VRF Product Overview and Core Features

AC-1-PDH

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Agenda

- VRF Overview
- Core Features
- Main Components
- System Features

VRF Overview

Variable System capacity varies with load

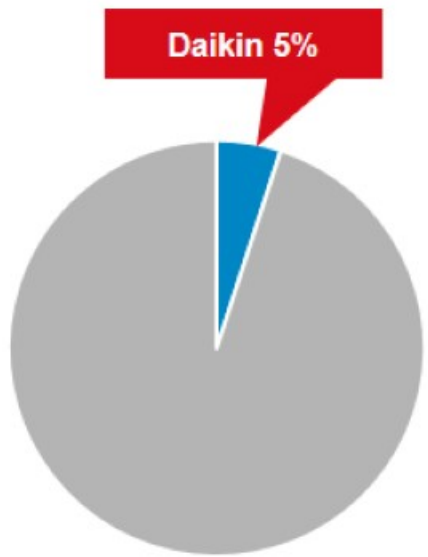
Refrigerant R-410A Direct Expansion System

Flow Refrigerant flow regulated by EEVs and variable speed compressor

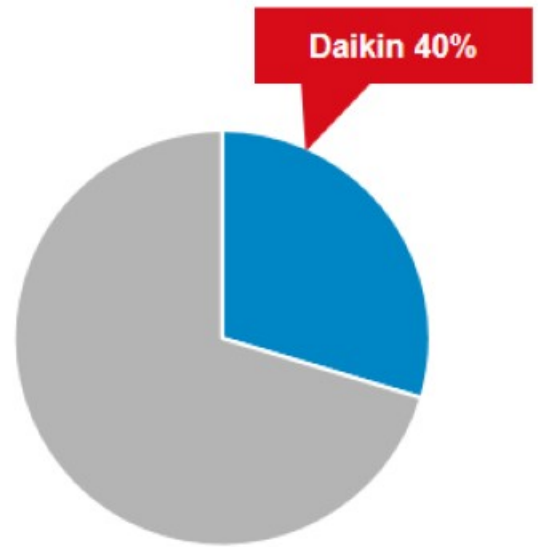
VRF = Industry term

- **Introduced in 1982**
  Worlds first VRF system
- Over **1 million installations** worldwide
- Over **40,000 (500,000-Tons)** systems in USA and Canada
- Commercial Market Share:
  US 5% EU 40%

U.S. Commercial Market Share



EU Commercial Market Share



History of VRF Development

Concept formed from energy crisis of 1970's

VRF is launched globally

1982

1987

1st Heat Recovery

1990

1991

Worlds first R410A ~ VRF introduced to the U.S. Market

1998

2003

VRF System installed at ASHRAE HQ

2005

2008

AHRI certification recognized ~ VRF chapter added to ASHRAE handbook

2012

World's first VRF system is developed

First Inverter Compressor

World's first R407C

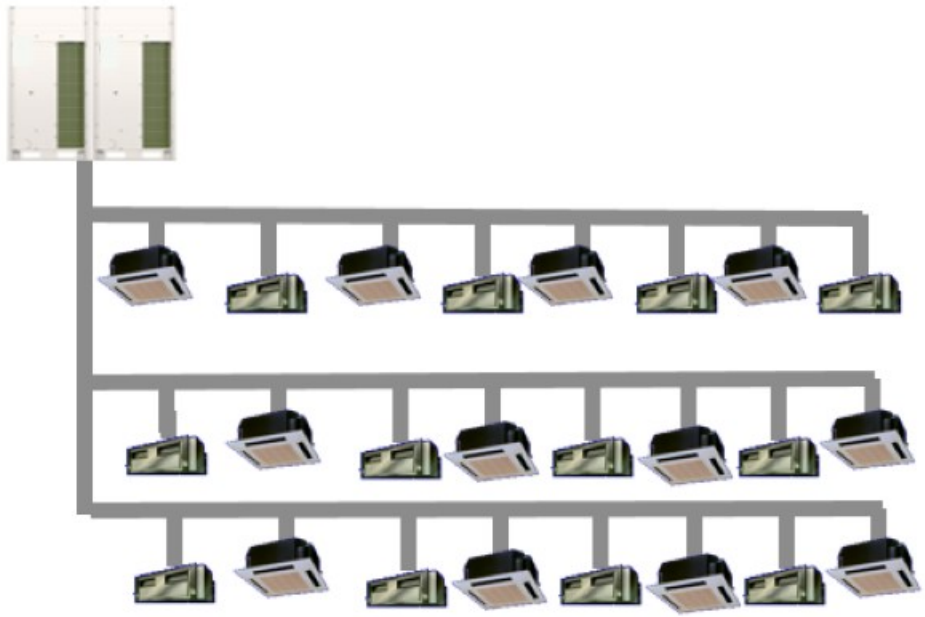
Auto addressing added
(no rotary or dipswitches)

2nd Generation VRF Water Cooled Technology

What is VRF?

VRF Concept

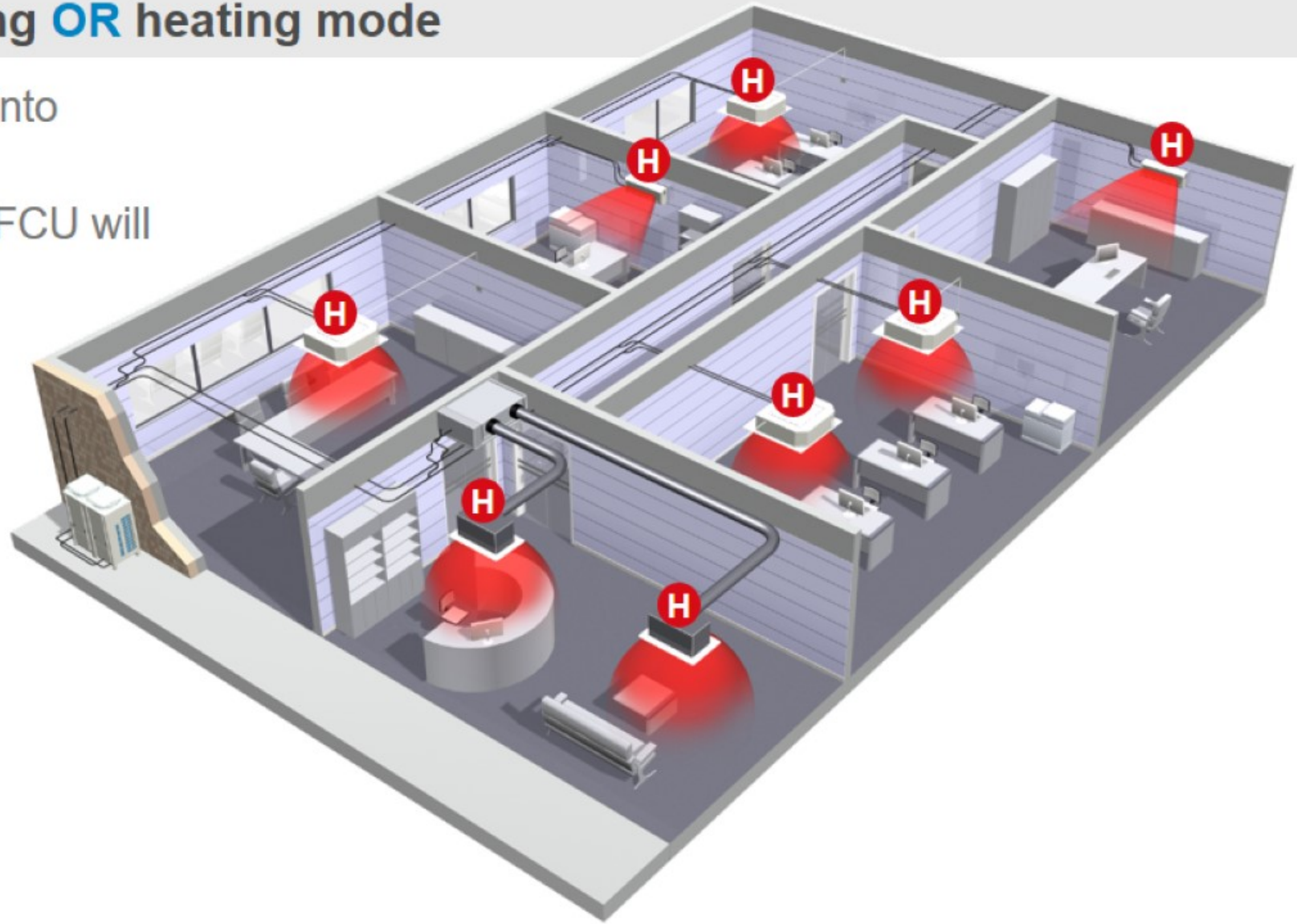
- Multiple indoor units connected to one outdoor unit
- Up to 64 on **a single** refrigerant piping network
  - Manufacturer dependent
- Available in either **air cooled** or **water cooled**



Heat Pump Series

Whole system is in cooling OR heating mode

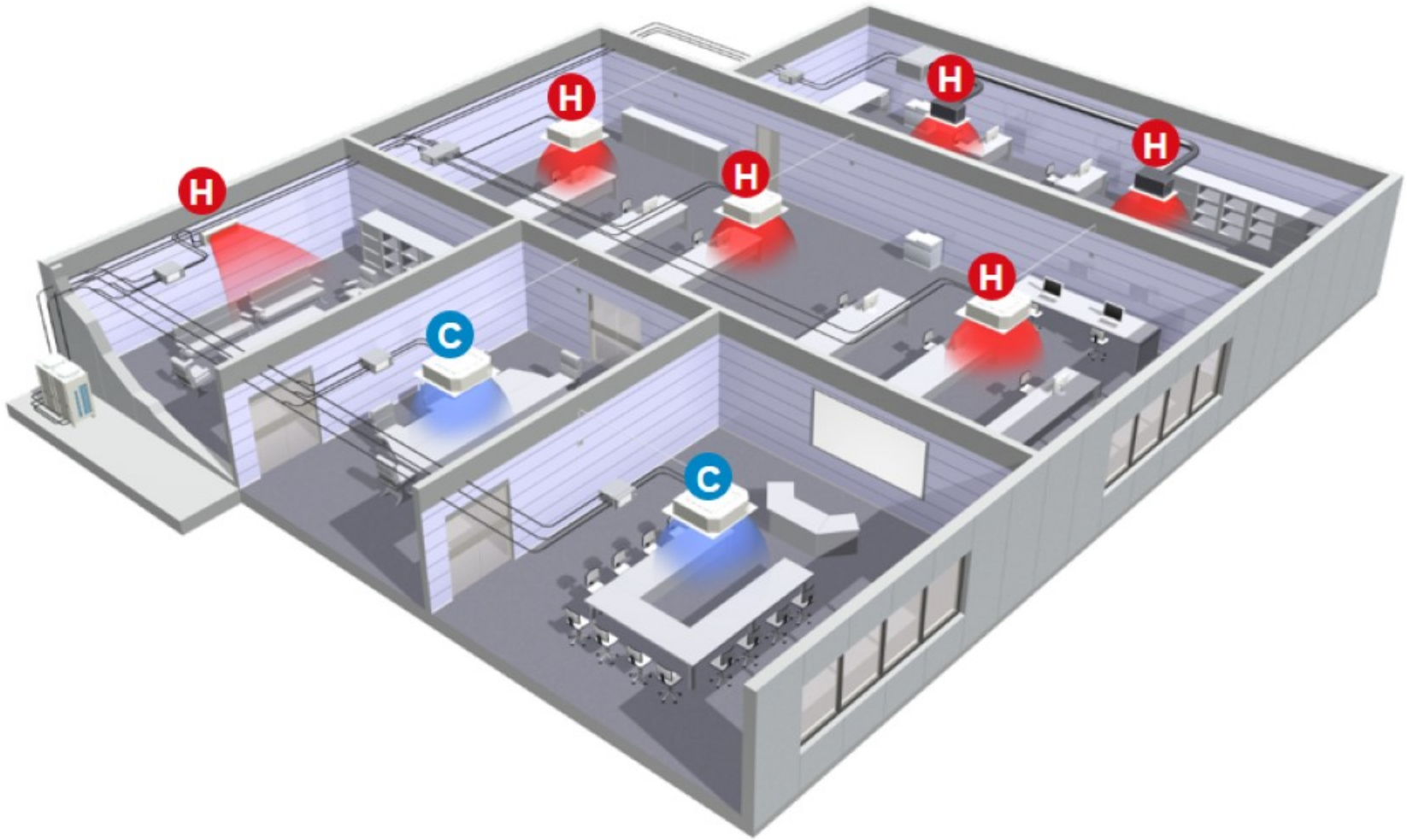
- **Note:** Units are not **forced** into heating or cooling
- If demand is not required a FCU will operate fan only



Heat Recovery Series

The system can cool AND heat simultaneously

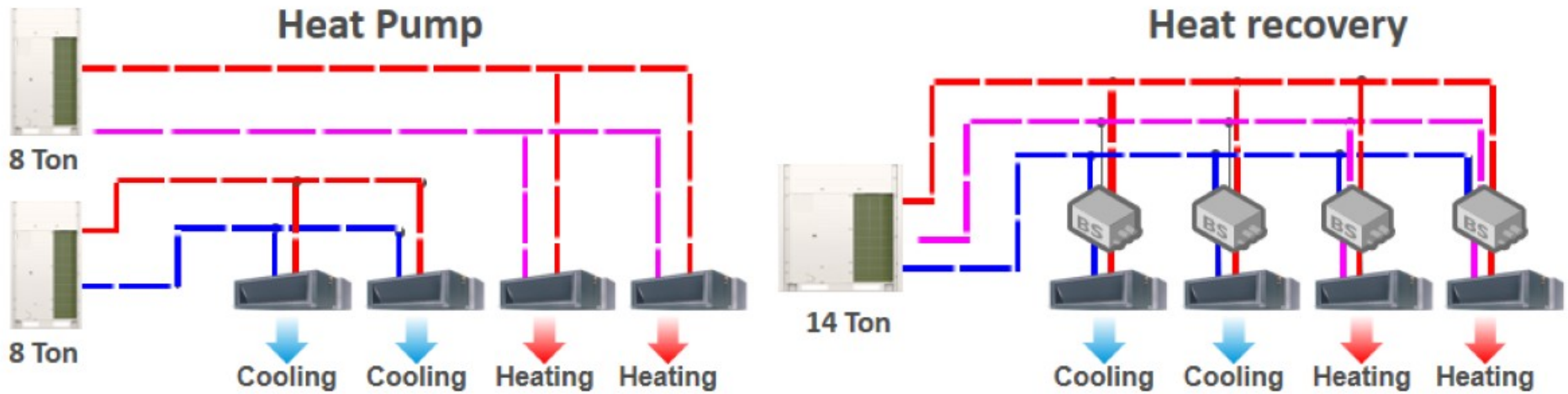
- The system will **ALSO** provide a Heat Recovery Process



What is VRF?

VRF Concept

- Think of a VRF system as a **heat pump chiller** that circulates refrigerant to each zone instead of water
- A heat pump system is equivalent to a 2 pipe chiller
  - Smaller heat/cool changeover zones
- A heat recovery system is equivalent to a 4 pipe chiller system



The VRF Brains- (Controls Vary per Manufacturer)

Brain #1: Condensing Unit Brain

Control System

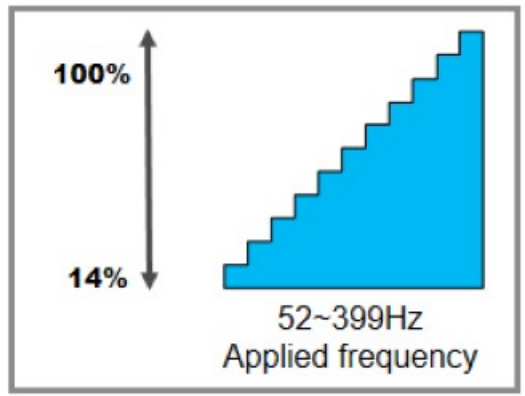
- Sets Target low and high pressure values at the Condenser
- Sets the Target evap. and cond. Temps in the indoor Fan Coils
- Local Remote Controllers initiate a system Thermo-ON with a 1° deviation from set point
- Local Remote Controllers initiate a system Thermo-OFF when all set points are reached

Condenser Control

- **COOL** Operation
  - Detects the system operating suction pressure at the condenser once every 20 seconds and Target Evap temp
- **HEAT** Operation
  - Detects the system operating high pressure at the condenser once every 20 seconds and Target Cond temp

Inverter Control

- Adjusts compressor speed (capacity) up or down to correct deviation from the target pressure values (system load)

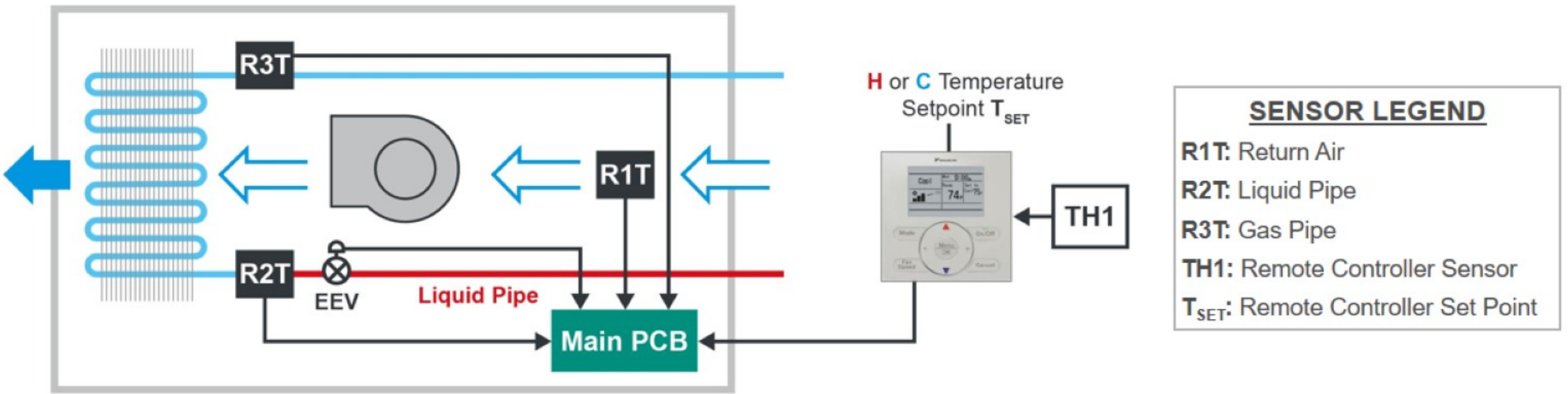


The VRF Brains (Controls Vary per Manufacturer)

Brain #2: Indoor Unit Brain

VRF fan coils have 1 or more thermistor sensors

- The sensor signals are used to regulate refrigerant volume through the fan coil using Proportional, Integral and Derivative (PID) control, to correct deviation from target temperature values by adjusting the Electronic Expansion Valve in pulses to modulate open and close



Agenda

VRF Overview

Core Features

Main Components

System Features

VRF Overview

VRF has three core features:

MODULAR DESIGN
Easy to Install

ULTRA-HIGH ENERGY EFFICIENCIES

EXCEPTIONAL COMFORT CONTROL

Simple Modular Concept

MODULAR DESIGN

Building Blocks

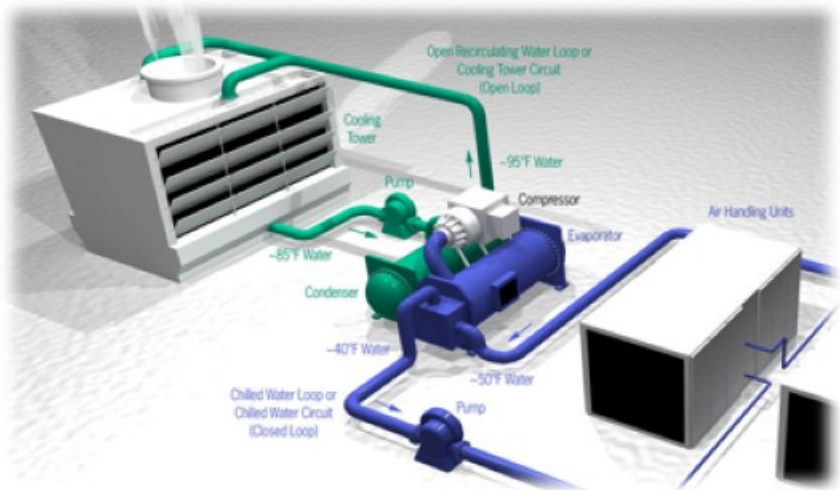
+

+

+

Outdoor Unit **Indoor Unit** **Piping** **Controls**

OR



+ **Ducts, Valves, Controls, Balancing, Etc.**

COMPLEX

VRF Fit by Building Size

MODULAR DESIGN

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

Heat Transfer Media

ENERGY EFFICIENCIES

A Key attribute of direct expansion systems is their Energy efficiency

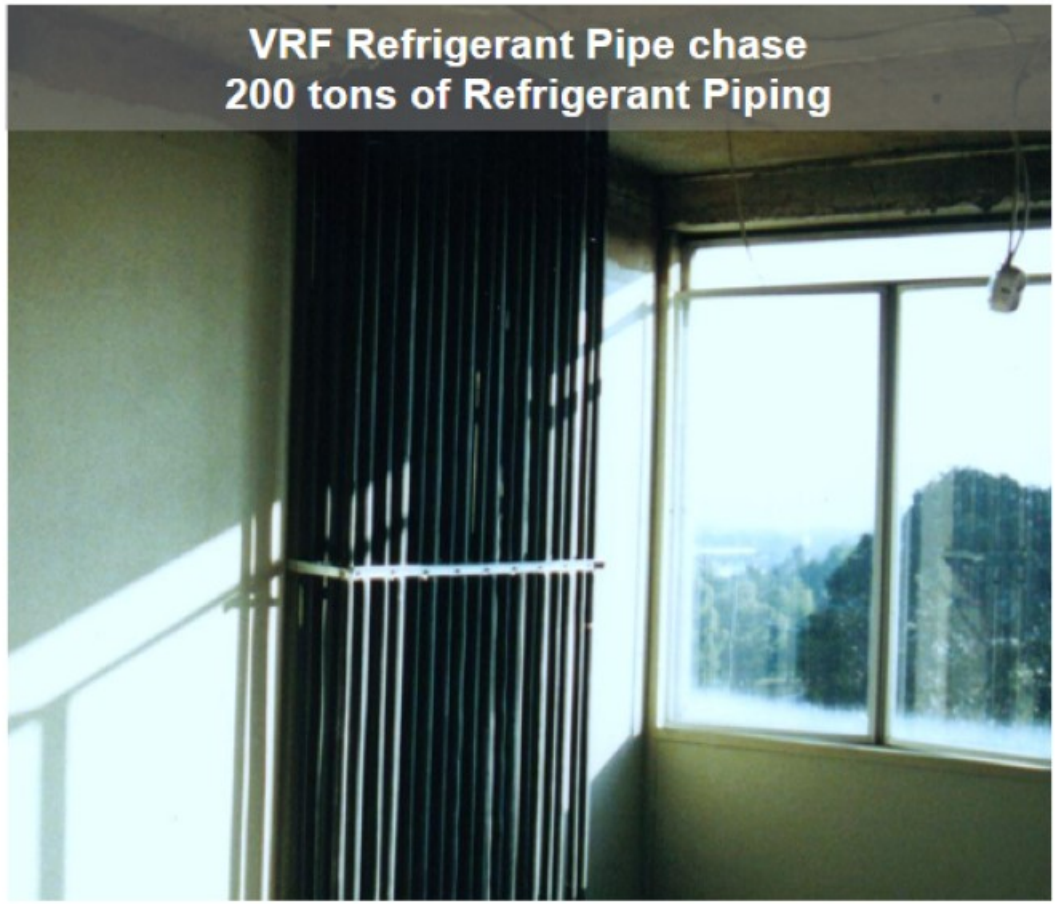
Medium	Heat Quantity* * At Equivalent Design / Operation Conditions	Demand Side Delivery Method	Power Input *(38-Ton of demand side load)*	Size of Pipe/Duct	Application Points of Consideration
Water	9.4Btu/lb q = 4,18 kJ/kgK / dt = 5 K	Pump and Coil/ Fan Unit	4.7 kW	2 x 3.5"	▪ Corrosion ▪ Pump Power ▪ Water Leakage ▪ EER/COP of Heat Source
Air	4.5Btu/lb q = 1,0 kJ/kgK / dt = 10 K	Duct work and 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 5/8" + 3/4"	▪ Piping Length ▪ Vertical Limits ▪ Capacity Correction due to pressure drop

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

Efficient Design

ENERGY EFFICIENCIES

Reduced Construction = Increased Space

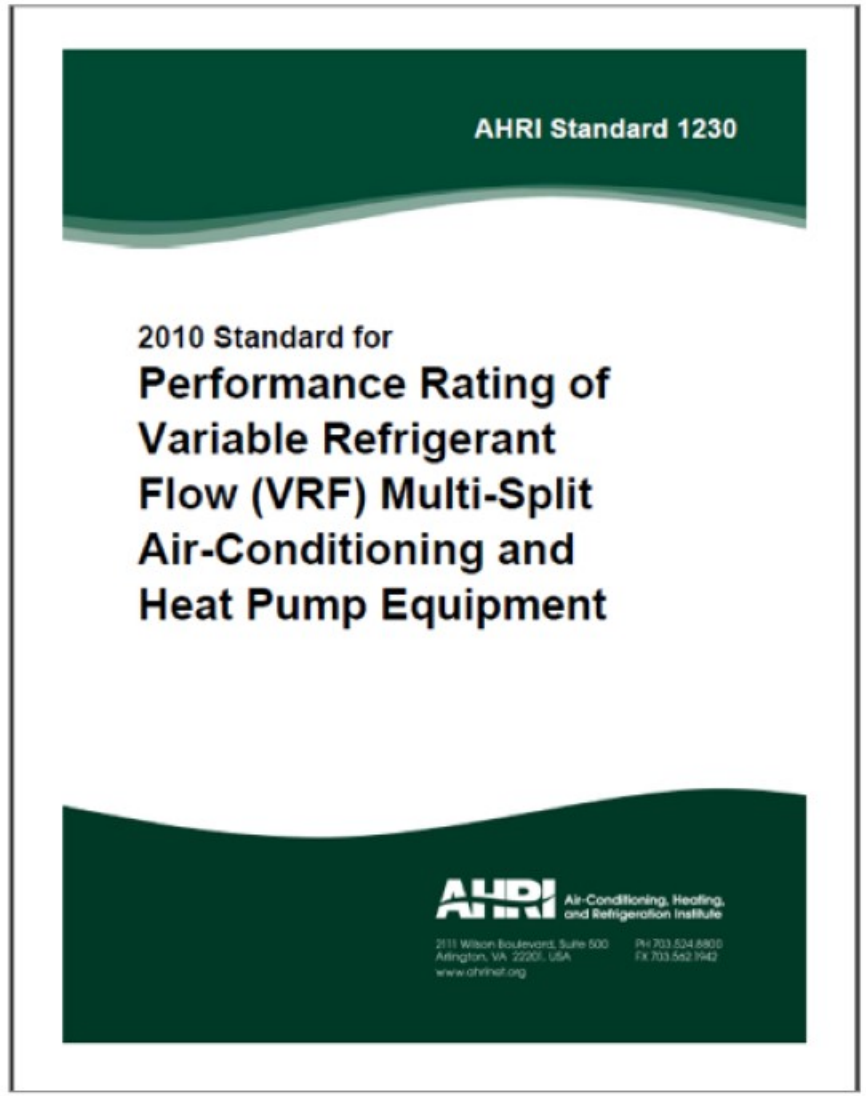


Reduced mechanical chases

No mechanical rooms!

What is AHRI 1230?

- **AHRI 1230** is a testing and rating standard specially designed for VRF systems
- This allows manufacturers to show **VRF efficiency levels** for:
  - Full Load
  - Part Load/Seasonal Cooling Performance
  - Heat Recovery
- **7 years of hard work** went into writing this standard
  - The hard work paid off in September 2011



Seasonal Efficiency

ENERGY EFFICIENCIES

Building Load

Winter

Summer

Fall

Spring

Efficiency Metrics

ENERGY EFFICIENCIES

How are we going to measure this?

EER (95°F)	IEER	COP (47°F)	COP (17°F)	SCHE
System full load cooling operation	System seasonal cooling efficiency	Full Load Heating Performance at 47°F	Full Load Heating Performance at 17°F	Simultaneous Cooling and Heating Efficiency (approx 50-50%)

In 2010, IEER (Integrated Energy Efficiency Ratio) replaced IPLV (Integrated Part Load Performance) as the means to measure part load performance of commercial HVAC systems over 65,000 Btu/h

Integrated Energy Efficiency Ratio (IEER)

- IEER is used to indicate part load energy performance of comparable systems
- For VRF systems AHRI Standard 1230 defines the process to calculate IEER
- IEER is calculated by operating the system at four different capacities and ambient conditions, then applying a formula:

IEER = (0.02 * A) + (0.617 * B) + (0.238 * C) + (0.125 * D)

A = EER at 100%	capacity at AHRI standard condition	**95°F**
B = EER at 75%	capacity and reduced ambient	**81.5°F**
C = EER at 50%	capacity and reduced ambient	**68°F**
D = EER at 25%	capacity and reduced ambient	**65°F**

Note:

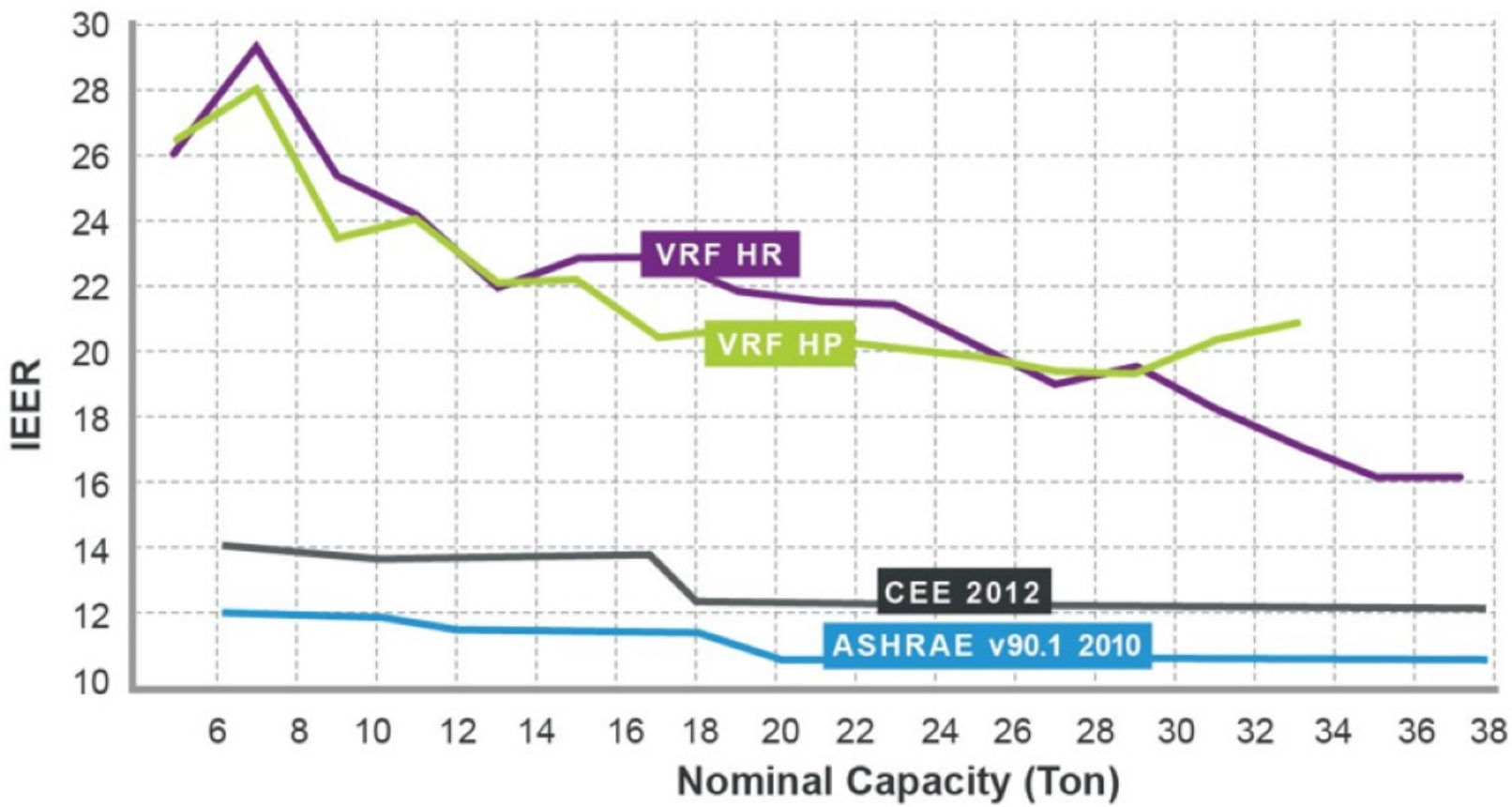
- Full load EER (100% capacity) represents only 2% of the overall IEER rating – It is recognized that VRF systems rarely operate at this condition
- As overall capacity is reduced the system EER increases significantly
- A systems efficiency could exceed the IEER rating depending on equipment sizing, environment and use of the system

ASHRAE Standard 90.1

ENERGY EFFICIENCIES

Current VRF systems in the US market tend to significantly exceed the minimum efficiency requirements set for electrically operated air to air VRF systems

IEER Ratings



Individual Room Control

COMFORT CONTROL

Room	Group	Floor	Tenant Building	Building or Campus	Multiple Site Locations

Room:
Local control that allows the occupant to change the settings to their comfort.

Group Control

COMFORT CONTROL

Room | **Group** | Floor | Tenant Building | Building or Campus | Multiple Site Locations

Group: Multiple indoor units can be combined into one zone to operate in unison, ideal for large spaces. Connect up to 16 indoor units to any single remote controller.

VRF Controls Scalability

COMFORT CONTROL

Room | Group | **Floor** | Tenant Building | Building or Campus | Multiple Site Locations

Floor: Robust scheduling function that allow 7-day scheduling,
5+2 Scheduling,
5+1+1 Scheduling,
Everyday and Holiday scheduling

Multiple Tenants

COMFORT CONTROL

Room | Group | Floor | **Tenant Building** | Building or Campus | Multiple Site Locations

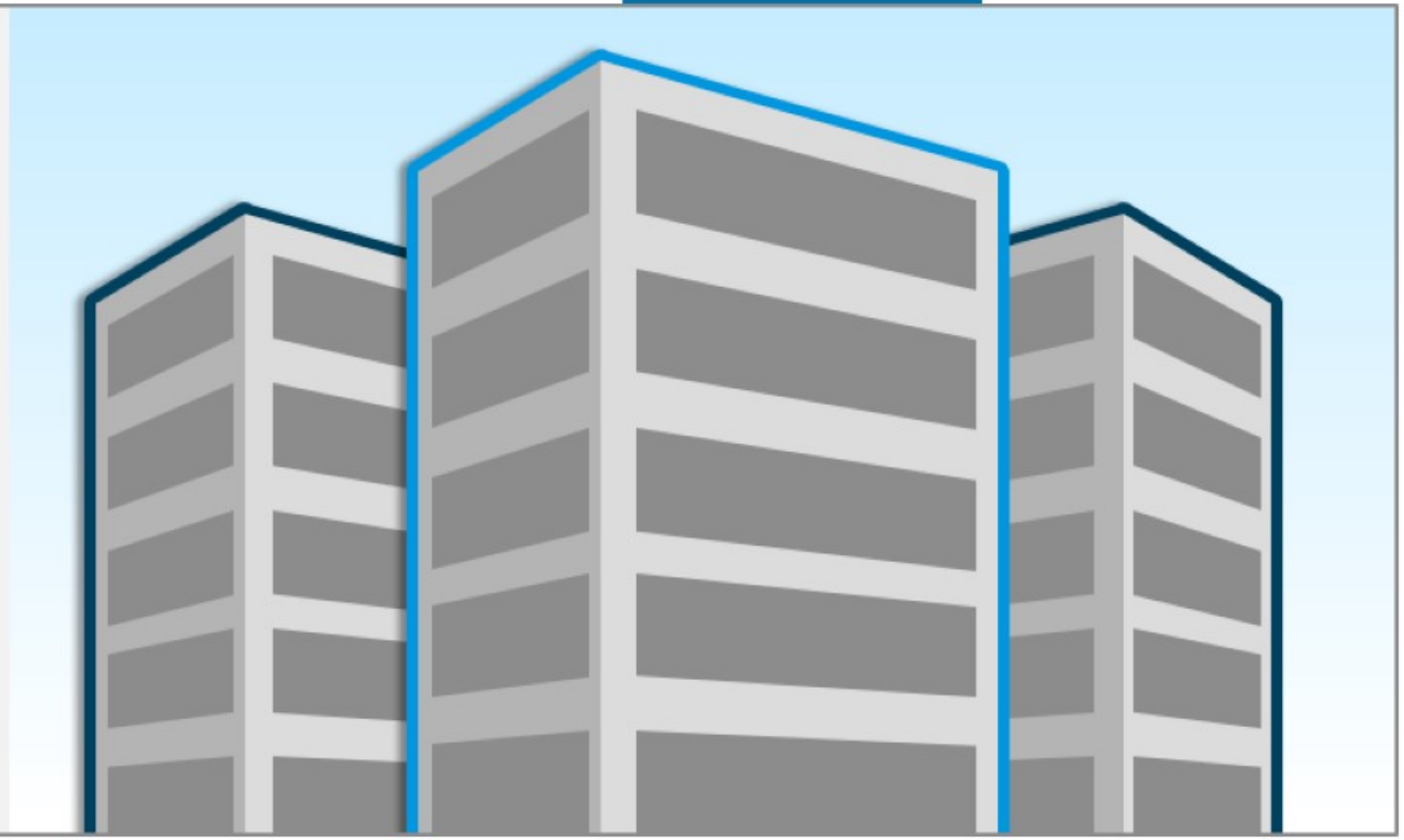
Tenant Building:
Divides the outdoor unit power consumption fairly between tenants using the PPD (Power Proportional Distribution) option

Building Control

COMFORT CONTROL

Room | Group | Floor | Tenant Building | **Building or Campus** | Multiple Site Locations

Building or Campus:
Take control of the building by integrating VRF, DOAS, Energy Recovery Ventilators, KWH meter, Fire Alarm, Pumps, fans , lighting and third party sensors/switches, Operate and monitor individual units and systems in the campus as if they were in the same building

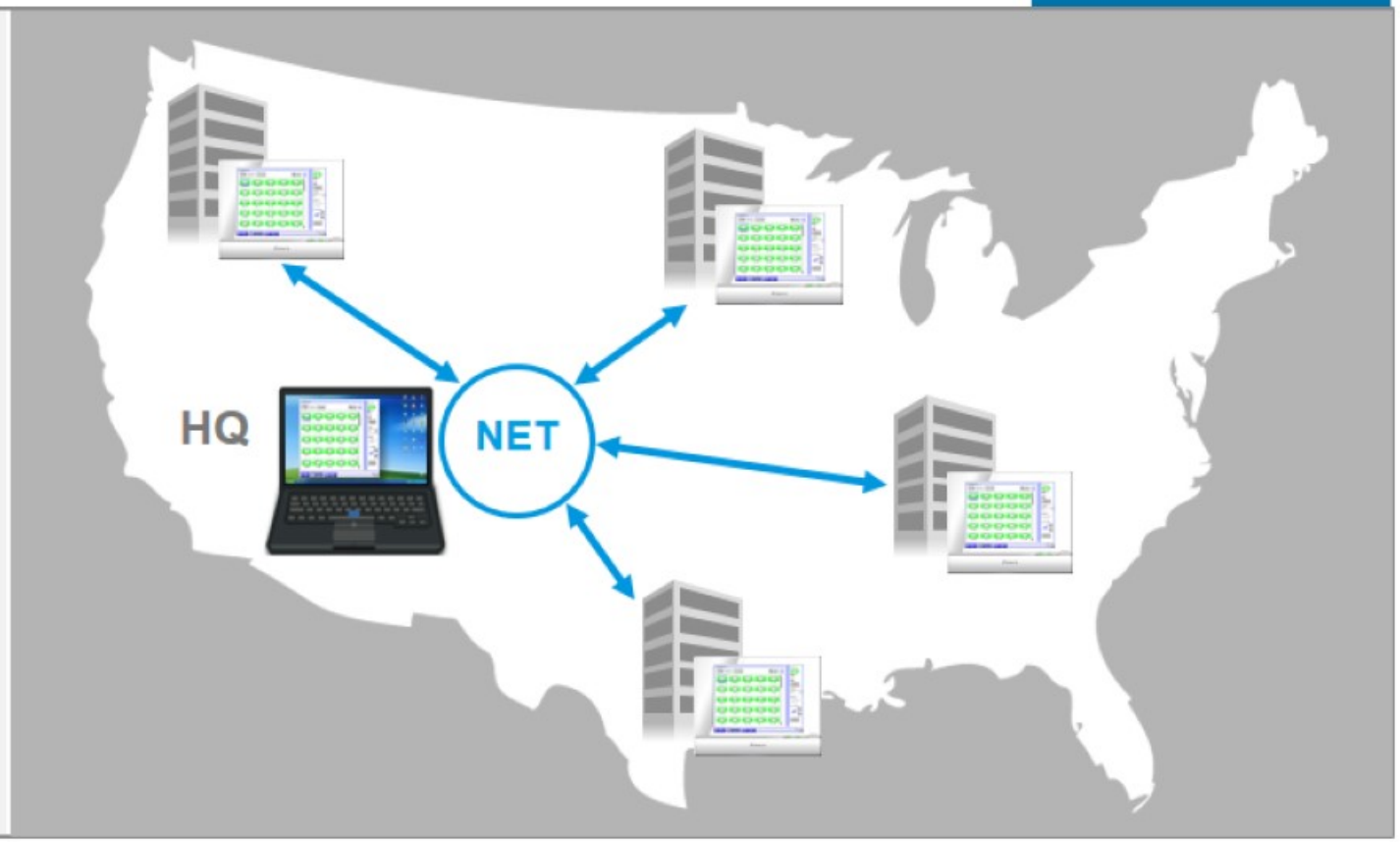


Multiple and Remote Site Control

COMFORT CONTROL

Room | Group | Floor | Tenant Building | Building or Campus | **Multiple Site Locations**

Multiple Site Locations: Multiple locations can be managed using a personal computer. Alert and malfunction codes can be sent to specified email address. Power usage data can be retrieved without visiting facilities



Agenda

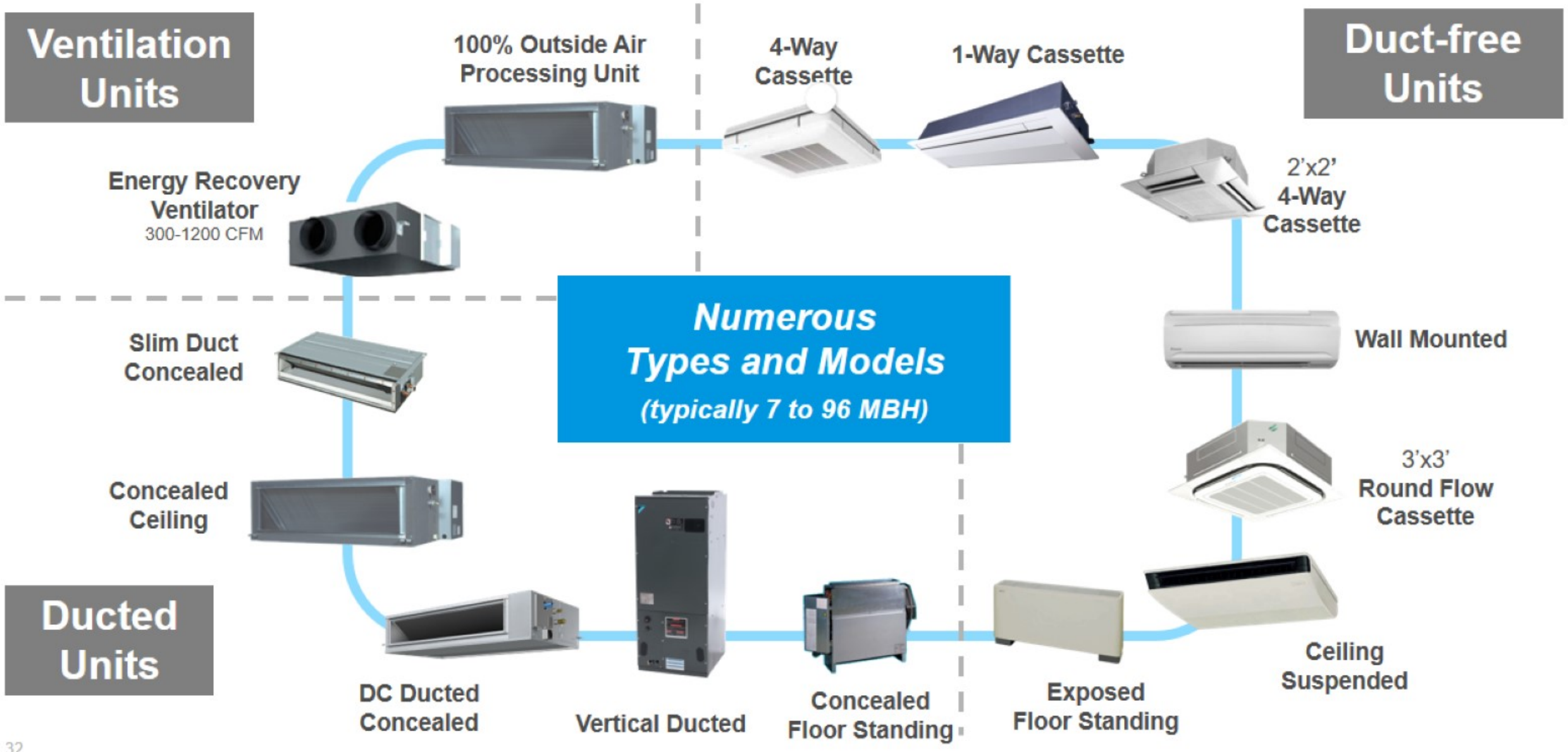
VRF Overview

Core Features

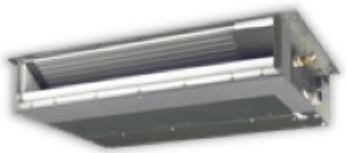
Main Components

System Features

Indoor Unit Options



VRF Indoor Unit Overview - Ducted Types

Type	Model	Description
	**Slim Duct Built-In Concealed Low Static**	▪ Low profile and low sound levels ▪ Ductless soffit or adapt to minimal ductwork ▪ Installation for supply and return ▪ Condensate Lift Pump ▪ Rear or Bottom Return
	**DC Ducted Concealed Medium Static**	▪ ECM blower for adjustable static pressure. ▪ Condensate Lift Pump ▪ Front Discharge – Rear Return ▪ MERV rated filters available ▪ Zoning option
	**Medium Static Ducted**	▪ Several capacity models available ▪ Standard blower motors ▪ Gravity condensate drain ▪ Front Discharge – Rear Return
	**Vertical Air Handler**	▪ Multi Position Airflow (Up, Down, Left, Right) ▪ ECM Blower motor for efficiency ▪ Automatic static pressure adjust ▪ Optional Heat Strip Kits
	**Floor Standing Unit (Concealed)**	▪ Top Discharge / Bottom Return ▪ Space saving free-standing or wall-mounted ▪ Optional Condensate Pump

VRF Indoor Unit Overview - Ductless Units

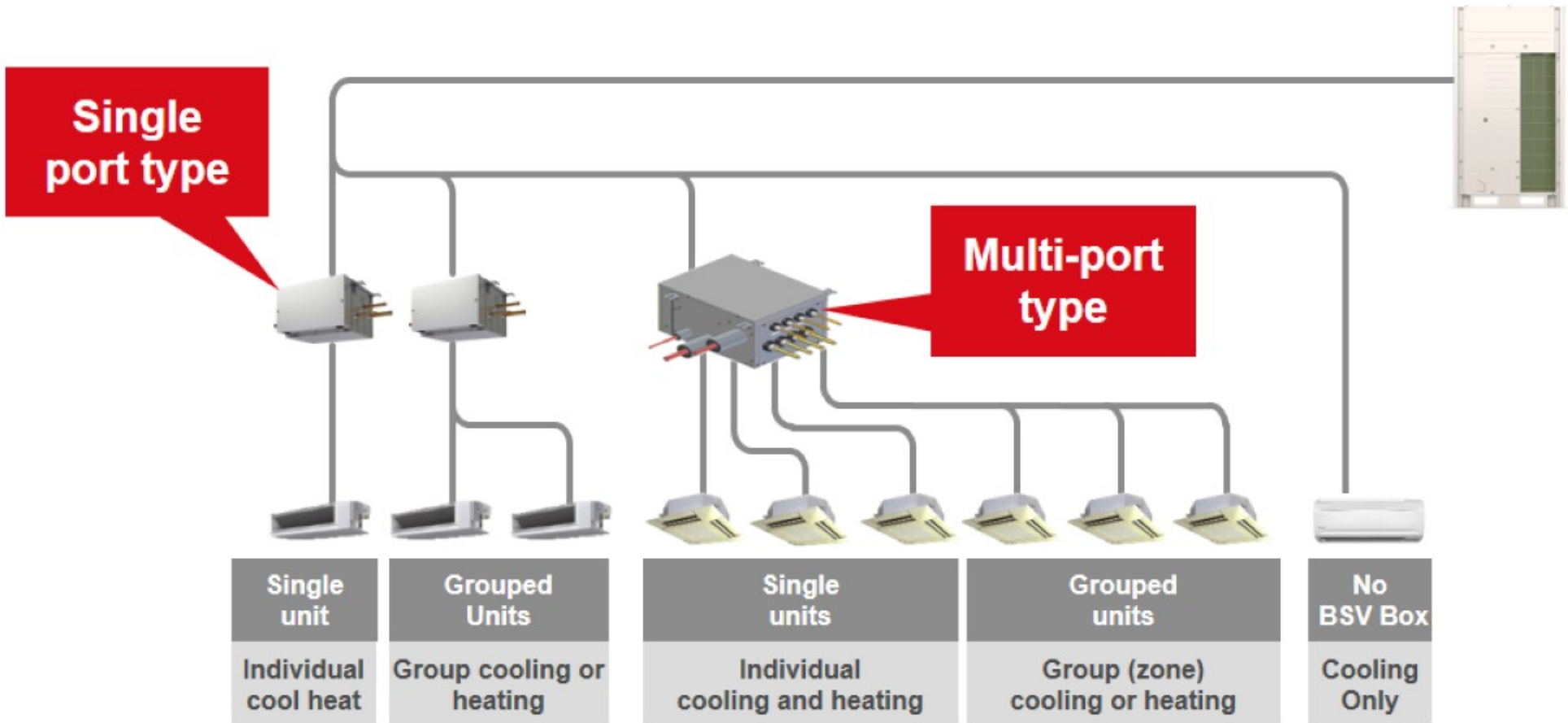
Type	Model	Description
	**Round flow sensing cassette**	▪ 360° Discharge air pattern with 23 field configured distribution patterns ▪ Integrated Floor and Presence Sensor ▪ Outside Air integration possible ▪ Factory Long-Life Filter or Self Cleaning Filter Opt
	**2' x 2' 4-Way Ceiling Cassette**	▪ 2, 3, or 4 way configured air flow ▪ Condensate Lift Pump ▪ Outside Air integration possible
	**Under ceiling cassette**	▪ Innovative Under Ceiling 4-Way Cassette ▪ 2, 3, or 4 way configured air flow ▪ Optional Floor and Presence Sensor Kit
	**One way blow Ceiling Cassette**	▪ Compact design ▪ Long Air throw (15 Ft) ▪ Condensate Lift Pump ▪ Outside Air integration possible

VRF Indoor Unit Overview – Exposed Ductless Units

Type	Model	Description
	**Wall–mounted Unit**	▪ Quiet operation ▪ Powered louvers – programmable ▪ Optional Condensate Pump Kit
	**Ceiling Suspended Unit**	▪ Wide air discharge with long throw ▪ Powered Louver – Programmable ▪ Less than 8’ high
	**Floor Standing Unit (Exposed Type)**	▪ Top Discharge / Bottom Return ▪ Space saving free-standing or wall-mounted ▪ Optional Condensate Pump

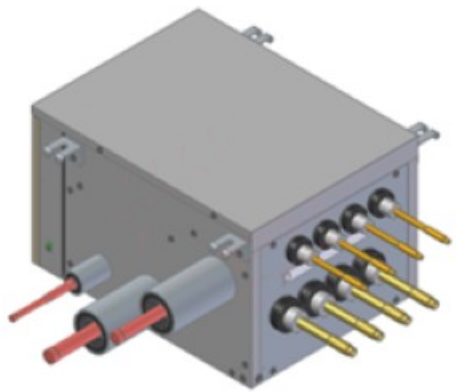
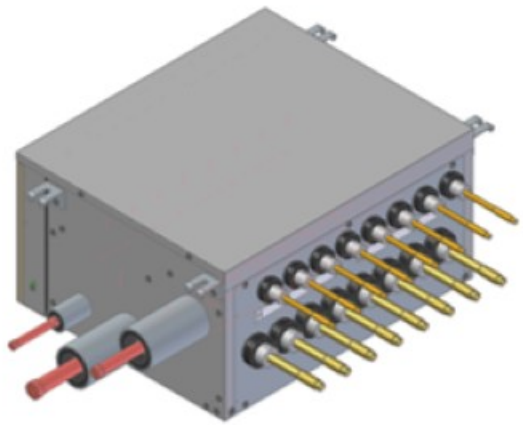
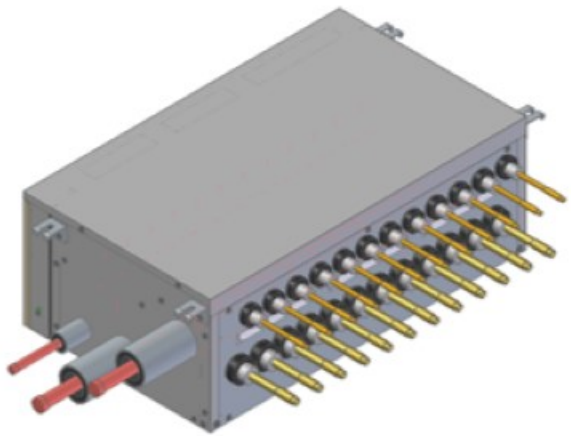
Single and Multi-Port Connections

Heat recovery systems can provide the option of single or multiple port branch selector boxes



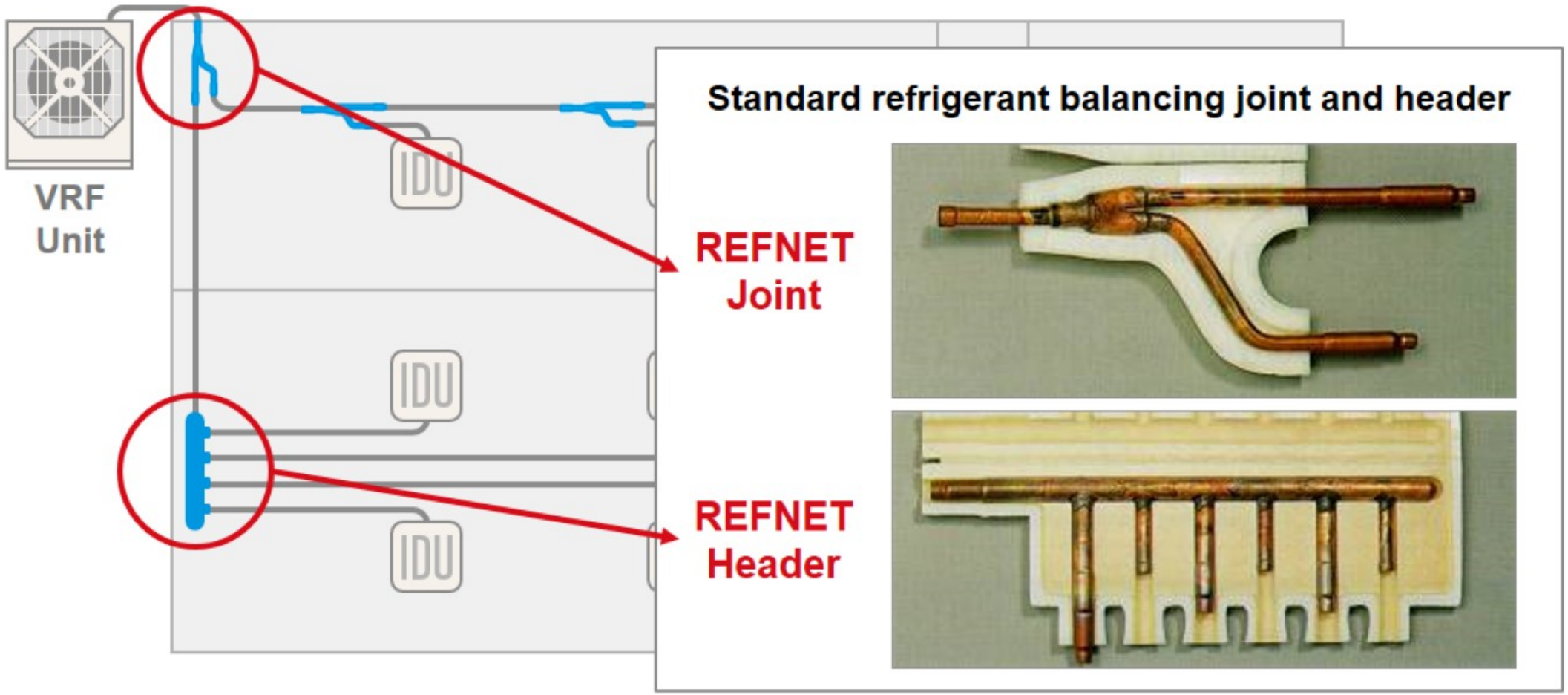
NOTE: When multiple units are grouped together in on a single port, although a single heat/cool zone is created, units still operate independent of each other irrespective of whether they are grouped together on one room controller or individual controllers

Branch Selector Boxes – (Vary per Manufacturer)

1 Port	4 Port	6 · 8 Port	10 · 12 Port
			

VRF Branch Piping

Simple Pre-Engineered Piping Installation



Typical VRF Control Lineup

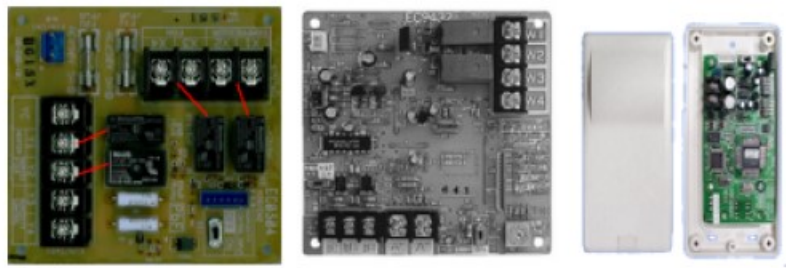
Integrated Control Options - (Vary per Manufacturer)

Individual Zone Controllers

Multi-zone Controllers

Open Protocol Interfaces

Adapter PCB's



User “Comfort” Control - Room Level

Room Controller Key Features

Typical Room Controller

Menu Based Access

- Large backlit LCD display

Time Clock Control

- Individual 7-Day time clock control

Lock Out Option

- Complete control lockout
- On/Off control only

Energy Efficiency

- Preset min/max temperature limits
- Programmable setback

After Hours Timer

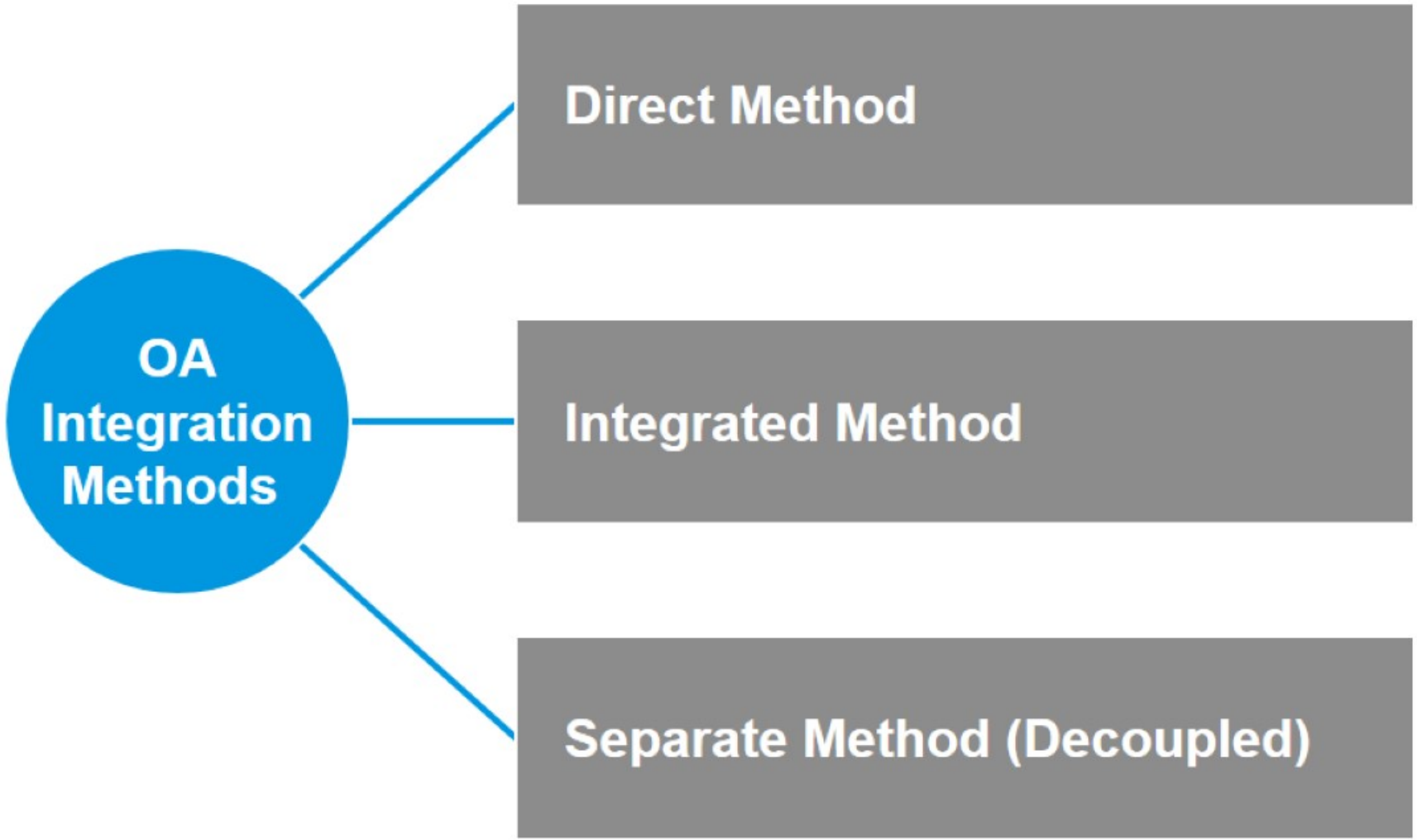
- Run-on timer from
- 30 min to 3 hours

Remote Controllers

Simplified Remote Controller

Hand-held Wireless Remote Controller

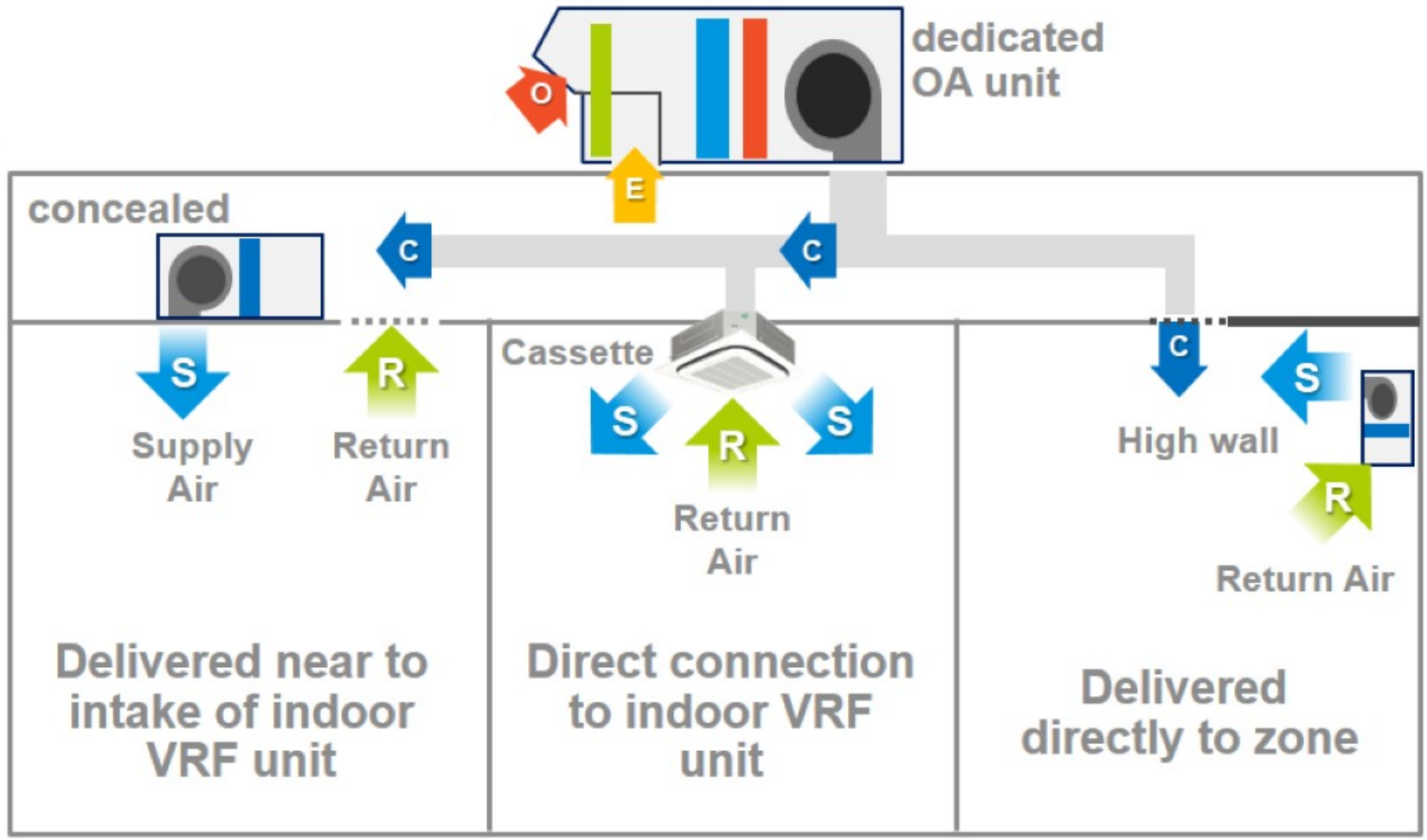
OA Integration Methods



ASHRAE Std 62.1 (2013)

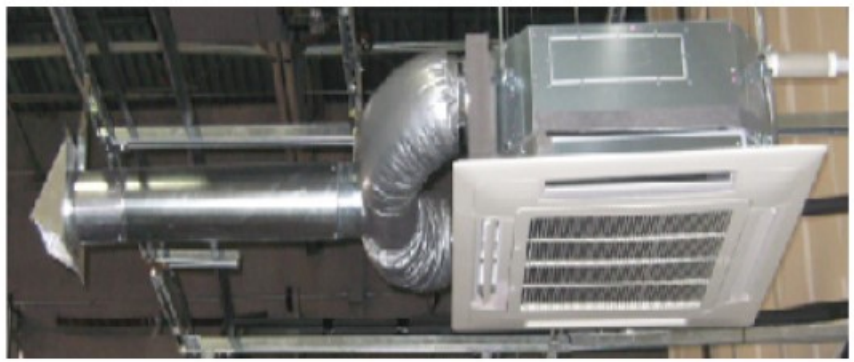
OA Delivery Configurations

O = Outside Air
R = Return Air
S = Supply Air
C = Conditioned Air
E = Exhaust Air



Direct Method

- Untreated outside air is supplied directly to the indoor unit
- Suitable for mild climates
- Small projects where low cfm volumes are required
- Projects with budget constraints



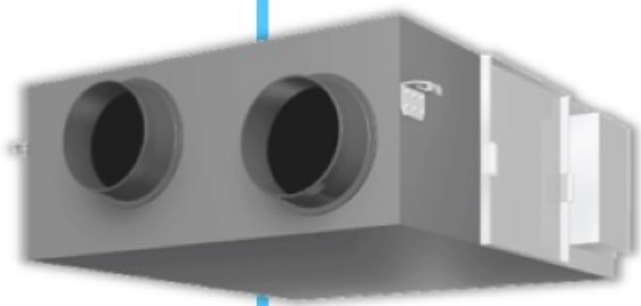
Indoor Unit Type	Outside Air Quantities
Cassette units w/o Fresh Air Kit	14 ~ 37 cfm (3% of air flow rate)
Cassette units with Fresh air kit (as illustrated)	92 ~ 244 cfm (20% of air flow rate)
1 way blow cassette units	31 ~ 80 cfm (15% of air flow rate)
Ducted unit range	56 ~ 500 cfm (20% of air flow rate)

Integrated Methods

100% Outside Air Processing Unit

2 Types
7 Models

Energy Recovery Ventilator

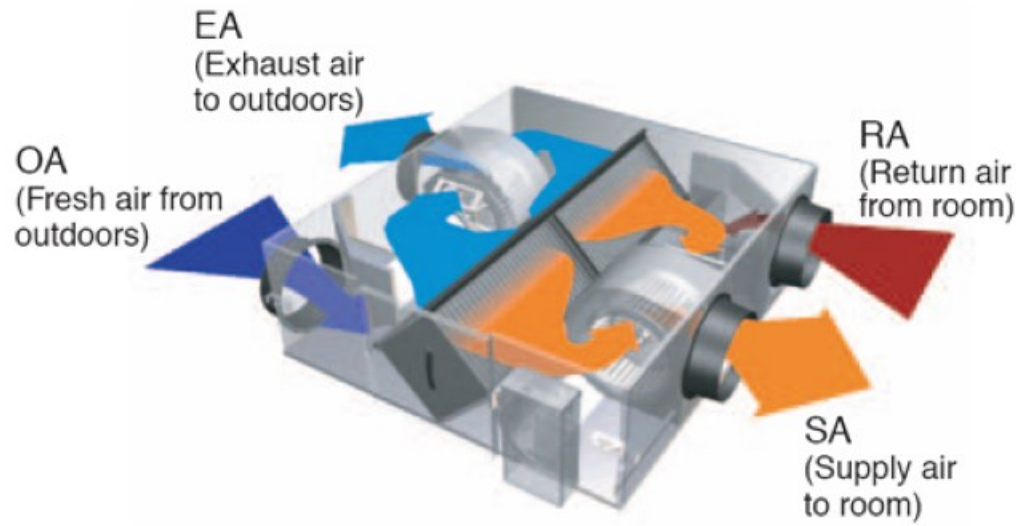


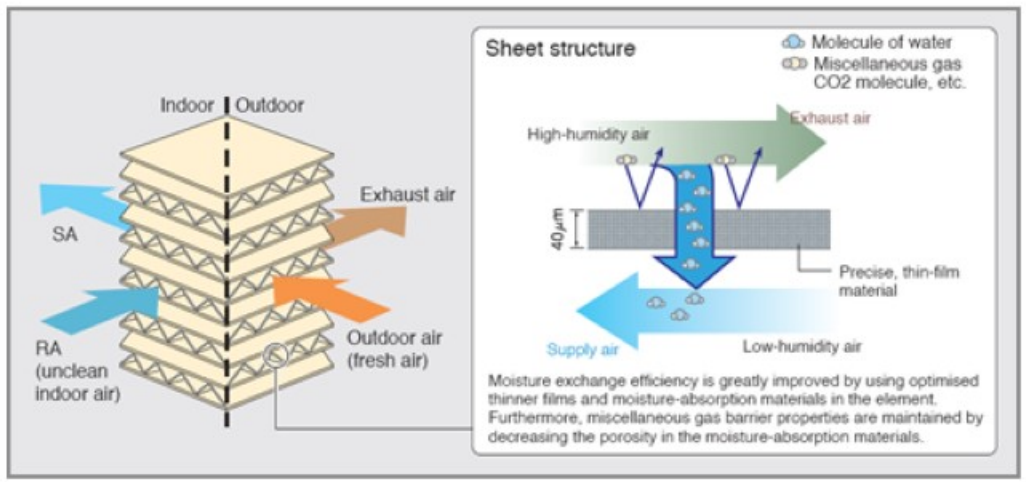
Energy Recovery Ventilation

- Supplies fresh air and exhausts stale air
- Heat exchange between supply and return
- Positive/Negative pressure possible
- Pretreated ventilation can be supplied directly to the indoor unit
- Allows for sharing load between ventilation system and VRF system

Application

- Decentralized (small to medium) applications
- Suitable for all climates
- Pre-heaters recommended below 32°f)



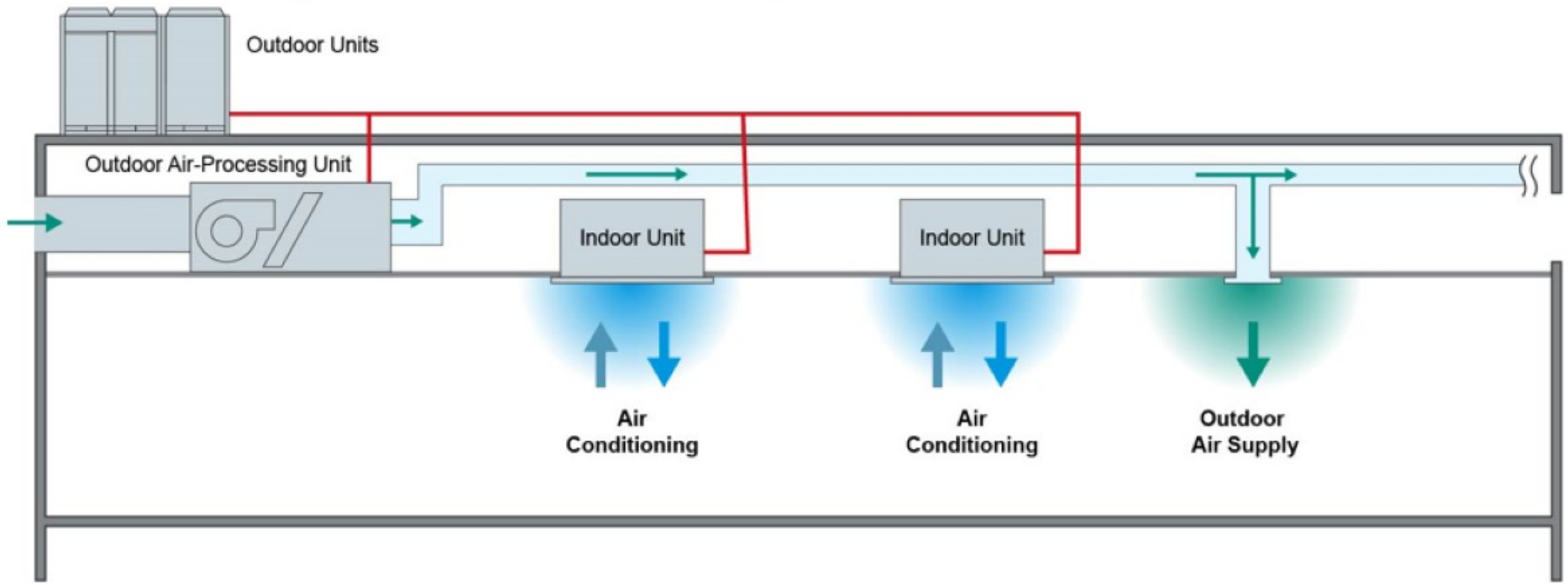


NOTE: ERV's are not just ventilation for VRF – they are often used as stand-alone equipment

Outdoor Air Processor

Main Features:

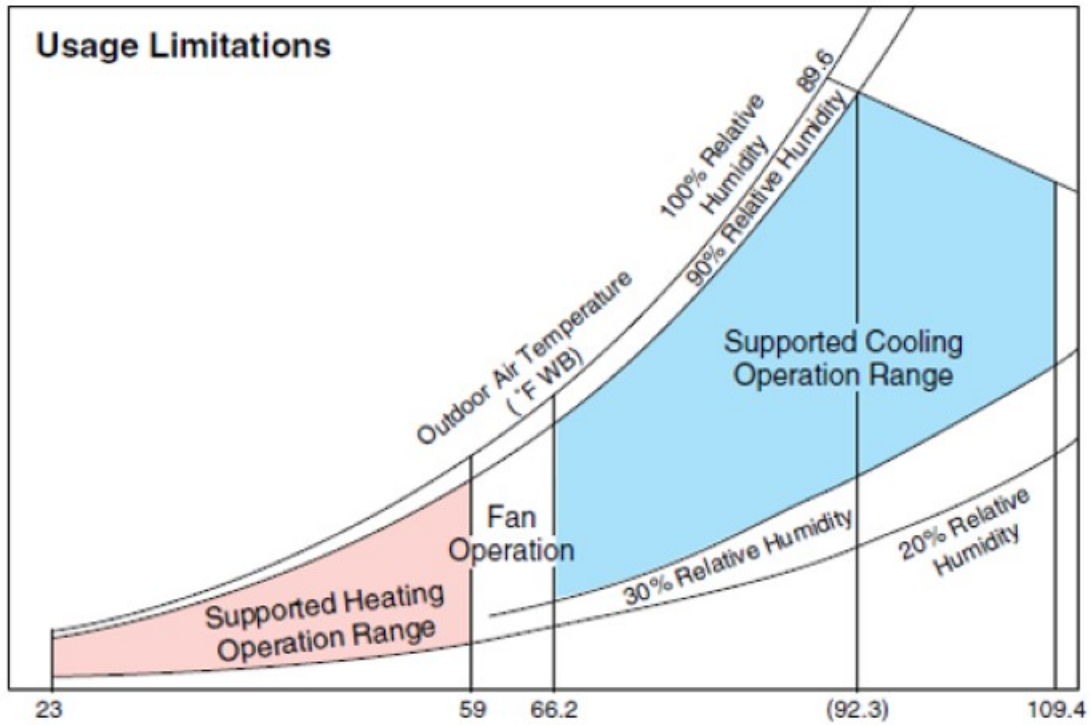
- DX coil linked to the VRF system
- 100% Supply Air Only System (Positive pressure system)
- Fixed Air Flow rates
- Maintains an off coil temperature into unit(s) or space



Outdoor Air Processor

Set temperatures (off-coil):

- Cooling 55°f ~ 77°f (factory setting 64°f)
- Heating 64°f ~ 86°f (factory setting 77°f)
- Economizer mode Between 59°f ~ 66°F



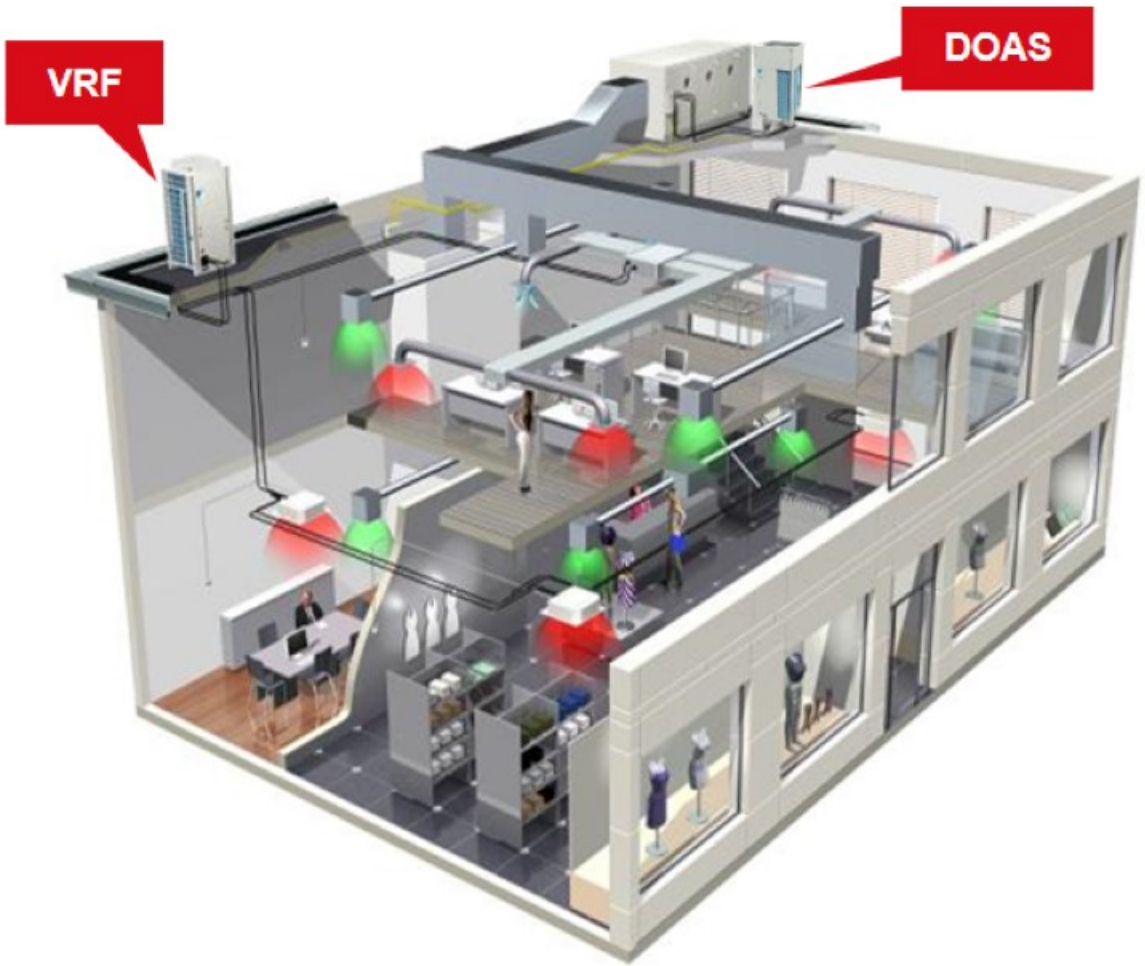
Check List

- FCU and OAP on same system possible but 30% maximum OAP
- OAP's together alone on system is possible
- When OAP are in use 100% capacity ratio only (i.e. no diversity)

- **Outdoor Air Processors are not a/c units and are designed to work in conjunction with comfort cooling systems.**
- **Use without FCU in transient areas is possible but control of temperature in the area is not the role of the unit**

Decoupled Method

DVS DOAS



- The **DOAS** is designed to handle the entire outside air load
- The **VRF** fan coils are sized only for the internal space load
- Used for applications in any climate, and situations requiring any amount of outside air
- The VRF indoor unit fan can be programmed to cycle on/off based on heating /cooling requirements, regardless of ventilation demands, increasing overall system efficiency

DVS DOAS

- Available with multiple cfm options
- Modulating HGRH as standard
- Connects to VRF heat recovery ODU
- ERV and Direct-Drive Power Exhaust Fan
- Direct-Drive Plenum Supply Fan with ECM Motor
- Optional Modulating Gas or SCR controlled Electric Heat
- Integrated System controller with BACnet and Lonworks options

Model			DVSV05 with ERW	DVSV10 with ERW	DVSV12 with ERW
Nominal Air Flow Nominal (Minimum-Maximum)		CFM	1,000 (670 - 1,350)	2,000 (1,600 - 2,650)	3,000 (2,000 - 4,000)
Nominal Cooling Capacity		BTU/h	41,000	73,000	127,000
Dimensions[1] (L x W x H)		in.	103 x 71 x 41	133 x 75 x 57	
Weight[1]		lbs.	1,287	2,266	2,371
Electrical			3-Phase 208V - 230V or 460V		
Refrigerant		Type	R410A		
Auxiliary heater	Gas furnace	MBH	80 / 120 / 160	200 / 300 / 400	200 / 300 / 400
	Electric heater	kW	6 / 12 / 18 / 30	30 / 36 / 54	36 / 54 / 72

Agenda

VRF Overview

Core Features

Main Components

System Features

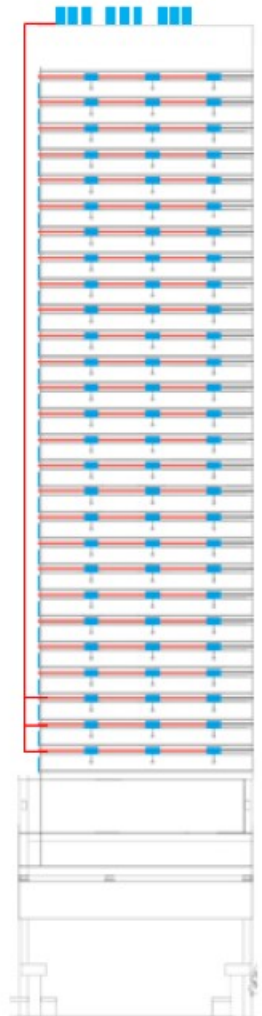
Refrigerant and Oil Management

Why are there piping limits?

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

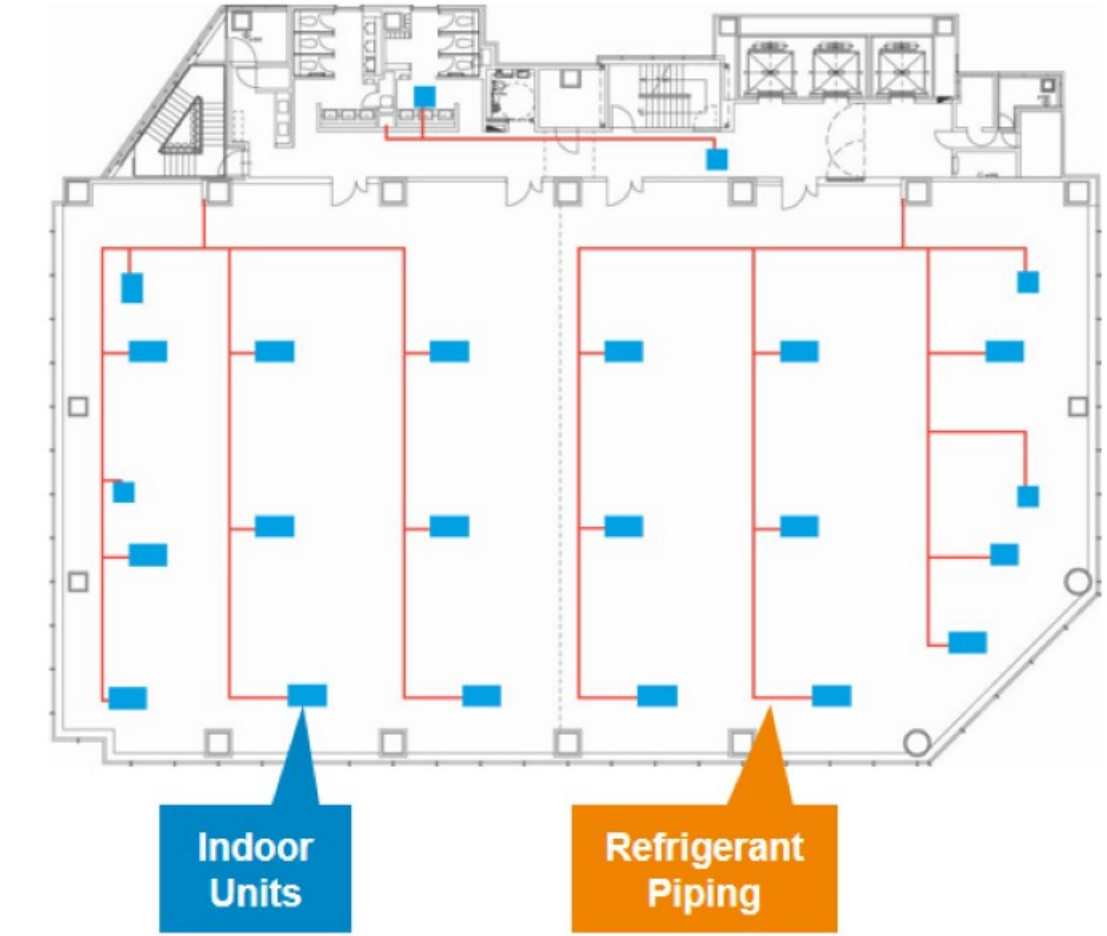
Correct pipe application ensures:

- 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

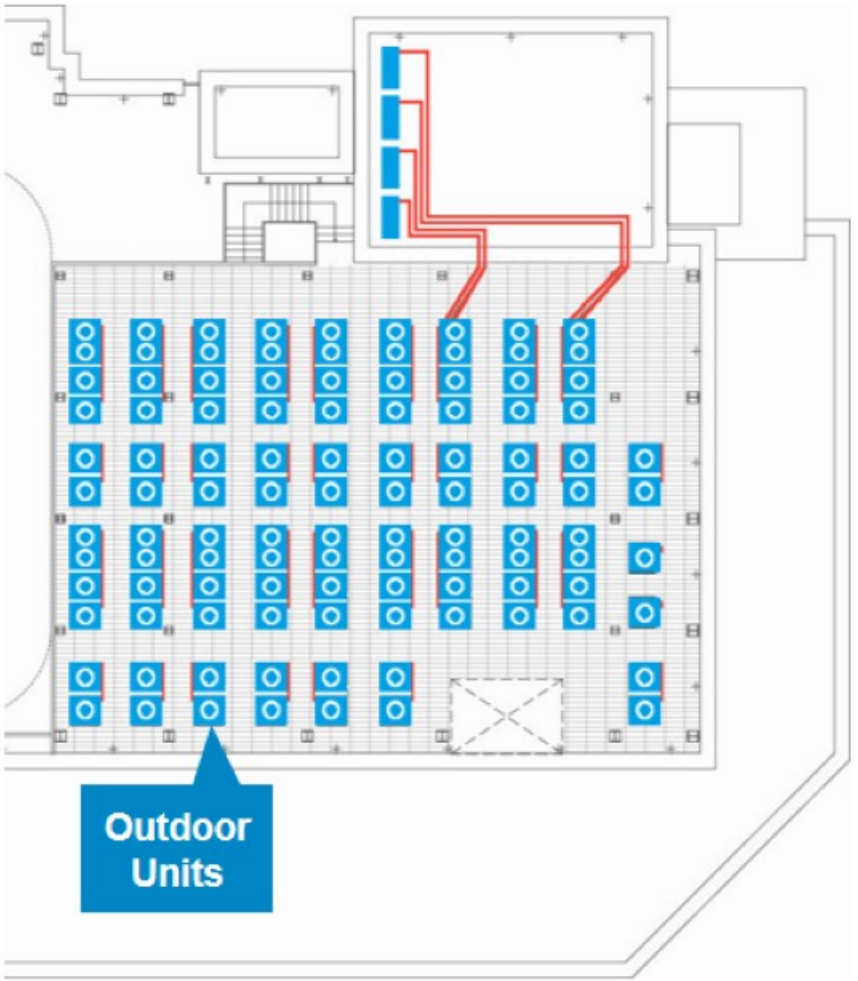


Example building (Office: Rooftop type)

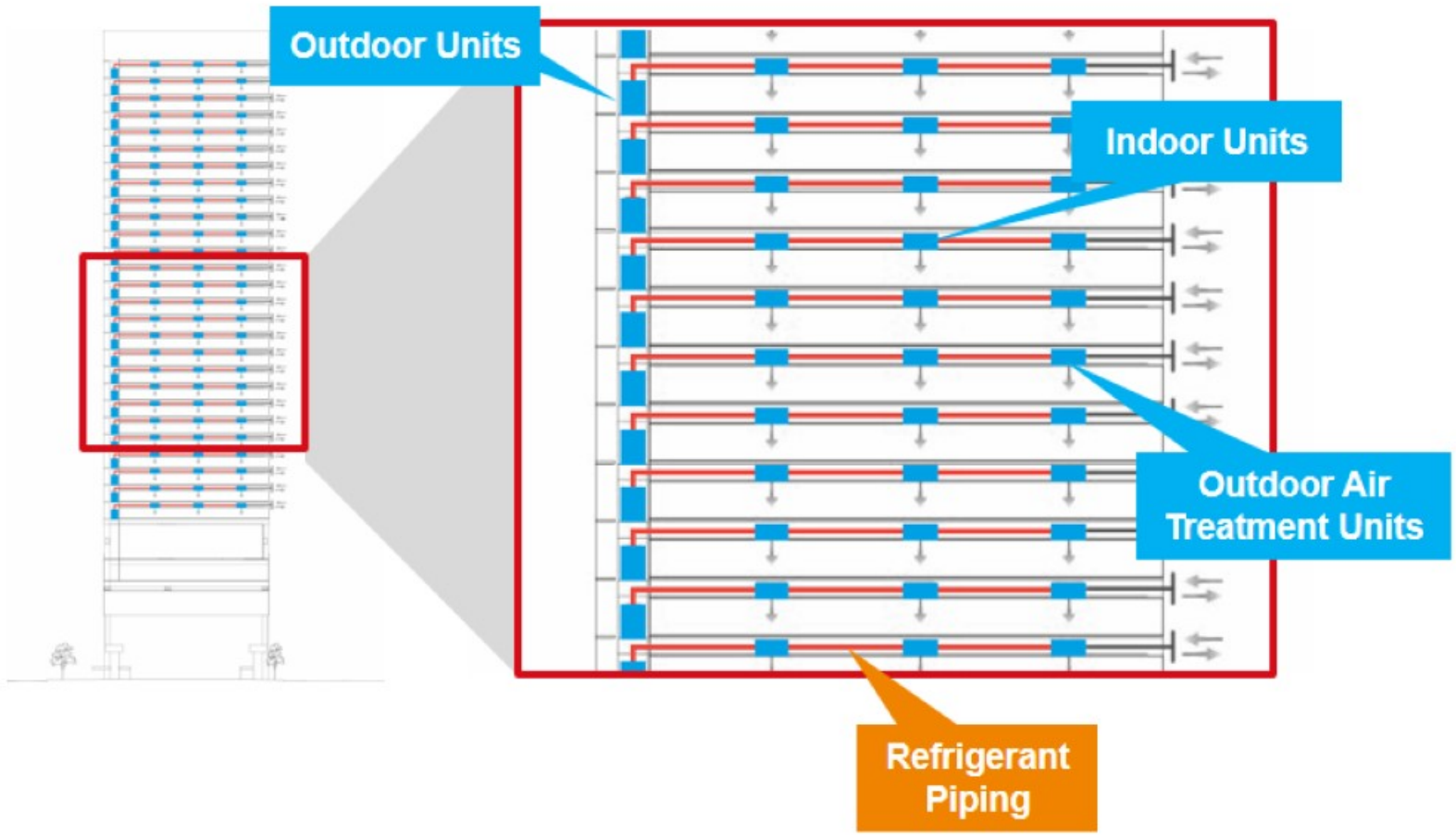
Typical Floor Plan



Roof Floor Plan



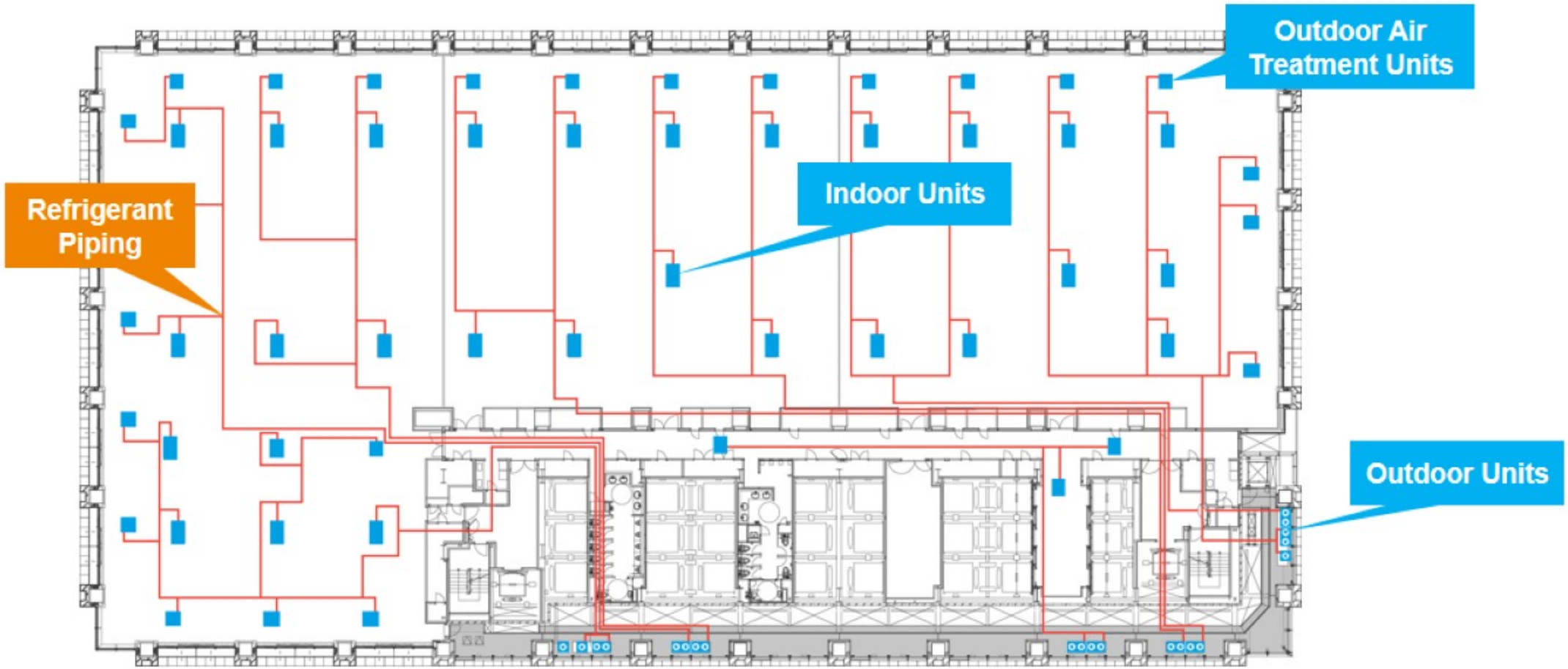
Example buildings (Office: Floor-by-floor type)



- Air-cooled outdoor units on each floor.
  (35 floors, 136,181 m^2 [1,465,840 sf])
- High energy efficiency - no auxiliary equipment, shorter refrigerant piping.
- Designed to control noise and exhaust hot air from outdoor units.

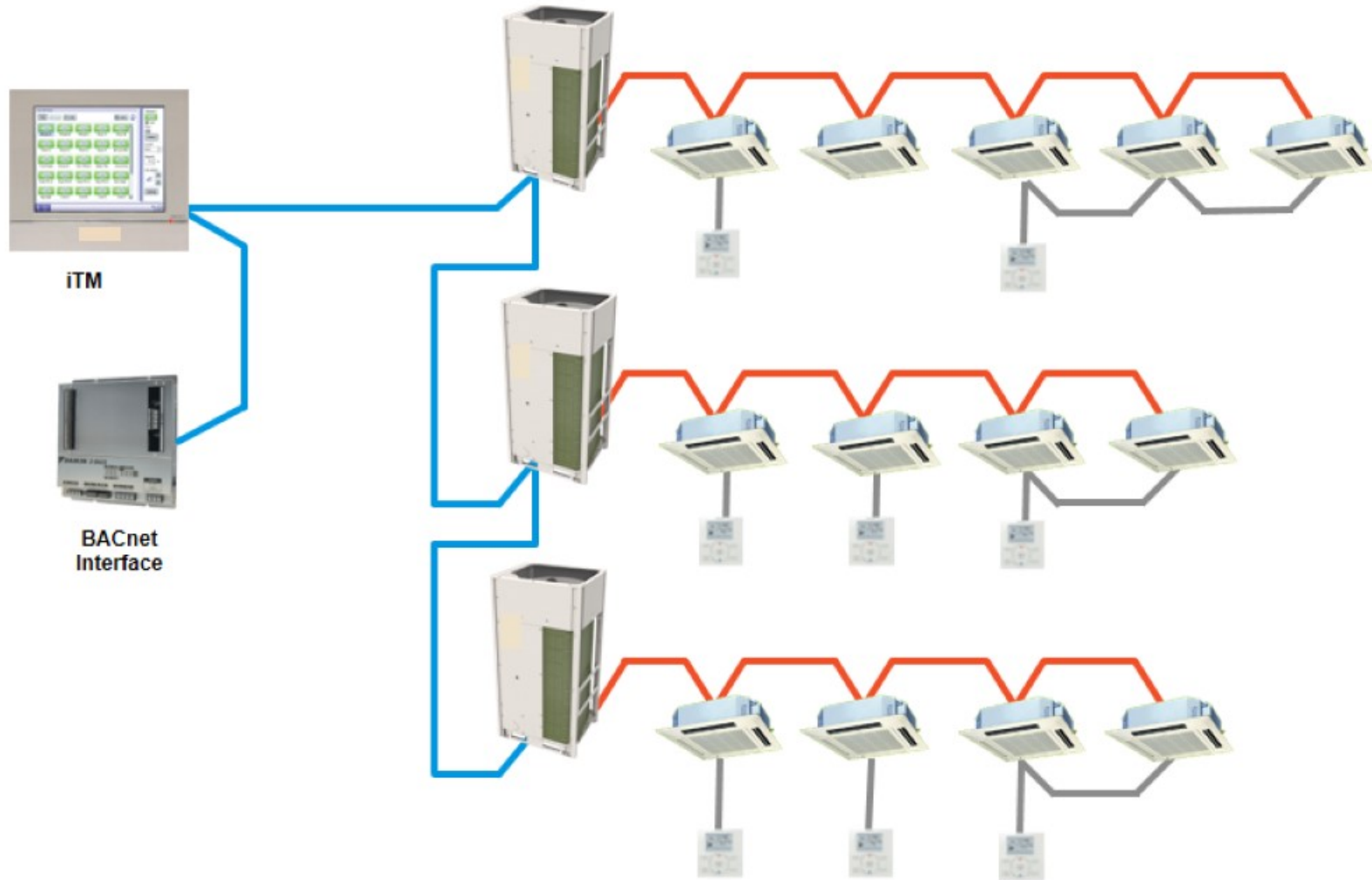
Example buildings (Office: Floor-by-floor type)

Typical Floor Plan



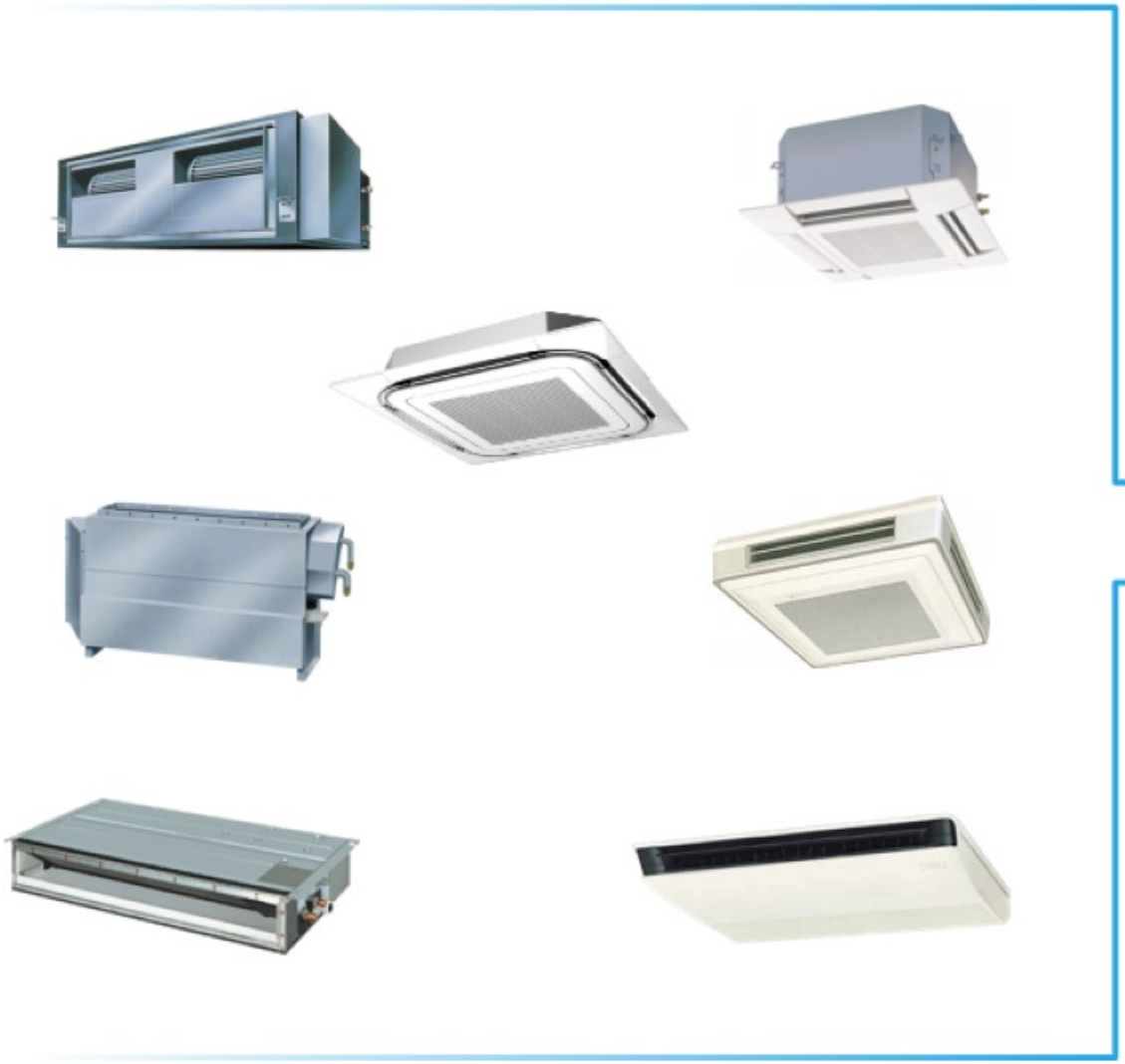
VRF Control Wiring

- 2 core daisy chain communication system
- 16-18 gauge AWG non shielded
- Stranded Wire
- Non polarized
- Up to 6560 ft. of total system wiring
- Longest linear length 3280 ft.



Simple, Easy, Flexible Wiring Installation

Connection Ratio



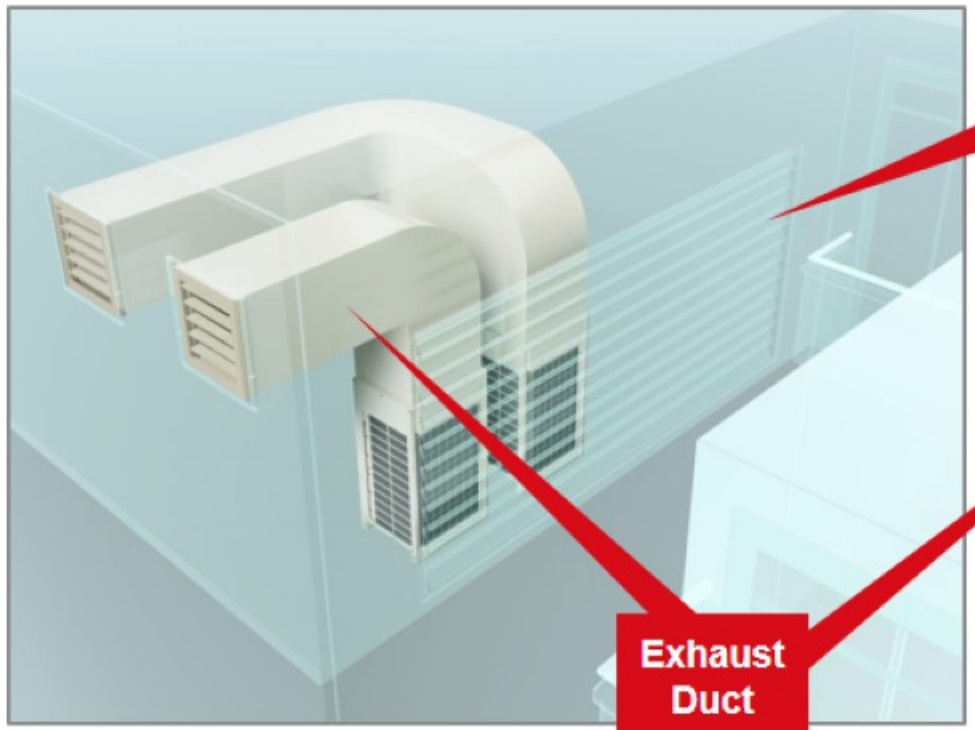
Maximum connection ratio can be:

130% **160%** **200%**

Depending on number of outdoor modules and indoor unit type

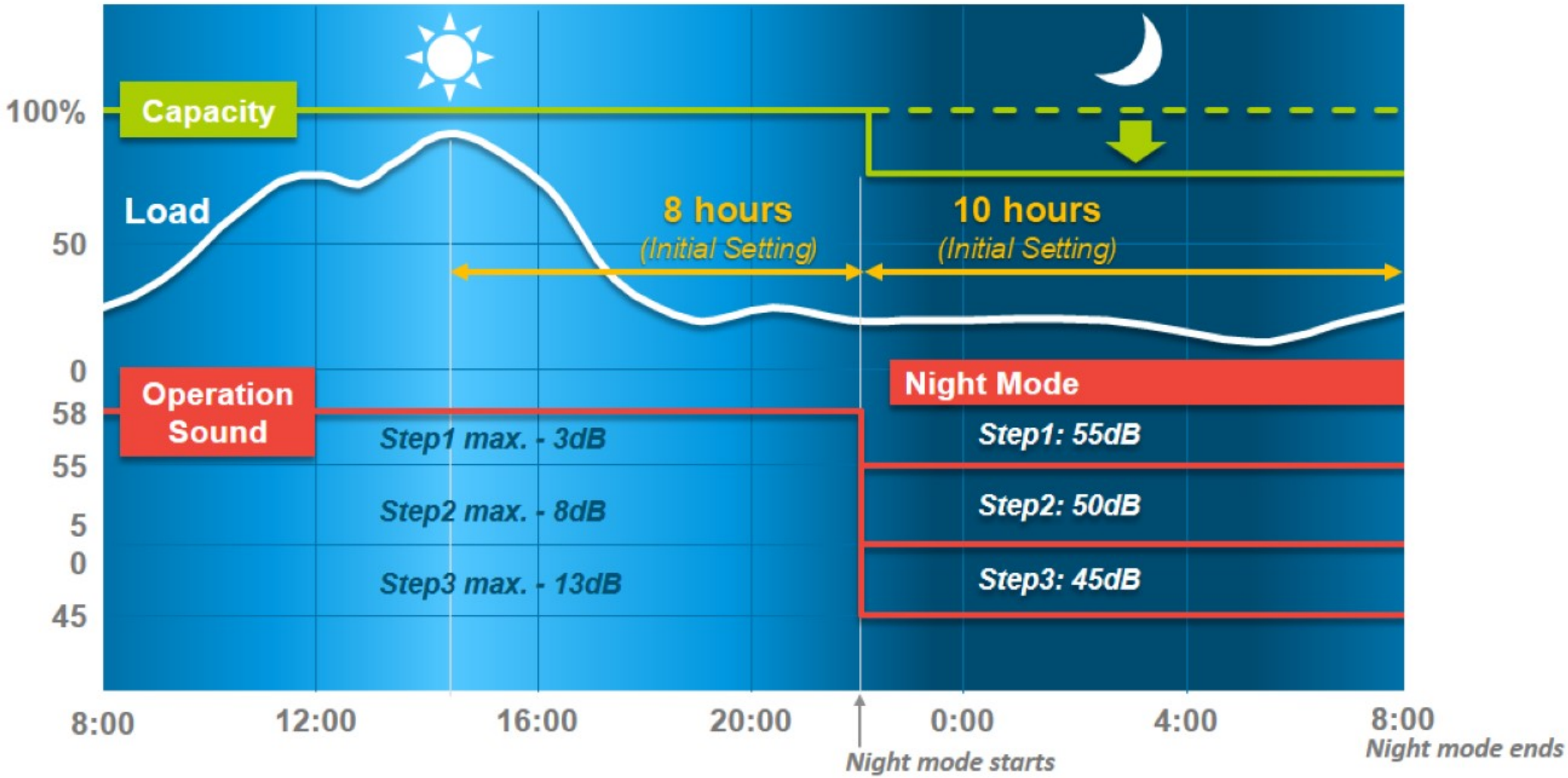
ODU Installation Flexibility

- Static pressures to 0.32WG (vertical discharge type)
- Internal/Restricted installs possible
- Noise, sight or location issues mitigated



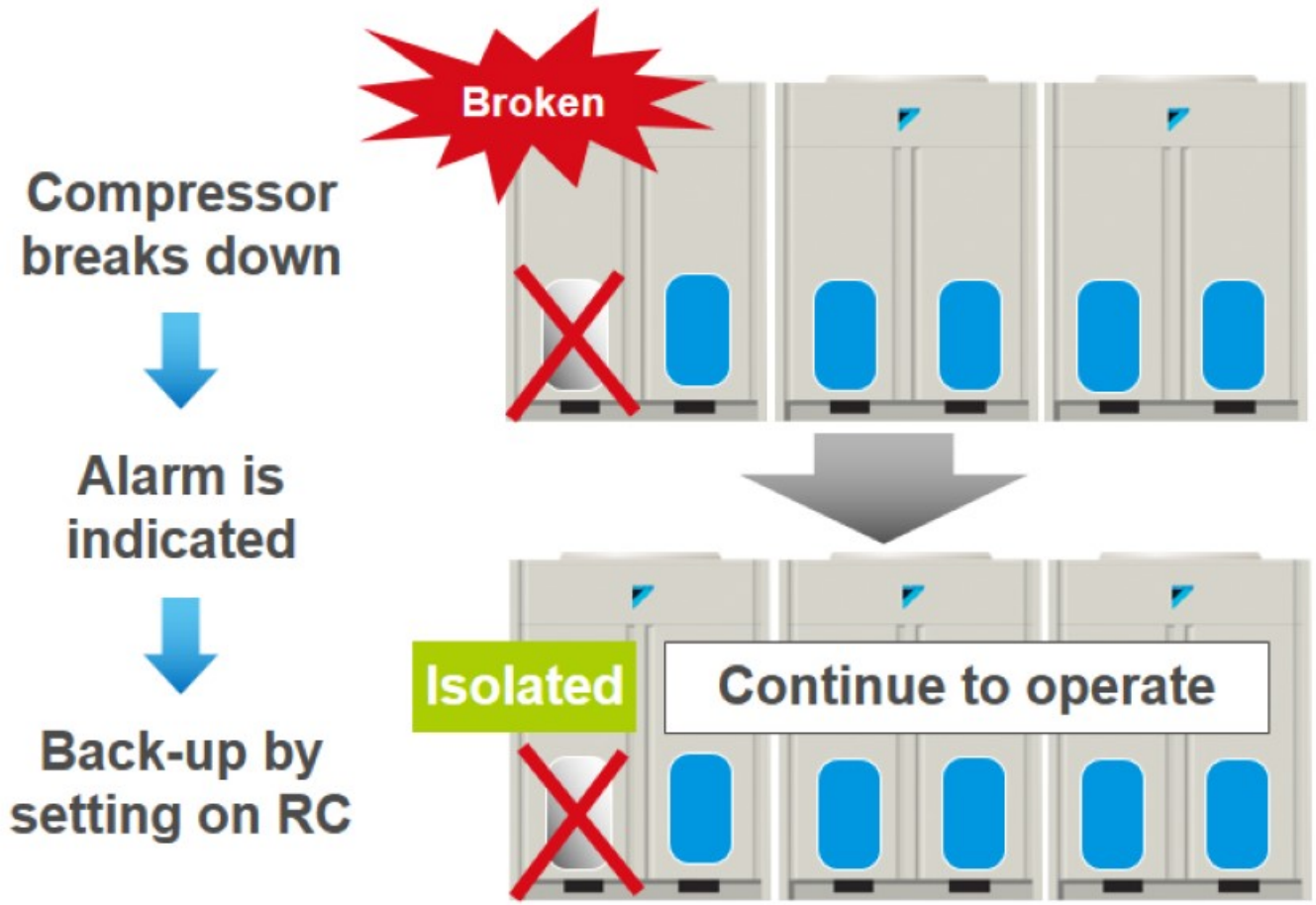
Acoustic performance during **night time** operation

Night Quiet Function



Compressor Failure - Back-up Function

Even though VRF compressor failure rate is extremely low the back-up function will give further “peace of mind”



The broken compressor can be repaired while the remaining units are still operating

In Summary

- VRF is an established method of air conditioning in the global market
- The concept was born out of a necessity to provide a more efficient commercial air conditioning system
- The modular DNA of the VRF equipment has seen it as a viable solution to applications from 1,000 ft² to an entire Industrial Campus
- The range and features of the indoor units provide the ability to optimize design for both efficiency and comfort
- The de-centralized nature of VRF, and the greatly reduced mechanical space requirements, sees it excel in refurbishment and phased installations
- The complexity of control available, both at room and building level, compliment efficiency and comfort requirements – and as a small % of overall equipment cost

Thank you for your time!

QUESTIONS?

This concludes the educational content of this activity

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