No

Warning: The selected answer does r
This item must be addressed and fix

Additional comments:
Vertical

Close-up photo of wiring:

Confirmation that system is receiving
☑ Yes ☐ No

Measured voltage for L1-L2 (V):

Measured voltage for L2-L3 (V):

Measured voltage for L1-L3 (V):

Customer-reported length of time po
86 hours

Opinion on whether or not the system (s) to warm up the compressor(s):
☑ Yes ☐ No

Commissioning Readiness

Evidence that the system was pressure tested per Daikin's standards:
☐ Yes, there is evidence that the system was properly tested
☐ There is evidence that the system was IMPROPERLY tested
☑ There is no available evidence of the testing

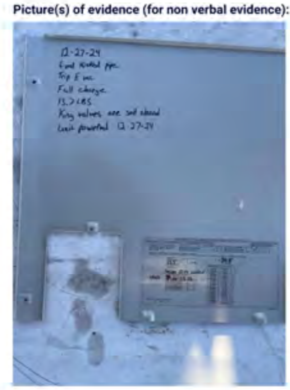
Warning: The selected answer does not align with conditions necessary for start-up eligibility.
This item must be addressed and fixed in order to be eligible for system start-up.

Reason for lack of evidence:
Not written

Evidence that the system was vacuumed per Daikin's standards:
☑ Yes, there is evidence that the system was properly vacuumed
☐ There is evidence that the system was IMPROPERLY vacuumed
☐ There is no available evidence for the system vacuum

Evidence of the vacuum:
Written on panel

Picture(s) of evidence (for non verbal evidence):



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Electrification of Commercial Office (Retro)

VRV driven semi-custom modular AHUs

VRV Heat Pump condensing units

All-Electric K-12 (New)

- VRV driven custom central VAV AHUs
- VRV Heat Pump condensing units

Typical All-Electric Commercial Office (NEW)

Ducted semi-centralized VRV systems

ASHP VRV driven packaged Rooftop ERVs

Low-Carbon Life Science / Lab! (Retro)

- VRV driven semi-custom AHUs
- Glycol heat recovery run-around loop
- VRV Heat Pump condensing units

All-Electric Veteran's Home (Chelsea)

- Geothermal
- Water-source VRV
- Air & Water Source Custom RTU ERVs

Rendering: Payette

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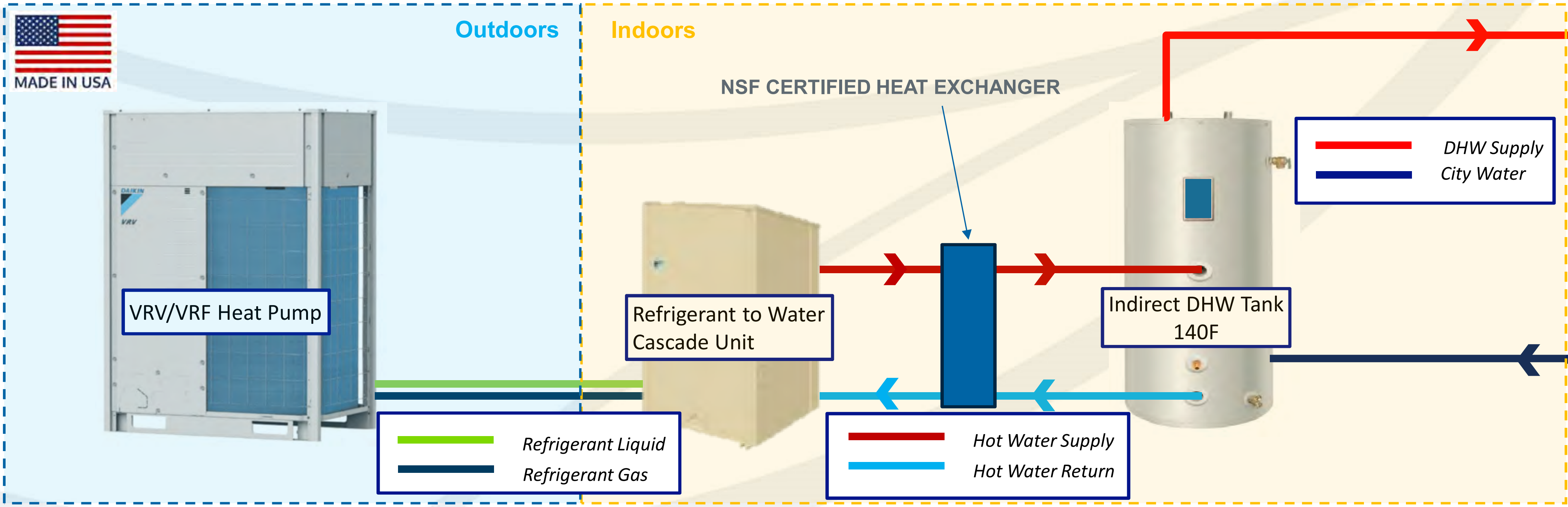
Cold climate VRV split modular domestic hot water heater



- 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

Cold climate VRV split modular domestic hot water heater

Resources

- Daikin ASHP “quick information” platform:
  - www.myVRVdrive.com
- DXS Refrigerant Transition Resource Center:
  - https://info.dxseng.com/dxs-refrigerant-transition-resource-center
- Refrigerant Transition Memo: will be sent after presentation
- Today’s presentation slides: will be sent after presentation

Questions? Fill out the form for a chance to win a drone!

Js.Rancourt@dxseng.com

Adam.Camillo@dxseng.co

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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"

Is there a point at which replacing components triggers the GWP limits for new systems?

Yes. Replacing 75% or more of the evaporators (by number) and 100 percent of the compressor racks, condensers, and connected evaporator loads of an existing system would trigger the requirements of new systems.

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

https://www.epa.gov/climate-hfcs-reduction/frequent-questions-phasedown-hydrofluorocarbons#technology-transitions-program