Manufacturer’s Roundtable

Cold Climate VRF

February 11, 2026

CEDA California Energy Design Assistance

nbi new buildings institute

WHAT IS CEDA?

CEDA

The California Energy Design Assistance (CEDA) program is the only statewide utility incentive program for new construction and major renovations.

- Promotes **electrification** and **decarbonization**
- CEDA works in collaboration with project teams to reduce energy demand, consumption, and carbon emissions.
- Serves commercial, public, high-rise multifamily, industrial, and agricultural projects in Pacific Gas & Electric (PG&E), Southern California Edison (SCE), SoCalGas (SCG), and San Diego Gas & Electric (SDG&E) service areas.

WHY PARTICIPATE IN CEDA?

CEDA

- Receive complimentary **decarbonization** analysis tailored to project goals to identify most effective measures to implement
- Gain analysis of **energy costs and paybacks**
- Receive **financial incentives** to help offset the costs of decarbonization measures
- Demonstrate commitment to high performance building practices and design

INCENTIVES

CEDA

$4,000
+
measure package incentive

- $4000 **Design team incentive** per project as a thank you for participation
- Based on the project measure package the design team chooses for implementation

HIGH PERFORMANCE MEASURES

CEDA

CEDA aims to exceed California's decarbonization standards by identifying high performance measures and providing educational opportunities to explore use cases and best practices.

This not only advances the market, but also qualifies participants for enhanced incentives through our program.

A current list of eligible high-performance measures can be found on our website here.

HAVE A PROJECT TO DISCUSS?

CEDA

For more information, please contact our program outreach specialists, visit our website, or fill out an interest form

Scan me to enroll a project

CaliforniaEDA.com

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Cold Climate VRF

In today's webinar we'll discuss:

- Exploration of current industry considerations on Cold Climate VRF
- Climate Zones and Load Considerations: Accounting for winter design temperatures
- Product Performance and Sizing
- Design and Installation Best Practices
- Case Studies: Real-world applications

Today’s Panelists

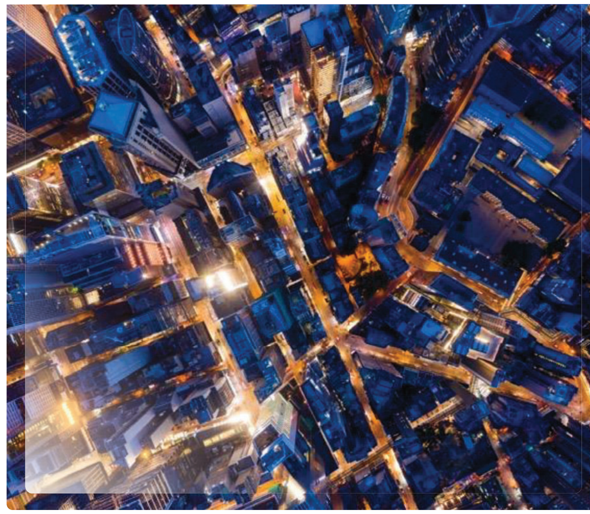
James Momperousse
Carrier

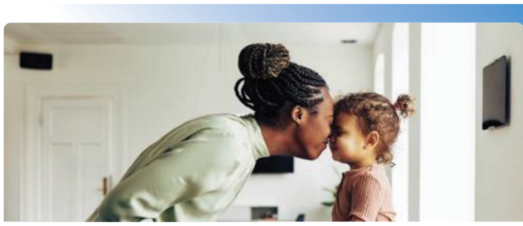
Matthew Connolly
Daikin

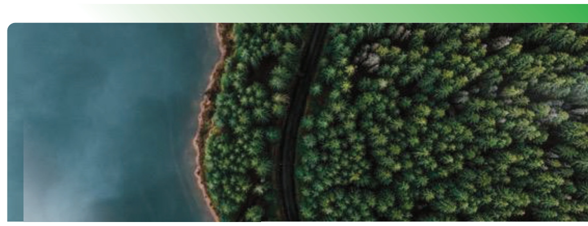
Chris Bradt
LG

Cain White
Mitsubishi

Cold Climate VRF Heat Pumps







Agenda

What is cold climate VRF

Examples / Considerations

Selection – Standard vs. High Heat

Cold Climate VRF

Examples and Considerations

Examples and Considerations – Northeast (Boston, MA)

2021 ASHRAE Handbook - Foundamentals (IP)

BOSTON LOGAN, MA, USA (WMO: 725090)

Lat:**42.361N** Long:**71.01W** Elev:**12** StdP: **14.69** Time zone:**-5.00 (NAE)** Period:**94-19** WBAN:**14739** Climate zone:**5A**

Annual Heating, Humidification, and Ventilation Design Conditions

Coldest Month	Heating DB 99.6%	Heating DB 99%	Humidification DP/MCDB and HR 99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	Coldest month WS/MCDB 0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS/PCWD to 99.6% DB MCWS	PCWD	WSF
1	7.7	12.8	-10.8	3.1	10.6	-6.3	3.9	15.9	31.8	36.6	28.3	31.0	16.0	300	0.602

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
7	14.7	90.8	73.0	87.7	71.6	84.5	70.0	76.0	86.1	74.4	83.2	72.9	80.7	13.6	240

Dehumidification DP/MCDB and HR 0.4% DP	0.4% HR	0.4% MCDB	1% DP	1% HR	1% MCDB	2% DP	2% HR	2% MCDB	Enthalpy/MCDB 0.4% Enth	0.4% MCDB	1% Enth	1% MCDB	2% Enth	2% MCDB	Extreme Max WB
72.8	121.8	80.8	71.4	116.1	79.0	70.2	111.0	77.8	39.3	86.4	37.8	83.2	36.4	80.8	80.6

Extreme Annual Design Conditions

Extreme Annual WS 1%	2.5%	5%		Extreme Annual Temperature Mean Min	Mean Max	Standard deviation Min	Standard deviation Max	n-Year Return Period Values of Extreme Temperature n=5 years Min	n=5 years Max	n=10 years Min	n=10 years Max	n=20 years Min	n=20 years Max	n=50 years Min	n=50 years Max
26.7	23.9	20.6	DB	2.2	95.7	5.0	3.0	-1.4	97.8	-4.3	99.6	-7.1	101.2	-10.7	103.4
			WB	0.3	78.4	4.5	1.5	-3.0	79.5	-5.6	80.4	-8.2	81.2	-11.4	82.3

Countries	US/Canada	State	Massachusetts	City	Boston
Custom	Load / Save / Default				

Cooling Entering Coil Condition			Heating Entering Coil Condition		
Indoor Dry Bulb	80.0	°F	Indoor Dry Bulb	70.0	°F
Indoor Wet Bulb	67.1	°F	Outdoor Dry Bulb	6.0	°F
Indoor Rel. Humidity	51.6	%	Outdoor Wet Bulb	5.1	°F
Outdoor Dry Bulb	91.0	°F	Outdoor Rel. Humidity	75.0	%
Altitude	15.0	feet			

Correction Factors		
System Capacity	1.05	0.63
Temperature	1.07	0.66
Piping Length	0.98	0.99
Altitude	1.00	1.00
Defrosting	-	0.96
Diversity	-	-
Additional Derates	1.00	1.00
Design Temperatures		
Indoor DB	80 °F	70 °F
Outdoor DB	91 °F	6 °F
Indoor WB	67.1 °F	
Outdoor WB		5.1 °F
Humidity	51.6%	75%

Correction Factors		
System Capacity	0.98	0.41
Temperature	1.00	0.43
Piping Length	0.98	0.99
Altitude	1.00	1.00
Defrosting	-	0.96
Diversity	-	-
Additional Derates	1.00	1.00
Design Temperatures		
Indoor DB	80 °F	70 °F
Outdoor DB	103.4 °F	-10.7 °F
Indoor WB	67.1 °F	
Outdoor WB		-11.4 °F
Humidity	51.6%	59.5%

<u>Design Considerations</u>

Humid Summer Conditions

For outside air (ventilation) applications additional de-humidification may needed

When bringing outside air into indoor units, consideration will be needed for final mixed air temperatures and moisture content

Cold Winter Design Temperature

Depending on manufacturer may need to operate in high heating mode or High Heating model, if available.

In extreme cases, may need to upsize the condenser for additional heating performance

For indoor unit performance, additional supplementary heating source may be required

Examples and Considerations – Mountain West (Boulder, CO)

2021 ASHRAE Handbook - Foundamentals (IP)

BOULDER, CO, USA (WMO: 720533)

Lat:**40.033N** Long:**105.217W** Elev:**5289** StdP: **12.10** Time zone:**-7.00 (NAM)** Period:**10-19** WBAN:**00160** Climate zone:**5B**

Annual Heating, Humidification, and Ventilation Design Conditions

Coldest Month	Heating DB 99.6%	Heating DB 99%	Humidification DP/MCDB and HR 99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	Coldest month WS/MCDB 0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS/PCWD to 99.6% DB MCWS	PCWD	WSF
12	4.6	9.6	-6.1	4.8	27.6	-1.8	6.1	30.6	32.3	51.5	26.3	47.4	2.1	50	0.475

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
7	25.7	94.8	59.4	90.9	59.0	89.5	59.0	64.5	78.4	63.4	78.5	62.1	77.6	6.6	60

Dehumidification DP/MCDB and HR 0.4% DP	0.4% HR	0.4% MCDB	1% DP	1% HR	1% MCDB	2% DP	2% HR	2% MCDB	Enthalpy/MCDB 0.4% Enth	0.4% MCDB	1% Enth	1% MCDB	2% Enth	2% MCDB	Extreme Max WB
61.2	98.5	66.8	59.3	91.9	66.7	57.2	85.2	67.3	32.6	77.4	31.6	77.9	30.6	77.7	71.4

Extreme Annual Design Conditions

Extreme Annual WS 1%	2.5%	5%		Extreme Annual Temperature Mean Min	Mean Max	Standard deviation Min	Standard deviation Max	n-Year Return Period Values of Extreme Temperature n=5 years Min	n=5 years Max	n=10 years Min	n=10 years Max	n=20 years Min	n=20 years Max	n=50 years Min	n=50 years Max
24.1	18.6	15.1	DB	-3.6	99.2	5.9	2.0	-7.8	100.6	-11.3	101.8	-14.6	103.0	-18.9	104.4
			WB	-3.4	67.1	6.1	1.7	-7.8	68.3	-11.4	69.3	-14.8	70.3	-19.2	71.6

Countries	US/Canada	State	Colorado	City	Boulder
Custom	Load / Save / Default				

Cooling Entering Coil Condition			Heating Entering Coil Condition		
Indoor Dry Bulb	80.0	°F	Indoor Dry Bulb	70.0	°F
Indoor Wet Bulb	67.1	°F	Outdoor Dry Bulb	2.0	°F
Indoor Rel. Humidity	53.5	%	Outdoor Wet Bulb	1.2	°F
Outdoor Dry Bulb	93.0	°F	Outdoor Rel. Humidity	75.0	%
Altitude	5445.0	feet			

Correction Factors		
System Capacity	0.95	0.53
Temperature	1.07	0.61
Piping Length	0.98	0.99
Altitude	0.90	0.90
Defrosting	-	0.96
Diversity	-	-
Additional Derates	1.00	1.00
Design Temperatures		
Indoor DB	80 °F	70 °F
Outdoor DB	93 °F	2 °F
Indoor WB	67.1 °F	
Outdoor WB		1.2 °F
Humidity	53.5%	75%

Correction Factors		
System Capacity	0.88	0.27
Temperature	0.99	0.32
Piping Length	0.98	0.99
Altitude	0.90	0.90
Defrosting	-	0.96
Diversity	-	-
Additional Derates	1.00	1.00
Design Temperatures		
Indoor DB	80 °F	70 °F
Outdoor DB	104.4 °F	-18.9 °F
Indoor WB	67.1 °F	
Outdoor WB		-19.2 °F
Humidity	53.5%	77%

<u>Design Considerations</u>

Elevation Derated Performance / Dry Winter and Summer Conditions

Condenser performance may be slightly derated due to elevation. Allow for additional margin when sizing condensing units

Indoor unit sensible performance may not be high enough for indoor spaces, where applicable upsizing indoor units may be needed.

Cold Winter Design Temperature

Depending on manufacturer may need to operate in high heating mode, if available.

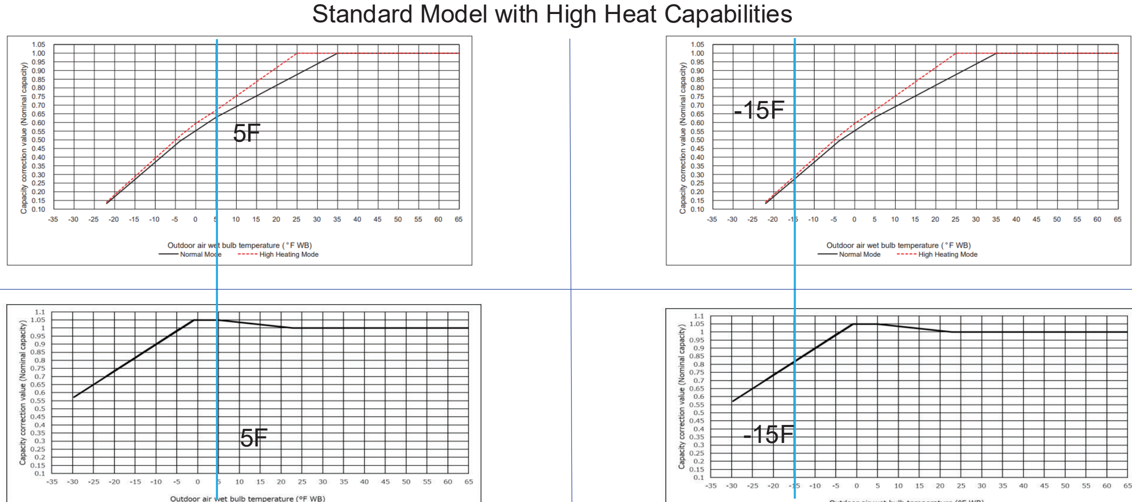
In extreme cases, may need to upsize the condenser for additional heating performance

For indoor unit performance, an additional supplementary heating source *may* be added

Selection

Selection – Standard Model vs. High Heat Model

Standard Model with High Heat Capabilities



High Heat Model

Proprietary and Confidential

Indoor air dry bulb temperature vs. capacity correction value

Selection – Additional Considerations

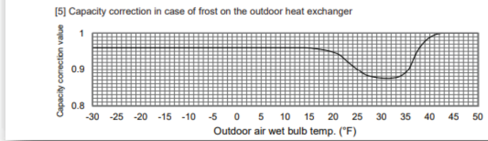
Winter Design Conditions

Defrost Operation

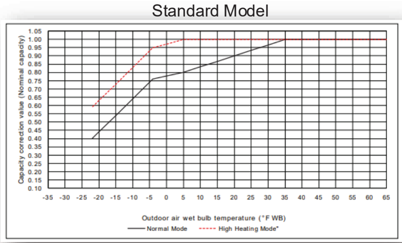
Elevation

Defrost

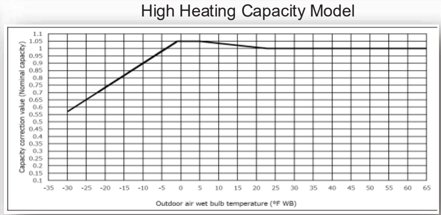
2-3-3. Capacity correction in case of frost on the outdoor heat exchanger when in heating
Correct the heating capacity when frost can be found on the outdoor heat exchanger.
Heating capacity = Capacity after correction of outdoor unit x Correction value of capacity resulted from frost
(Capacity after correction of outdoor unit: Heating capacity calculated in the above item 2.)



Standard Model



High Heating Capacity Model



Basic Info

Indoor Units	13 / 1 to 46
Capacity	266 / 132 to 356.4(100.7%)
Total Pipe Length	216 / 3937 feet
Furthest Actual	53 / 623 feet
Furthest Equiv.	53 / 771 feet
After 1st Branch Actual	40 / 295 feet
After 1st Branch Equiv.	40 / 295 feet
Max Height Between IDU/IDU	0 / 131 feet
Max Height Between IDU/ODU (Above)	0 / 230 feet
Max Height Between IDU/ODU (Below)	0 / 131 feet

Correction Factors

System Capacity	0.98	0.90
Temperature	1.00	0.95
Piping Length	0.98	0.99
Altitude	1.00	1.00
Defrosting	-	0.96
Diversity	-	-
Additional Derates	1.00	1.00

Design Temperatures

Indoor DB	80 °F	70 °F
Outdoor DB	83 °F	41 °F
Indoor WB	67.1 °F	
Outdoor WB		37.8 °F
Humidity	51.6%	75%

Additional Refrigerant	28.54 lb
Total Refrigerant Amount	61.54 lb
Min Allowable Room Volume(cuft)	2366.81

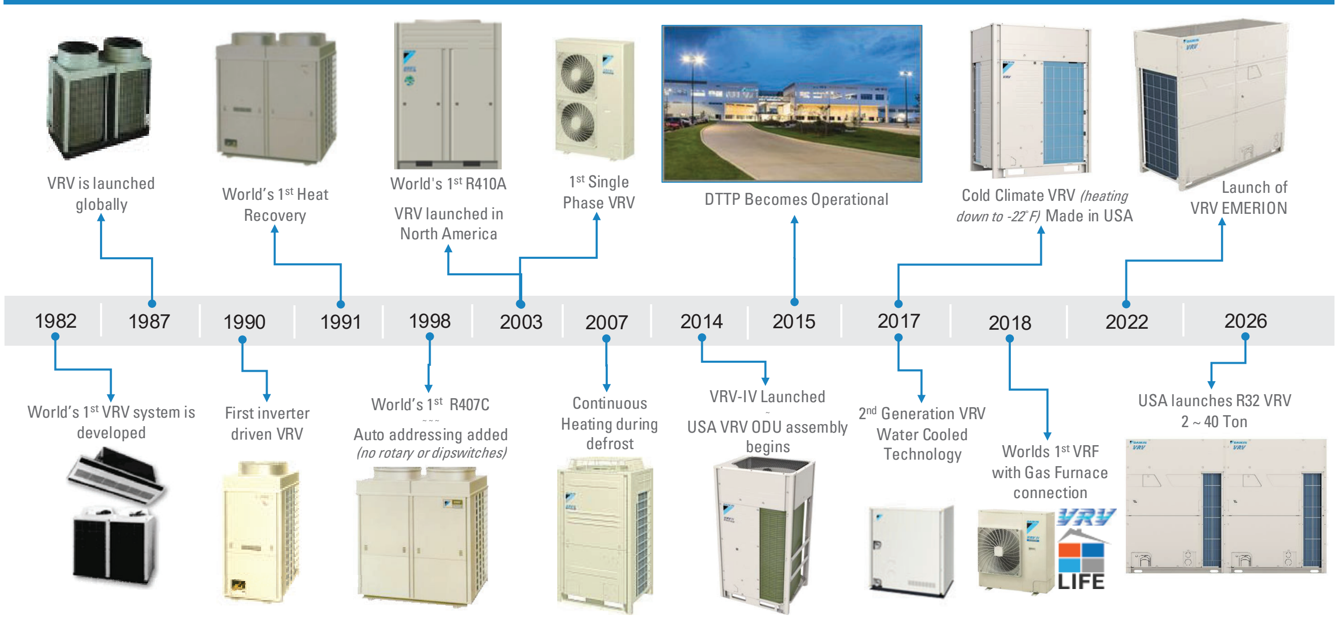
Altitude	1.00	1.00

Thank you

Contact Information: James Momperousse
Carrier Energy & Utilities Sales Manager

History of VRV Development

VRF concept formed from energy crisis of 1970's ~ Global adoption of technology thru 1990's ~ Firmly established in North America



VRV Overview

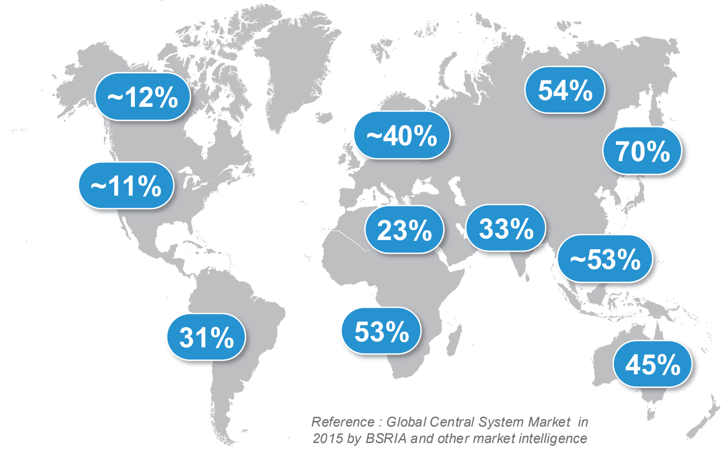
Variable *System capacity varies with load*

Refrigerant *R-32 Direct Expansion System*

Volume *Refrigerant Volume regulated by EEVs & variable speed compressors*

VRV = Daikin Registered trademark
VRF = Industry term

- **Introduced by Daikin in 1982**
  Worlds first VRF system
- VRF technology is 40% of the global commercial HVAC market share
- VRF introduced to North America in the early 2000's



Reference : Global Central System Market in 2015 by BSRIA and other market intelligence

Product & Technology

VRV has three core features:

MODULAR DESIGN
Ease of installation

ULTRA-HIGH ENERGY EFFICIENCIES

EXCEPTIONAL COMFORT CONTROL

Modular Design

- VRV technology is not restricted by project size
- VRV can (and is) put into projects from 2 ton to comfortably over 1000 ton
- Largest project (and growing) is a 12K ton business park in India
- Modular design means that the rules that apply to the smallest job are the same as large commercial applications
- The only restriction to an installer taking on these sites is time and labor

Building Size (Tons):	<50	<100	<250	<500	<1000	>1000
VRV	●	●	●	●	●	●
PTAC	●	●				
SPLIT SYSTEM	●	●				
CV RTU	●	●				
VAV ROOFTOP		●	●			
AIR COOLED CHILLER		●	●	●		
WATER COOLED CHILLER				●	●	●
CENTRAL AHU	●	●	●			
CUSTOM AHU				●	●	●
FAN COIL		●	●			
UNIT VENTILATOR	●	●	●			

Energy Efficiencies – Heat Transfer Media

A Key attribute of direct expansion systems is their Energy efficiency

Medium	Heat Quantity* ** At Equivalent Design /Operation Conditions*	Demand Side Delivery Method	Power Input *(38-Ton of demand side load)*	Size of Pipe/Duct	Application Considerations
Water	9.4Btu/lb q = 4,18 kJ/kgK / dt = 5 K	Pump & Coil/ Fan Unit	4.7 kW	2 x 3.5”	▪ Corrosion ▪ Pump power ▪ Water leakage ▪ EER/COP of heat source
Air	4.5Btu/lb q = 1,0 kJ/kgK / dt = 10 K	Duct work & Fan	7.4 kW	36”	▪ Sound levels ▪ Fan power ▪ Space for ducting ▪ Fire protection
Refrigerant	91.6Btu/lb Evaporating at 32°F	Coil/Fan Unit	2.5 kW	1 ⅝” + ¾”	▪ Piping & vertical limitations ▪ Capacity correction due to pressure drop ▪ RCL guidelines

Using refrigerant as the direct means of heat transfer is extremely efficient

Air Cooled or Water Cooled?

Internal Plate
Heat Exchanger

Air to air *VRV* systems make up the majority of *VRV* installations

This is due to the following:

- Ease of installation (no water system required)
- Less initial capital costs

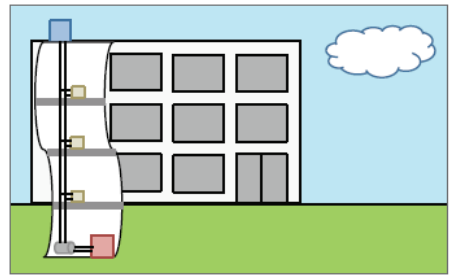
However Water-Cooled *VRV* can have certain advantages:

- Greater energy efficiencies
- Localized CU installation (reduced pipe runs)

These advantages come in to play when the following are present:

- An existing chilled water loop
- Extreme ambient conditions
- An ability & desire to utilize a
- local geothermal source

Water-Cooled *VRV* - Existing Water Loop



Boiler ~ Tower Water Loop

By utilizing an existing water loop in the building, the advantages of greater energy efficiency can be promoted without having to offset capital costs

In addition, *VRV* Water-Cooled Series CUs are usually located locally to the area they are serving and will typically attach to the water loop already running through the building

This negates the need to run copper piping through risers to a remote plant space (be aware that *VRV* Water-Cooled Series CUs are internal mounting units)

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VRV in Cold Climates

- VRV Technology has pushed the limits on the use of Air-Source DX Heat Pump in colder climates
- Further improvement of capacity and temperature range, is now moving the boundaries still further

“Sub-Arctic” Conditions

AURORA **VRV** (With or w/o secondary heat*)

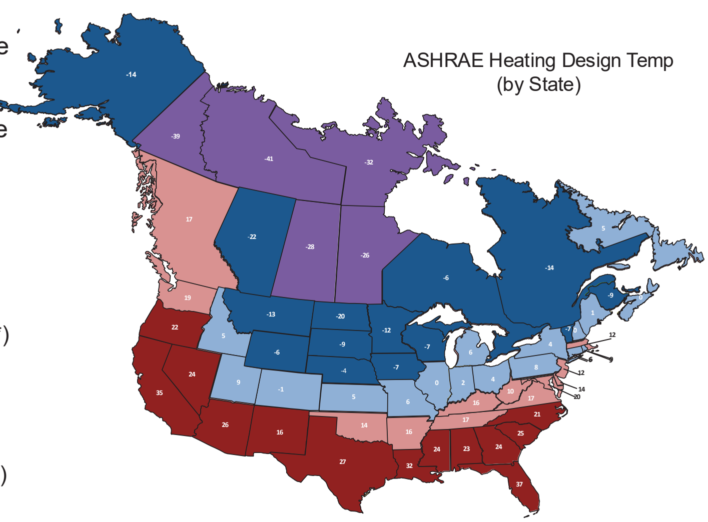
AURORA **VRV** (100% Heating Capacity**)**

Standard VRV (With or w/o secondary heat*)

Standard VRV (100% Capacity)

* Ultimately depends on the Designer

ASHRAE Heating Design Temp
(by State)



Note: These temperature values represent dry-bulb temperatures corresponding to 99.6% annual cumulative frequency of occurrence (cold conditions) and are from the ASHRAE 2017 Handbook

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Design Methods

Levels of System Design:

PEAK LOAD

The ODU is sized to achieve the combined peak (maximum) demand of every unit on the system

- This will often reduce the outdoor unit size compared to above and still guarantee ZERO DIVERSITY on the system
- The connection ratio will usually exceed 100%
- Selecting over 100% connection ratio but still providing the peak load demands is typical for:
  - Design & Build projects
  - Cold Climate projects where heating demand takes priority

Name	FCU	Tmp C [°F]	Rq TC [BTU/h]	Max TC [BTU/h]
ODU	REYA240AATJA	95.0		
BS 1	BSF8A54AAVJ			
A				
IDU 1	FXFA30AAVJU	75.0/63.0	24150	26471
B				
IDU 2	FXFA30AAVJU	75.0/63.0	21960	26484
C				
IDU 3	FXFA30AAVJU	75.0/63.0	21960	26484
D				
IDU 4	FXFA30AAVJU	75.0/63.0	23150	26484
E				
IDU 5	FXFA30AAVJU	75.0/63.0	25700	26484
F				
IDU 6	FXFA30AAVJU	75.0/63.0	23500	26484
G				
IDU 7	FXFA30AAVJU	75.0/63.0	23500	26484
H				
IDU 8	FXFA30AAVJU	75.0/63.0	25250	26484

SUM OF REQUIRED PEAK LOADS

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Correct Sizing

- The design of heat pump system should optimize the performance of the system during all conditions including part load conditions as well as full load
- Therefore, the Minimum capacity output is just as important as the Maximum and the key is to find the performance range that provides enough capacity at low outdoor ambient temperatures, without sacrificing performance the rest of the year

Undersized

Unable to reach temperature (discomfort)

Reduced Efficiency

Excessive defrost and overwork of the system

Sized Correctly

Correct load calculation and proper design ensures the best performance

Oversized

Overheating and temp swings in cooling

Poor dehumidification in cooling

Reduced Efficiency

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Refrigerant & Oil Management

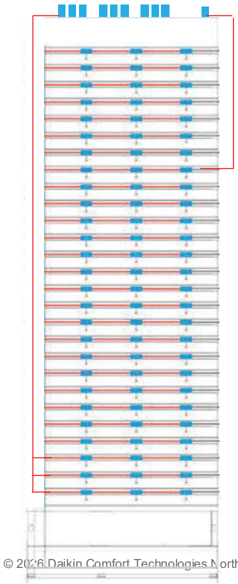
Why are there piping limits?

The main reasons for piping limitations are for proper refrigerant management and effective oil return

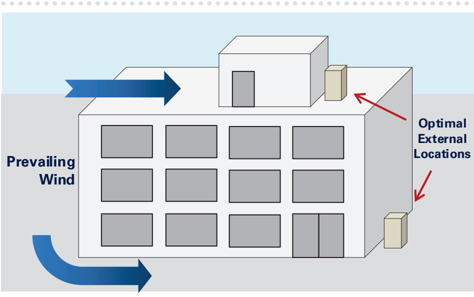
Correct pipe application ensures:

- Proper refrigerant feed to evaporators
- Practical sizes without excessive pressure drop
- Prevent excessive oil trapping
- Protect compressor from loss of oil
- Prevent liquid and oil slugs from entering the compressor

- **There is a heavy focus on oil management.** In addition to large compressor sumps and oil separators, VRF systems have a built-in oil recovery cycle
- This typically involves fully opening all expansion valves and running the compressor at full speed to "flush" the oil back to the compressor



Outdoor Unit Location



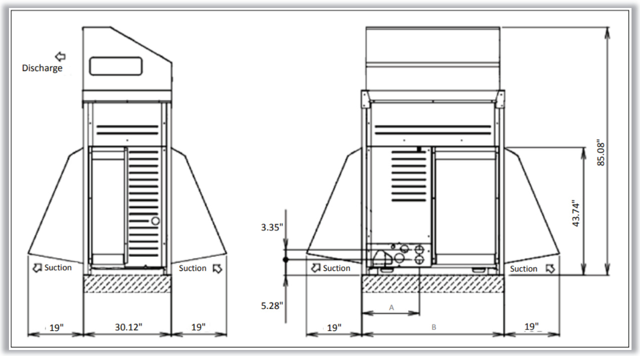
Cold Climates

- ODU location is an important factor to help optimize capacity and efficiency of a VRV system
- Wind can have an adverse effect on the performance of an outdoor unit: most notably, fan performance
- On days of extreme ambient conditions, this is particularly important to help mitigate stress and even the possibility of compressor failure on days of extreme ambient conditions
- Wherever possible, locate the ODU in a location sheltered from the prevailing wind
- If an ODU is exposed to prevailing winds, baffle plates or snow hoods are strongly recommended

NOTE: In multiple ODU groupings, it may not be necessary to install a snow hood over every exposed heat exchanger

Duct Requirements for Low Ambient Cooling

- When a project demands for cooling in ambient conditions below 23°F (also known as Low Ambeint Cooling), protection of the outdoor units is mandatory
- Snow hoods are an effective measure but not the only solution
- As with all exhaust duct applications, one duct per fan is required

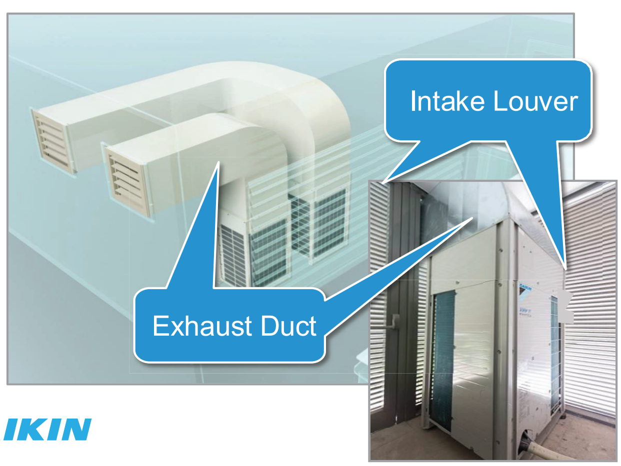


ODU Installation Flexibility

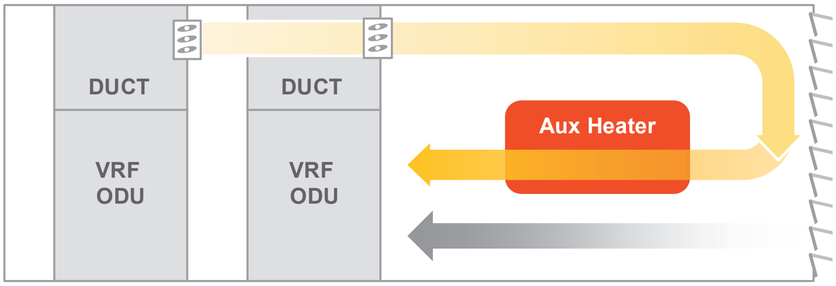
- ❑ Internal/Restricted installs possible
- ❑ Noise, sight or location issues mitigated

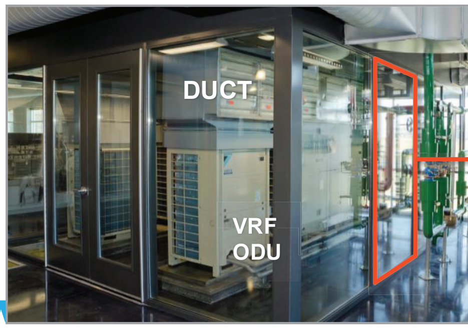
There are 4 criteria to overcome:

- AIR STARVATION
- SHORT CIRCUITING
- SERVICE SPACE
- MAX. 0.32WG ESP

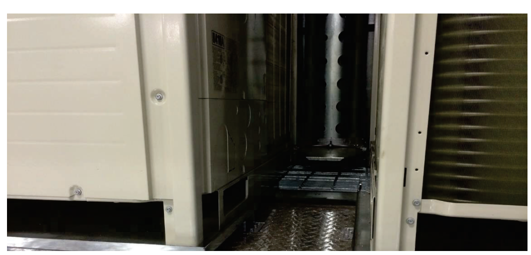


Ventilated Mechanical Room





Mechanical Enclosure - Inside



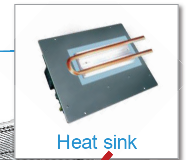
Defrost Cycle (Single Module)

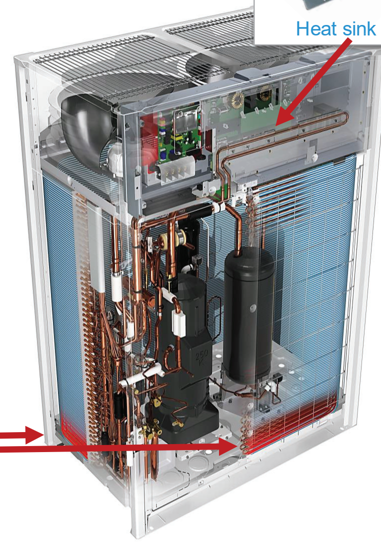
Optimum Performance in Defrost Cycle

- Ice can accumulate in the drain pan when operating a heat pump in a cold climate
- A common countermeasure for this is to add a drain pan heater
- However, this adds cost and reduces efficiency
- HR ODU's have a hot gas circuit which functions as a drain pan heater to mitigate the build up of ice on the heat exchanger

Hot Gas Circuit performs two functions:

- As an equivalent to a drain pan heater
- A heat sink to keep the inverter PCB at a stable temperature





Multiple ODU Module System Features

Optimum Performance in Defrost Cycle

There are several issues with the need for a defrost cycle:

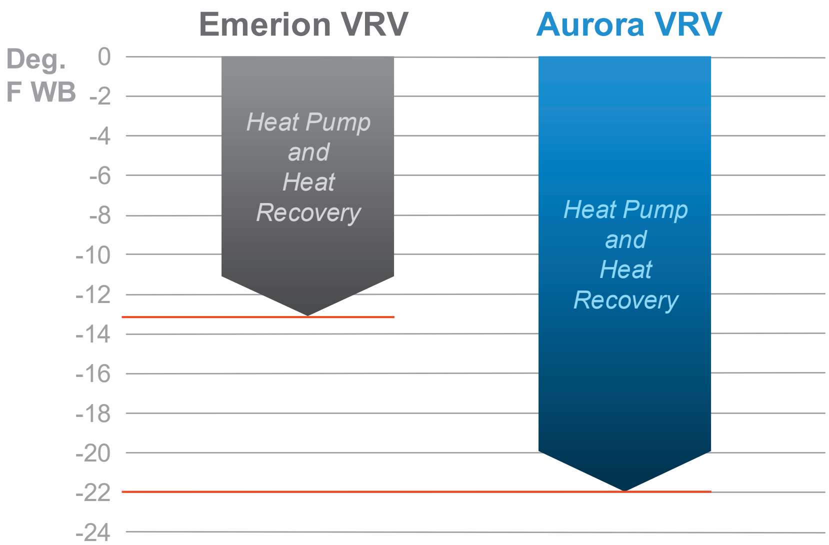
- Performance drop off
- Reduced efficiency
- Cold Drafts

Continuous heating mode during defrost ensures:

COMFORT	No more cold drafts
EFFICIENCY	No energy demand to reheat the piping and indoor coil (up to 8% savings)

NOTE: Applies to 16~20-ton single modules as well as multi modules

Continuous Operational Range



- ***Emerion VRV*** operates continuously down to **-13°F** and down to **-22°F** as standard
- The ***Daikin Aurora*** system will provide <u>continuous</u> operation in heating down to **-22°F**

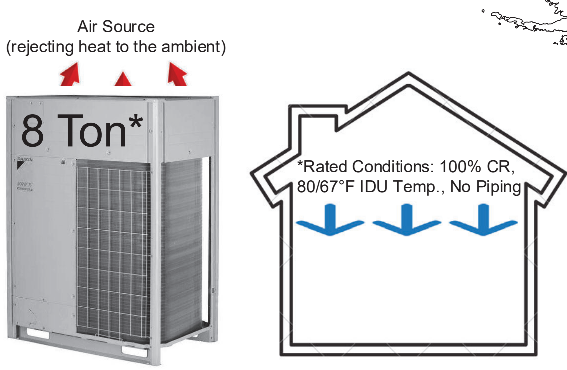
NOTE: Neither system type operates a "hard-stop" at these ambient limits

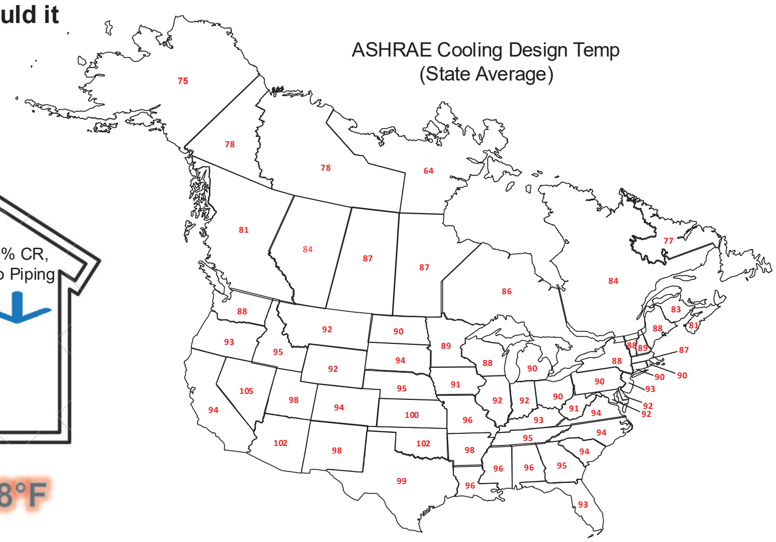
They will continue to run until head pressure safety cut out

Auxiliary Heat - Why

VRV Cooling… What kind of temperatures would it take outside to lose 20% capacity?

…118°F





No State's Average is > 118°F

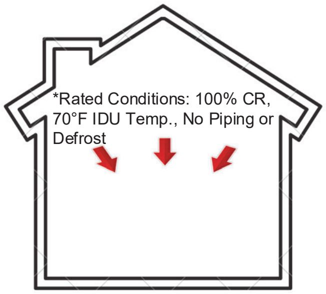
Note: These temperature values represent dry-bulb temperatures corresponding to 0.4% annual cumulative frequency of occurrence (hot conditions) and are from the ASHRAE 2017 Handbook

Auxiliary Heat - Why

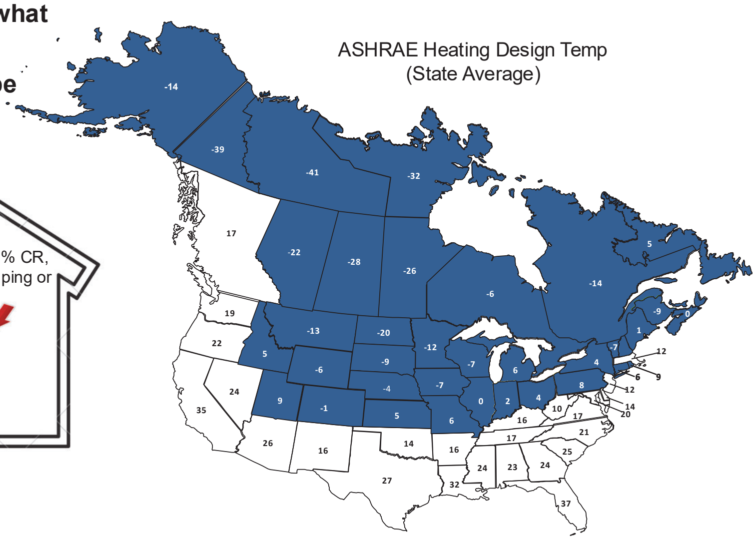
VRV Heating = Anybody want to take a guess what temperature I'm at for 80% capacity?

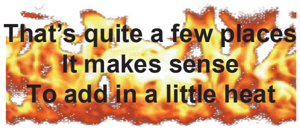
That would be 9°F

Air Source
(absorbing heat from the ambient)



ASHRAE Heating Design Temp
(State Average)





Note: These temperature values represent dry-bulb temperatures corresponding to 99.6% annual cumulative frequency of occurrence (cold conditions) and are from the ASHRAE 2017 Handbook

Aurora VRV Performance

High heating capacity

The AURORA product has been developed to provide solutions to the coldest and warmest regions of North America

Up to **100%** of nominal **@ 0°F** (-18°C)

Up to **85%** of nominal **@ -13°F** (-25°C)

Up to **60%** of nominal **@ -22°F** (-30°C)

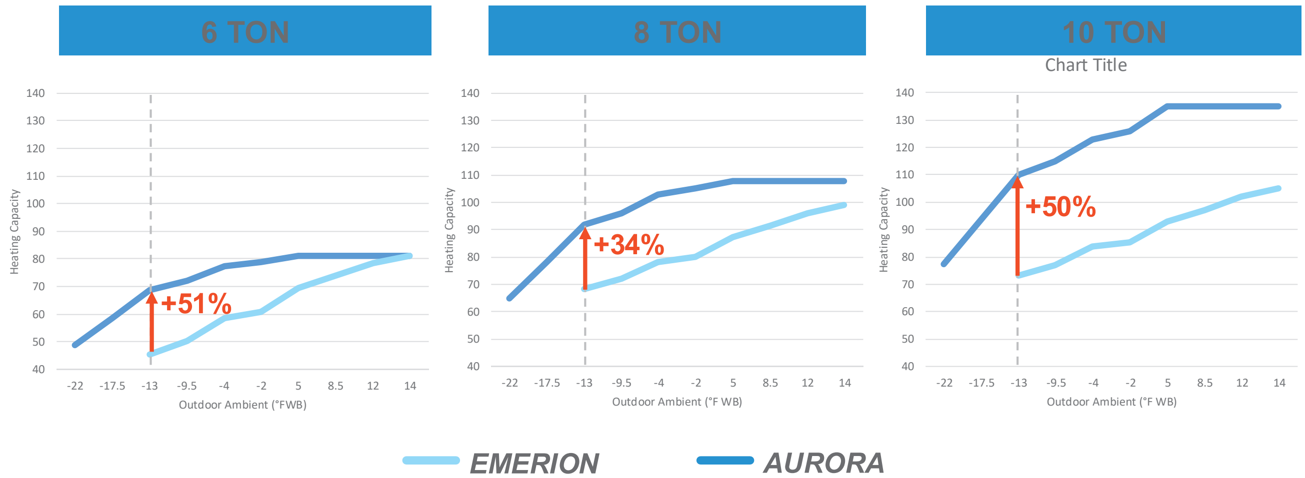
Heating down to -22°F (-30°C) as standard

Cooling up to 122°F (50°C) as standard

Cooling down to -4°F (-20°C) extended

Performance

Aurora VRV technology allows for greater heating performance



Outdoor Unit capacities at 100% Connection Ratio & 70°F DB

AIR INTELLIGENCE™

Better Life for All

For the Planet

Carbon Neutrality
Pursuing carbon neutrality and use of renewable energy

Circularity
Building a circular economy with recycling of waste

Clean Technology
Developing products/services considering the environment

For People

Decent Workplace
Strengthening supply chain ESG risk management

Diversity & Inclusion
Organizations that grows with a foundation of diversity

Design For All
Developing products/services that are convenient for all

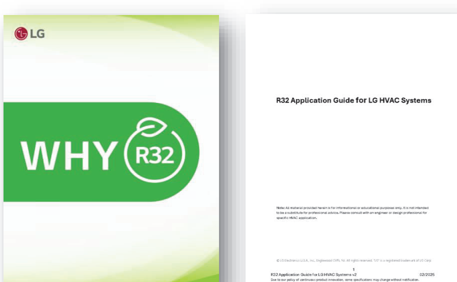

LG
AMERICA'S MOST
RELIABLE
LINE OF APPLIANCES*
LG is a leading proponent of America's electrification movement.
We are proud to offer an incredible portfolio of home electrification products from air-to-air & air-to-water heat pumps and water heaters to heat pump dryers and the first ENERGY STAR certified induction cooktops.
LG Air Conditioning Technologies
*According to a 2023 leading consumer testing organization
Life's Good.


LG
Building Solutions
Hospitality
Commercial Real Estate
Residential/ Multifamily
Retail
Industrial
Healthcare
Cruise
Green Energy
Stadium
Airport
Life's Good.

Innovating with low GWP products

R32 Transition: Air-to-Air Systems

- LG has been using R32 in Europe & Asia
  - Built on existing platforms
  - Lower total lifecycle emissions
  - No PFAs
- Product is available
  - Residential equipment here & ready
  - Larger VRF equipment on schedule



Next horizons

- R32 Scroll Chillers
  - Since 2022 in US market
- Hydronic & Hybrid Systems
  - Spring 2026: hydronic fan coils
- R513A for next generation HPWH
  - Planned for US HPWH step down
- R290 AWHP (in market in Europe)
  - Engaging on US demos & code

R290 Outdoor & Hydro Combi Units

- ✓ All-in-one Combi Unit with integrated hot water cylinder
- ✓ Saves space with a small footprint
- ✓ Installation time reduced with pre-installed components

What's a heat pump?

Heat Pump
Single Phase

SINGLE

MULTI F

MULTI F MAX

Cold climate: LGRED°

Heat Pump & Heat Recovery
(1) Phase & (3) Phase

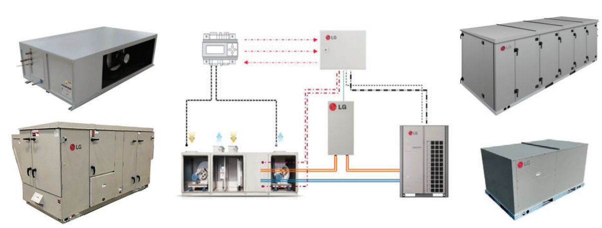
MULTI V S

Cold climate: LGRED°

LG Inverter Compressor Technology

High Efficiency VRF & Splits

Direct Outside Air Supply & Rooftop Units



Integrated System Controls

Air Cooled Inverter Scroll Heat Pump Chiller

VRF Systems

Water Source System

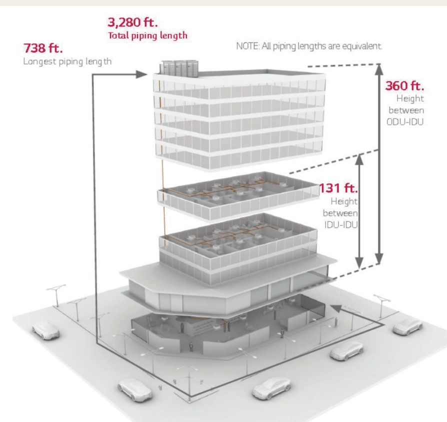
Multi V Water 5
(6~48 Tons)
208/230-3-60
460-3-60

Air Source System

Multi-V i
(6~44 Tons)
208/230-3-60
460-3-60

Multi-V S
(2~8 Tons)
208/230-1-60
6 & 8 tons @ 460-3-60

Oh, the Places You Can Go with VRF



- ❖ Capacities 2-44Tons; Heating -22-61°F WB; Cooling 5-122°F DB; Simultaneous Operation 14-81°F DB
- ❖ Quiet indoor unit operation down to 23 dB(A)
- ❖ Flexible piping layout reduces materials & labor
- ❖ Use Hydro Kit for DHW or process water heating
- ❖ Optimize for electrical service & utility costs
- ❖ System control & building energy management systems

VRF Indoor Options

Ductless


1-way Cassette


Art Cool Mirror


4-way Cassette


Art Cool Gallery


2-Way Cassette

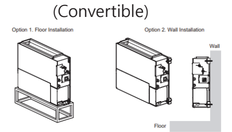

Floor Standing
(with & without case)

Ducted


Multi-Position Air Handler Unit


Low Static Ducted

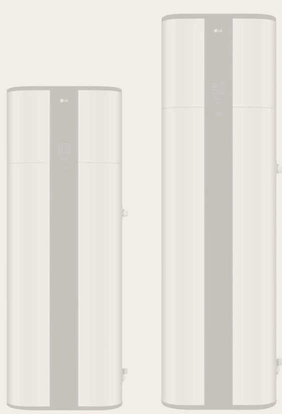

Mid Static Ducted
(Convertible)




High Static Ducted

Hot Water Solutions

Inverter Heat Pump Water Heater

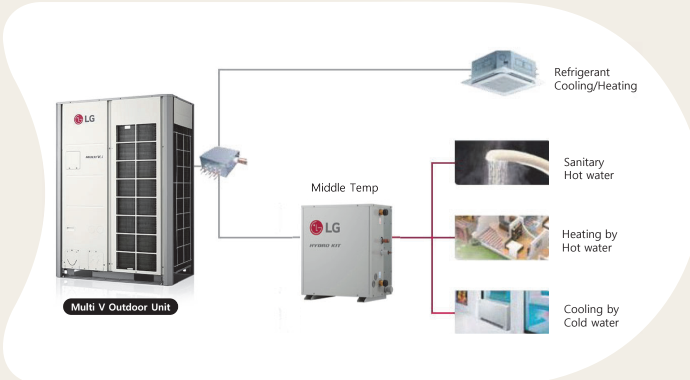


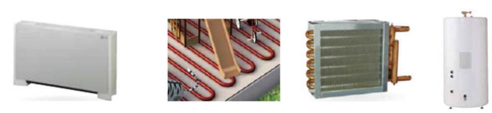
Air-to-Water Heat Pump (AWHP)

Hydro Kit

Hydro Kit
What is a Hydro Kit?

Hydro Kit: hot or chilled water
- Used with Multi V™ systems
- Contains a refrigerant-to-water heat exchanger
- Recovers waste heat when used with heat recovery systems
- Flexible applications
  - Domestic Hot Water
  - Boiler Pre-Heat
  - Radiant Floor Heating
  - Preheat/Reheat Applications





Life's Good.

Hydro Kit Overview

Hydro Kit comes in two types

	Mid-Temperature K2 Chassis		High Temperature K3 Chassis	
	ARNH423K2A4	ARNH963K2A4	ARNH423K3A4	ARNH763K3A4
Hot Water Out	**122°F**	**122°F**	**176°F**	**176°F**
Cold Water Out	41°F	41°F	N/A	N/A
Cooling Capacity	42,100 Btu/h	107,500 Btu/h	N/A	N/A
Heating Capacity	47,200 Btu/h	95,900 Btu/h	47,000 Btu/h	86,000 Btu/h
Range of Flow (GPM)	5.3 – 10.4	8 – 24.3	5.2 – 10.6	5.3 – 19
Product Size (W x H x D)	20-5/8 x 24-7/8 x 13-1/8 in.		20-5/8 x 42-1/2 x 13-1/8 in.	
ODU Combination	Multi V™ i, Multi V Water 5®, Multi V S®			

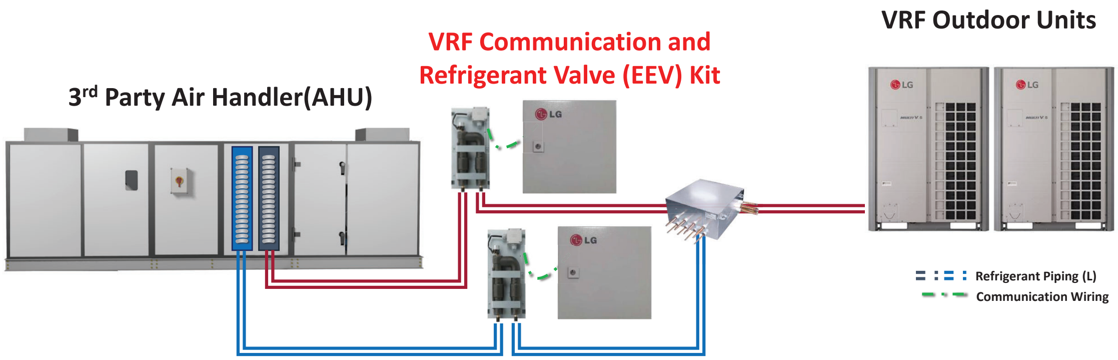
K2

K3

Life's Good.

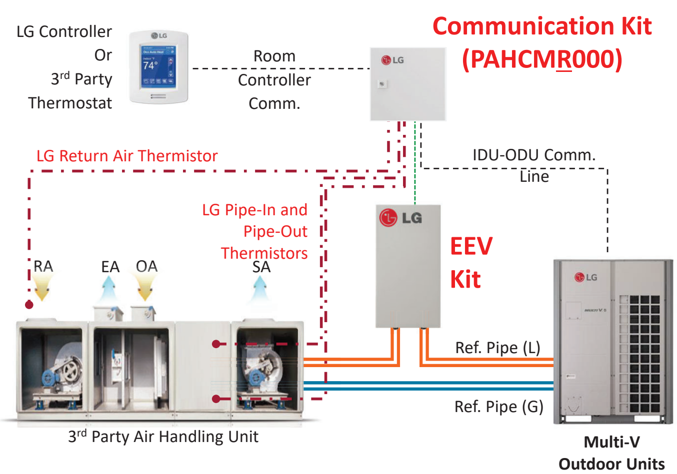
What is the LG VRF AHU Kit?

LG AHU Kits allow any fan coil or air handler to work with LG VRF systems.



LG AHU KIT | Return Air Control- PAHCMR000

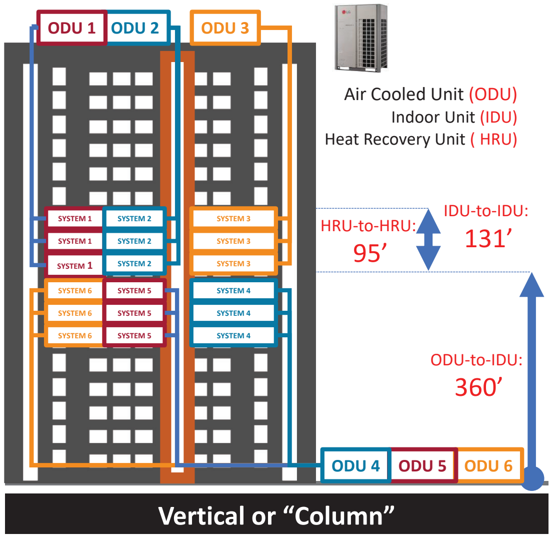
Return Air Control operates like a standard VRF indoor unit and is compatible with heat recovery systems.

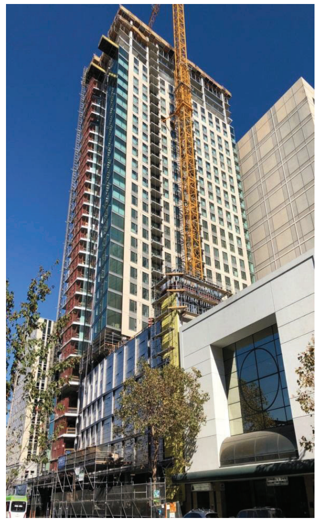


Medical Office Building

Livingston, California

Options for System Layout on High Rise





Multi-Family Residential

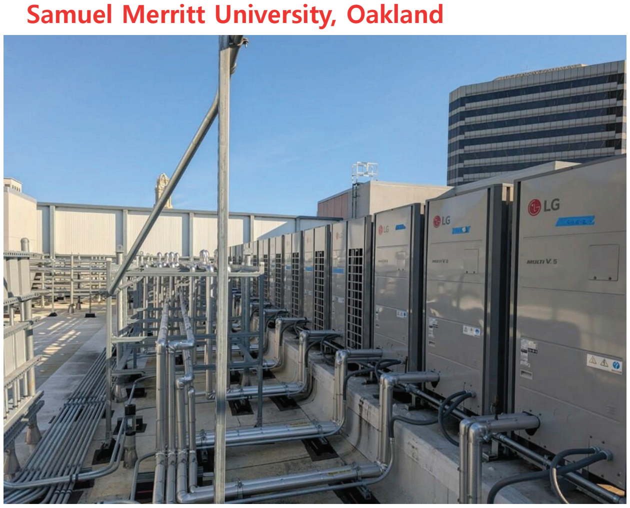
Oakland, California

Outdoor Unit	Indoor Units	Controls
MV-IV HR (604 Tons)	Ducted x (356)	Dry-Contact 3rd Party Thermostat

- 34-story tower with 354 apartment units.
- **Vertical or “Column” Layout**
  - VRF systems feeding multiple floors.
  - Can reduce over-all piping with short floor-to-floor runs.
  - Multiple piping risers throughout building.
  - More complicated to design, commission, service, and retrofit as multiple floors are linked together.

DMG in California

Samuel Merritt University, Oakland



Client ACCO

Year 2025

Hydro Kit Application Lessons from Klima NY

TECHNOLOGY	APPLICATION BENEFITS	INSTALLATION NOTES
Medium Temp Hydro Kit Chilled water to 41F and hot water to 122F. 3.5 & 8 ton capacities.	Modular design and flexible piping enable clients to replace small to medium sized chillers without having to touch existing chilled water air handlers.	For individual occupancies (including multifamily), using the 42K Hydro Kit systems can allow the condensing unit and Hydro Kit to be fed from each tenant's own power meter.
High Temp Hydro Kit Heating-only with leaving water temperatures to 176F. 3.5 & 6.5 ton capacities.	176F leaving water temp is close to the typical 180F target of hydronic boiler systems. Indoor Hydro Kit has smaller footprint and service space requirements compared to a traditional boiler.	For larger applications, multiple Hydro Kits can be installed in parallel and staged to maximize efficiency. Having multiple systems offers some additional level of redundancy over larger central plants.

Based on projects with Klima New York. More information at:
https://www.klimany.com/post/lg-hydro-kit-understanding-its-benefits-and-purpose

Klima in NY

326 Rockaway Ave

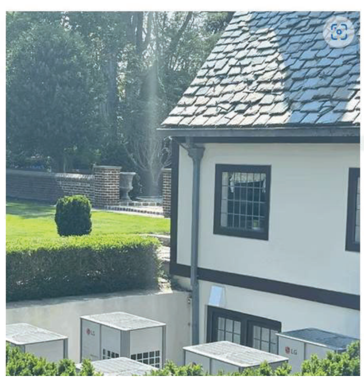
CLIENT
N/A

LOCATION
Brooklyn NY

YEAR
2025

PROJECT SCOPE

- Air Source Heat Pump Domestic Hot Water Solution
- 960,000 BTUs of Domestic Hot Water Application Utilizing LG High-Temperature Hydro Kits
- Reverse Indirect Domestic Hot Water Arrangement With Turbo Max Heat Exchangers and Thermal Storage Tanks



Gold Coast Mansion

CLIENT
Thermal Solutions

LOCATION
Long Island, NY

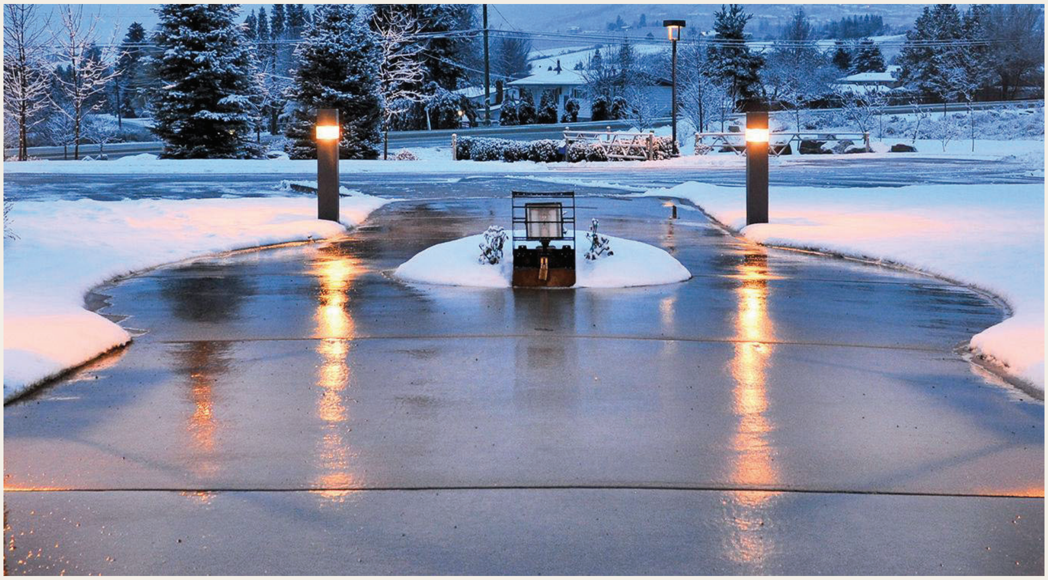
YEAR
2025

PROJECT SCOPE

- 60 tons of LG VRF
  Radiant heating, hydrokits, ERVs & more
  Seamless control via mobile interface

https://www.klimany.com/projectprofiles

Commercial Snow Melting



Thank you!

Andrew Shutt
Regional Sales Engineer
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Andrew.Shutt@LGE.com

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Utility Sales & Market Transformation
305-804-2536
Christopher.Bradt@LGE.com

LG

Thank you

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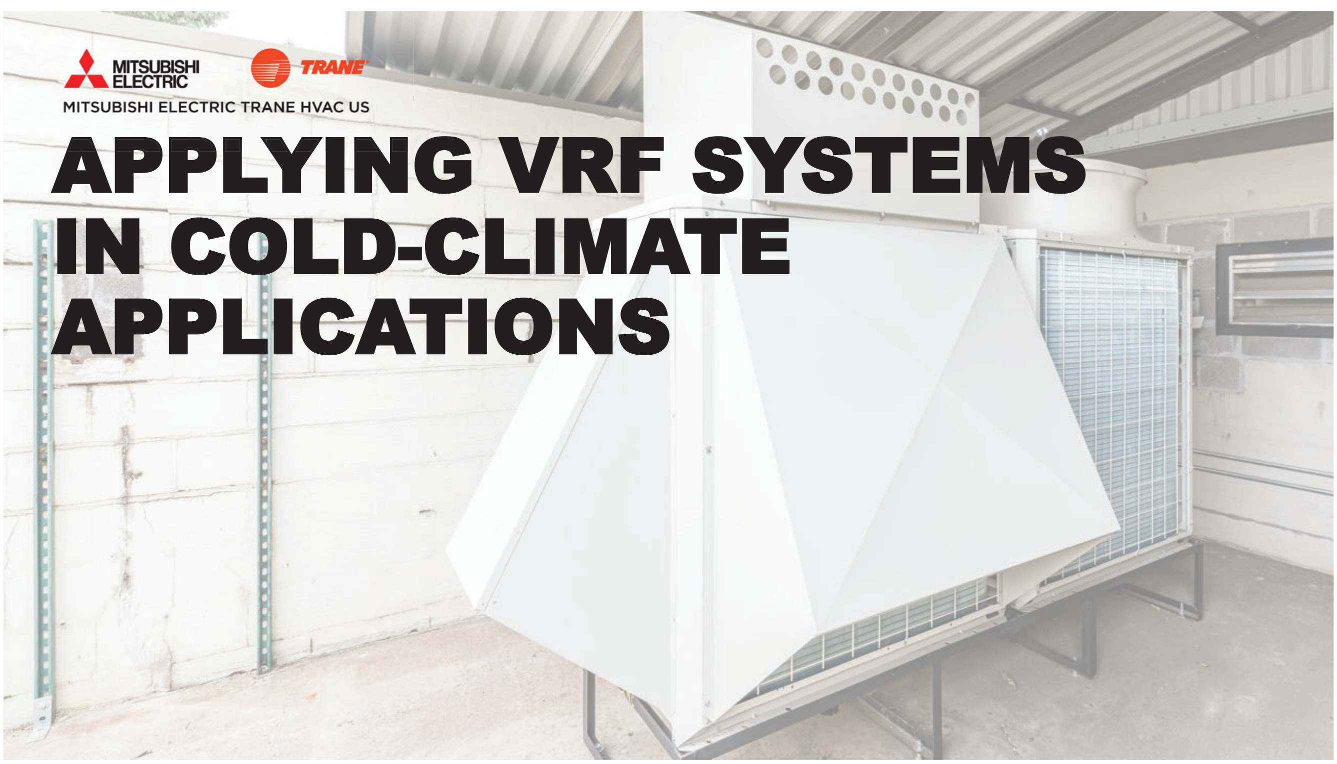
MITSUBISHI ELECTRIC TRANE

MITSUBISHI ELECTRIC TRANE HVAC US

APPLYING VRF SYSTEMS IN COLD-CLIMATE APPLICATIONS



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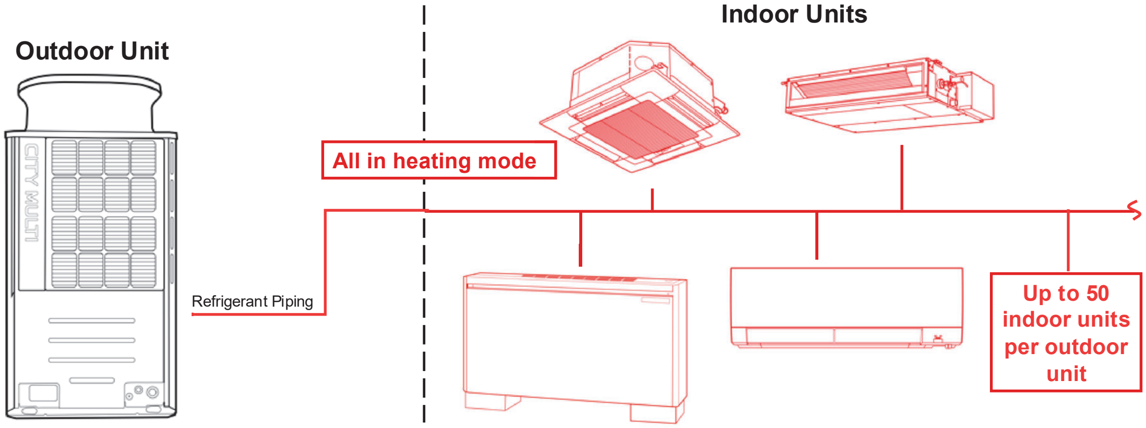
Heat Pump: Heating Mode



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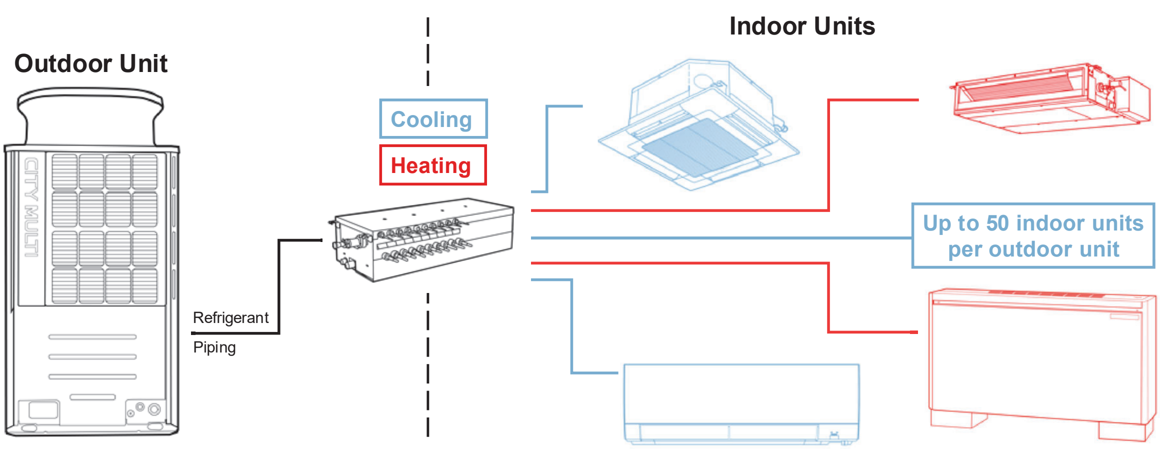
Heat Recovery - Simultaneous Heating and Cooling

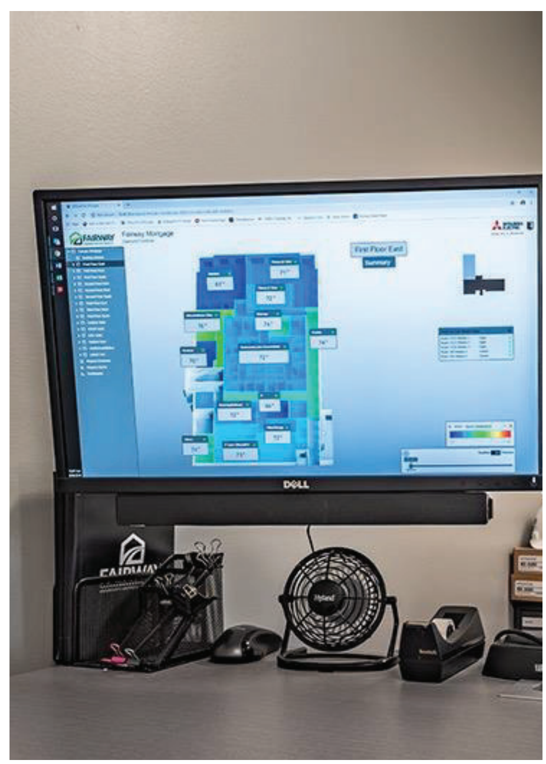


Variety of Indoor Unit Options

- Ducted
- Ductless
- Combination

VRF Controls and Third-party Equipment

- Can integrate with non-proprietary platforms
- Can integrate with third-party building automation systems through standard protocols
- Can manage complementary HVAC equipment including ventilation equipment, chillers and auxiliary heating systems
- Centralized control and insight for facility managers

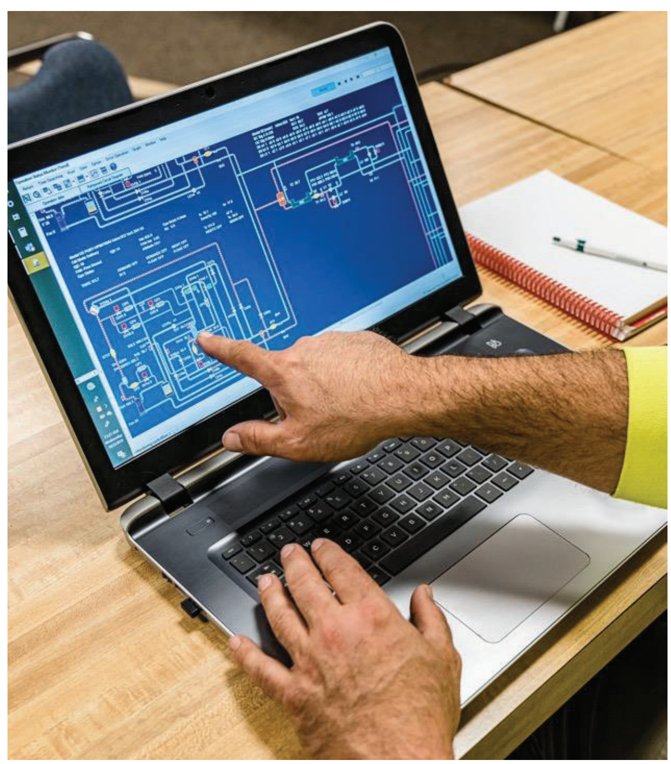


DESIGN CONSIDERATIONS FOR LOW-AMBIENT HEATING

MITSUBISHI ELECTRIC TRANE HVAC US

Design Objectives

- Reliable comfort
- Resiliency
- Energy Efficiency



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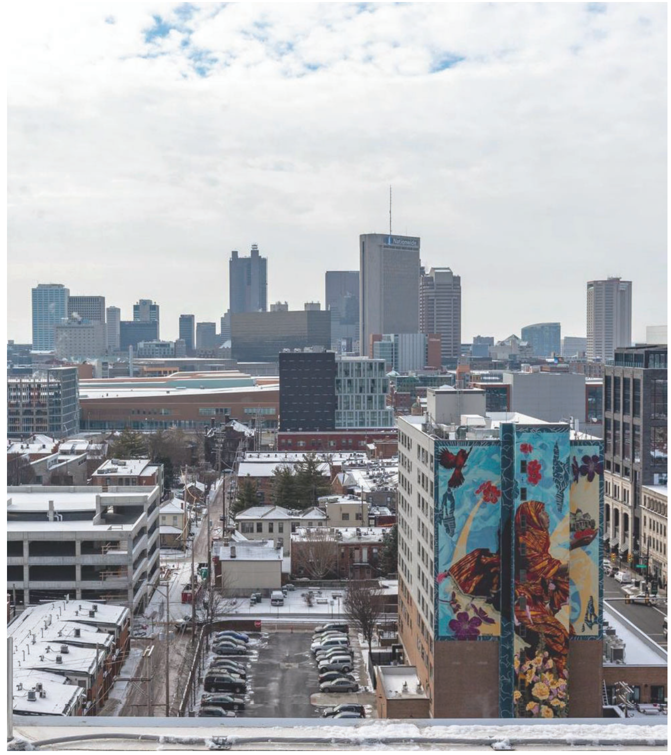
4 Options for Solving Derating Challenges

1. Flash-injection technology
2. Auxiliary heat
3. Install outdoor units inside
4. Water-source VRF systems

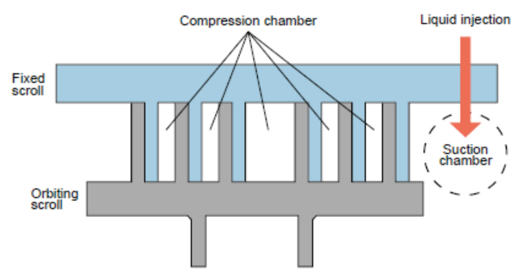


MITSUBISHI ELECTRIC TRANE HVAC US

Option 1: Flash-injection Technology

During low ambient conditions:

- Compressor speeds up to maintain discharge pressure and temperature
- Small amount of refrigerant cools compressor
- Cooled refrigerant transferred to compression chamber using flash-injection technology
- Cools compressor, prevents excessive discharge gas temperatures, enabling higher speeds and increases heating capacity



This mechanism suppresses the temperature rise of the discharge gas and supports the heating operation at low outside temperatures.

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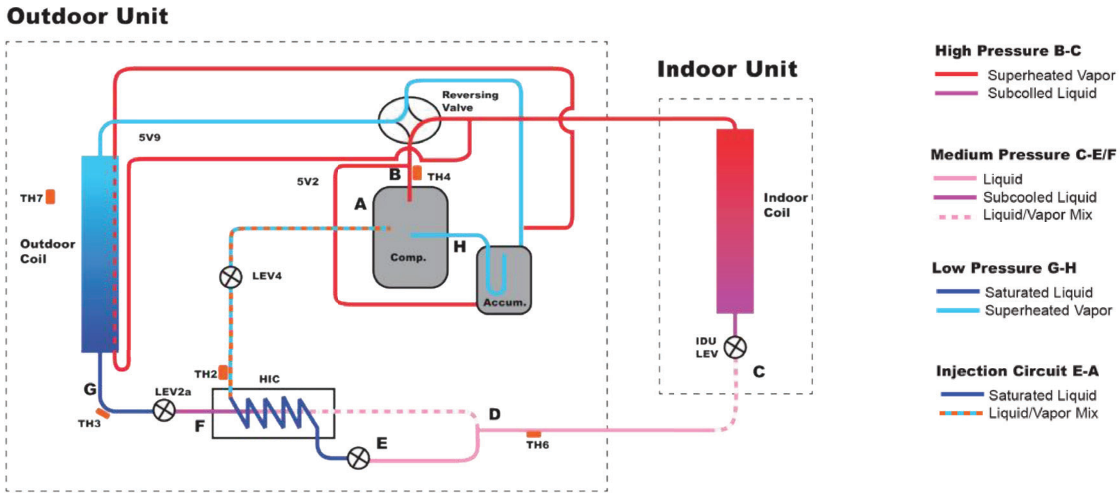
Flash-injection Process



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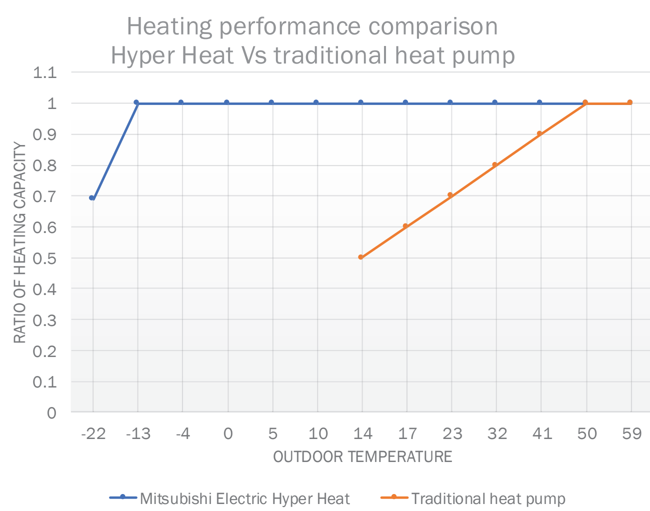
Flash Injection Performance

- Perform at temperatures as low as -30°F
- Hyper heat systems
  - Up to 100% heating capacity at -13°F
  - Up to 69% heating capacity at -22°F
- High-efficiency systems
  - Up to 90% heating capacity at -13°F
  - Up to 58% heating capacity at -22°F



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Option 2: Auxiliary Heat

Typical:

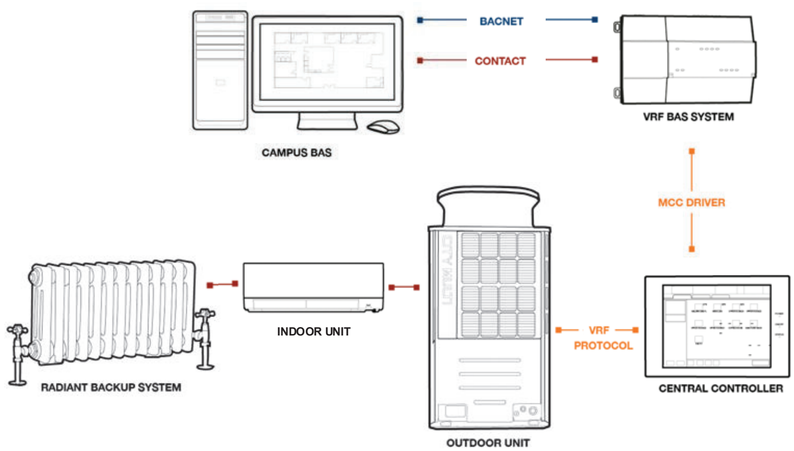
- VRF = 1st stage
- Aux = 2nd stage

With district heat:

- VRF = 2nd stage

Energizing methods:

- Space temperature drop
- Outdoor temperature



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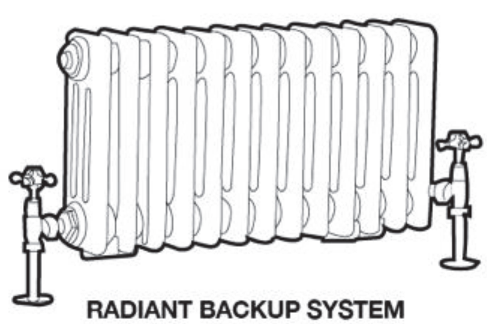
How Often Will Auxiliary Heat Run?

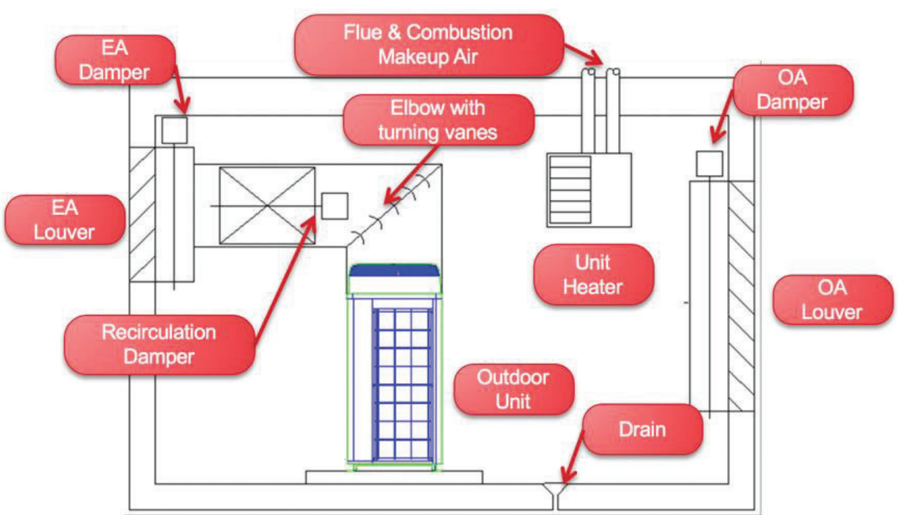
- Not often with flash injection technology
- Most winter days require just part-load heating
- Adequately sized VRF systems limit the need for auxiliary heat



Option 3: Install Outdoor Units Inside

- Limits derating during severe cold weather
- Central location for auxiliary heat
- Simplifies service and maintenance
- Useful in dense urban environments with limited rooftop space

Install Outdoor Units Inside: Sample Design



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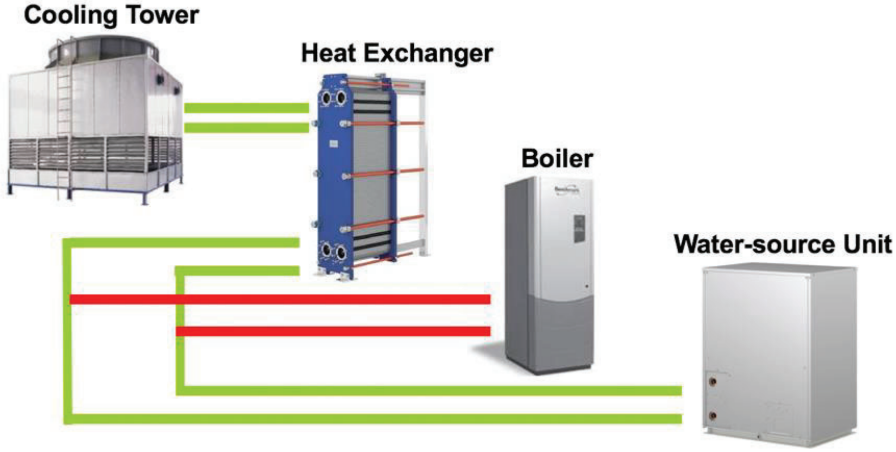
Option 4: Water-source VRF Systems

- Installed indoors
- No derating based on outdoor air temperature
- Capacity based on entering water temperature (EWT)
- Available as a heat pump or with heat recovery

MITSUBISHI ELECTRIC TRANE HVAC US

Water-source VRF System: Sample Design

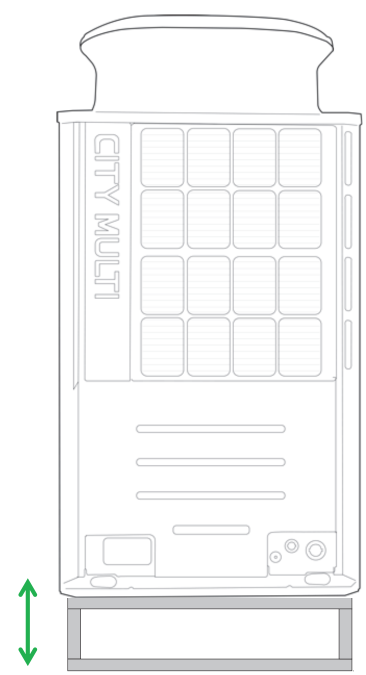


INSTALLATION CONSIDERATIONS

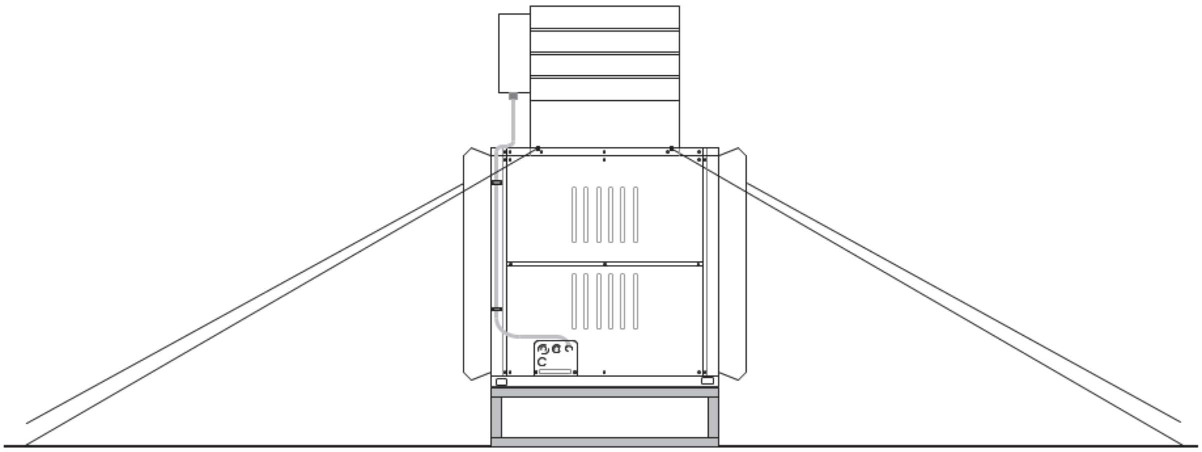
MITSUBISHI ELECTRIC TRANE HVAC US

Mounting Outdoor Units

- Mount outdoor unit at least 12 in. above maximum expected snow depth
- Minimize snow drifting against unit with open design for base
- Consider an area drain to reduce the risk of puddles or ice near the unit
- Exercise caution putting ODUs under drip edge of roof to avoid icicle damage



High-wind Conditions



Snow Hoods and Hail Guards

- Protect outdoor unit coil surfaces from hail damage and snow
- Improve defrost efficiency in windy conditions

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Planning for Winter

- Keep equipment above snow line
- Prepare for defrost and ice accumulation
- Drain condensate away from outdoor units and areas where people walk
- Use panel/base pan heater to prevent ice buildup
- Exercise caution putting ODUs under drip edge of the roof to avoid icicle damage

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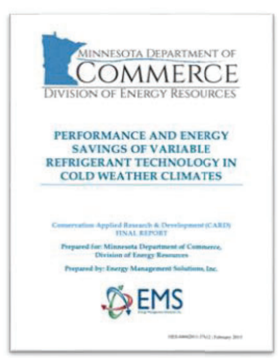
Third-party Studies

- Field studies demonstrate effectiveness of VRF systems in cold-climate applications
- Minnesota Department of Commerce Division of Energy Resources report on cold-climate VRF performance
- Field studies closely watched by policy makers and advocates for decarbonization



MINNESOTA DEPARTMENT OF COMMERCE
DIVISION OF ENERGY RESOURCES

PERFORMANCE AND ENERGY SAVINGS OF VARIABLE REFRIGERANT TECHNOLOGY IN COLD WEATHER CLIMATES

Conservation Applied Research & Development (CARD) FINAL REPORT
Prepared for: Minnesota Department of Commerce, Division of Energy Resources
Prepared by: Energy Management Solutions, Inc.

EMS

CASE STUDIES

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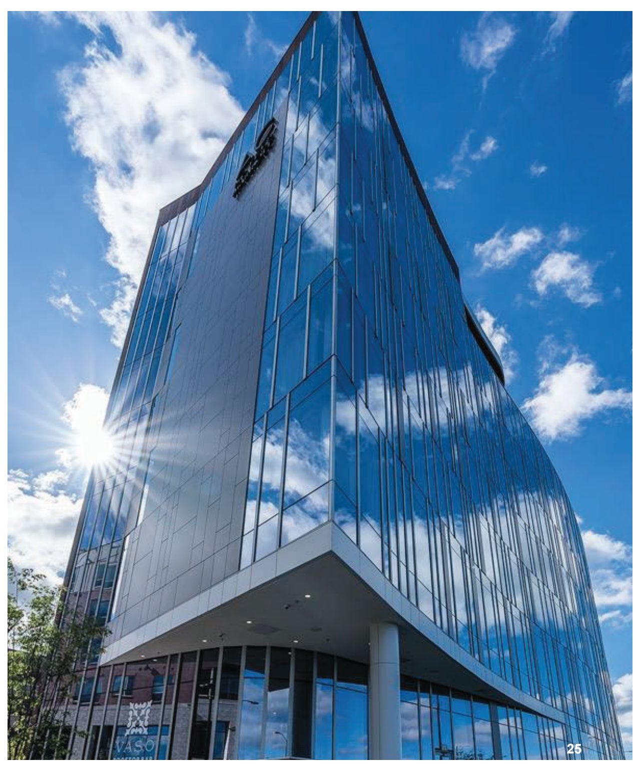
Case Study: AC Marriott Bridge Park

- High-end, luxury hotel in Dublin, Ohio
- **104,250-square-feet**, 8 stories
- AC Marriott brand focused on sophistication, service and design
- Harsh winters, temperatures dip below zero
- VRF provides personalized comfort, whisper-quiet operation and cost savings through operational and energy efficiency



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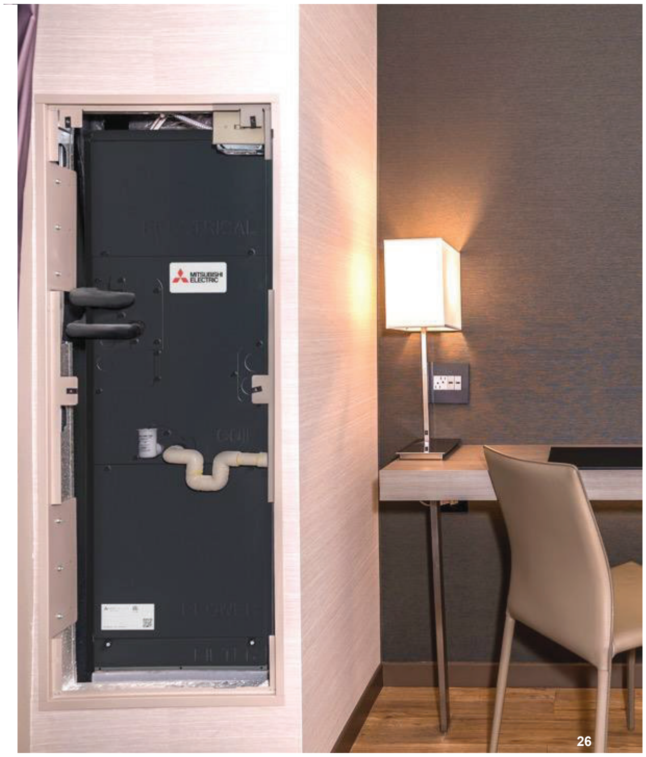
Case Study: AC Marriott Bridge Park

- Total installed mechanical costs for VRF system were $550,000 less than for conventional water-source heat pump HVAC system initially considered by developer
  - More efficient VRF system required less total equipment
  - Number of compressors reduced from 182 to 19
  - Total count of water pumps reduced from 190 to 5
- VRF system uses heat recovery to save money and increase energy efficiency even in extreme temperatures



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Case Study: Minnesota Power

- Utility company in Cloquet, Minnesota serving 145,000 people
- **5,000-square-foot** office space
- Utility company working to help state reduce reliance on oil and natural gas
- Staff pride themselves on promoting energy-efficient technologies and saving their customers money
- Retrofit to replace faulty HVAC system and demonstrate feasibility of **strategic electrification**

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Case Study: Minnesota Power

- Cold climate with low-ambient design temperature of **-20°F**
- Challenge solved with heat-recovery system equipped with hyper-heating flash-injection technology and auxiliary heat
- Demonstrates how local universities and city buildings in Minnesota's climate can reduce reliance on fossil fuels and electrify while maintaining reliable comfort

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Takeaways

- Modern VRF systems perform reliably in cold climates with some systems providing heat down to -30° F
- Solve derating challenges with flash injection, auxiliary heat, indoor installation and water-source VRF systems
- Auxiliary heat runs infrequently, even in heating-dominant regions
- Preparation for cold weather includes installing outdoor units above the snow line, using snow hoods and considering defrost, ice accumulation and condensate drainage
- Cold-climate performance makes VRF technology a primary heating and cooling solution for any climate and positions it for growth as decarbonization and strategic electrification gains momentum

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Additional Resources

- Visit our websites: MitsubishiComfort.com Mitsubishipro.com
- Read some real-life examples (Case Studies)
- Find a qualified HVAC contractor or VRF system distributor