



ASHRAE NB/PEI
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VARIABLE REFRIGERANT FLOW SYSTEMS

Technology Overview

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VRF Presentation Contents

1. What is Variable Refrigerant Flow?
2. Why do we use VRF system?
3. How does VRF work?
4. VRF Indoor/Outdoor Units Capacity Control
5. Benefits of VRF Capacity Control
6. Different VRF Systems
7. Design Around Diversity
8. Comparing VRF to « Conventional Systems »

What is Variable Refrigerant Flow?

The Variable Speed Technology has advanced dramatically over the past years.

VAV: Variable Air Volume (Air handlers)

VFD: Variable Frequency Drive (Pumps & Fans)

VRF: Variable Refrigerant Flow

VRV: Variable Refrigerant Volume

What is Variable Refrigerant Flow?

ASHRAE Journal April 2007

The term “*Variable Refrigerant Flow refers to the capability of a HVAC system to control the amount of refrigerant flowing to each of the indoor units/evaporators, enabling the use of multiple evaporators of differing capacities and configurations, individualized comfort control, simultaneous heating and cooling in different zones with heat recovery from one zone to another*”

AHRI Standards & Policy Committee June 2009

Variable Refrigerant Flow (VRF) System is an engineered direct expansion (DX) multi-split system incorporating at least one variable capacity compressor distributing refrigerant through a piping network to multiple indoor fan coil units each capable of individual zone temperature control, through a zone temperature control devices and common communications network. Variable refrigerant flow implies three or more steps of control on common, inter-connecting piping

What are VRF Multi Split units?

VRF Multi Split
Direct expansion systems

Used to cool and heat buildings

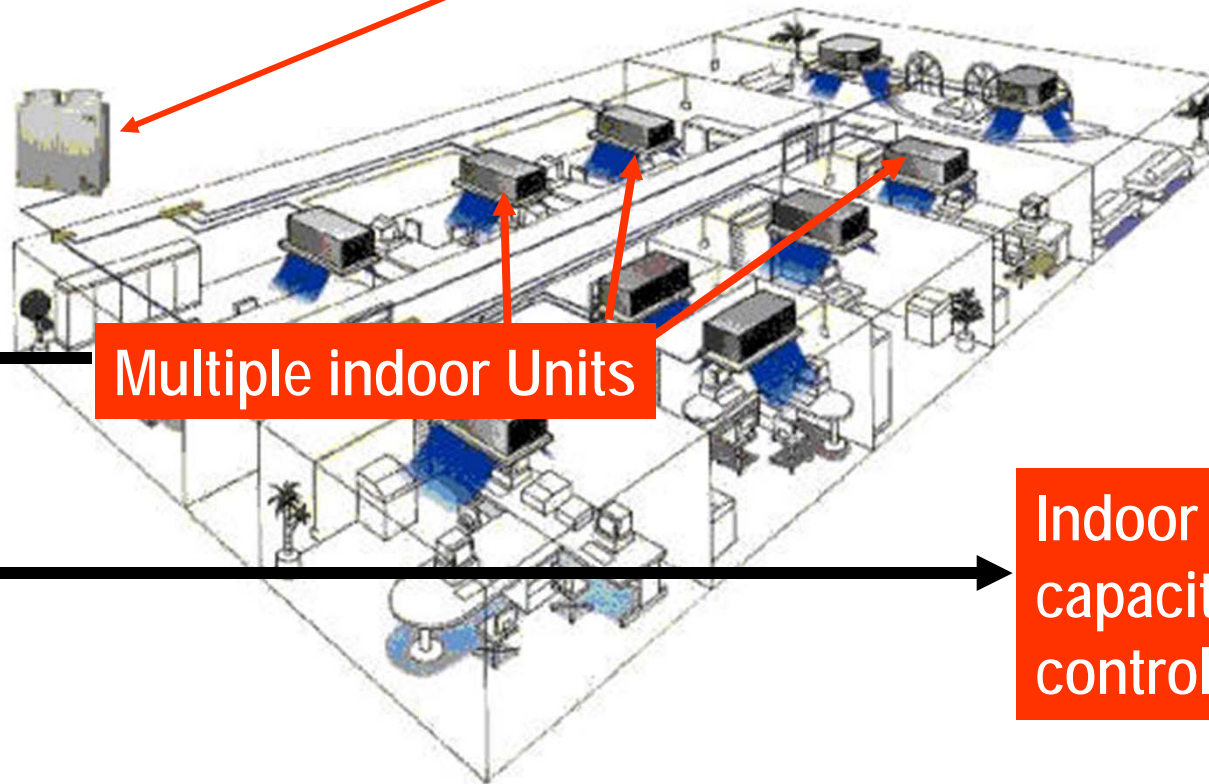
Variable
capacity
Compressor

1 Outdoor Unit

Multiple indoor Units

Individual
control of
indoor units

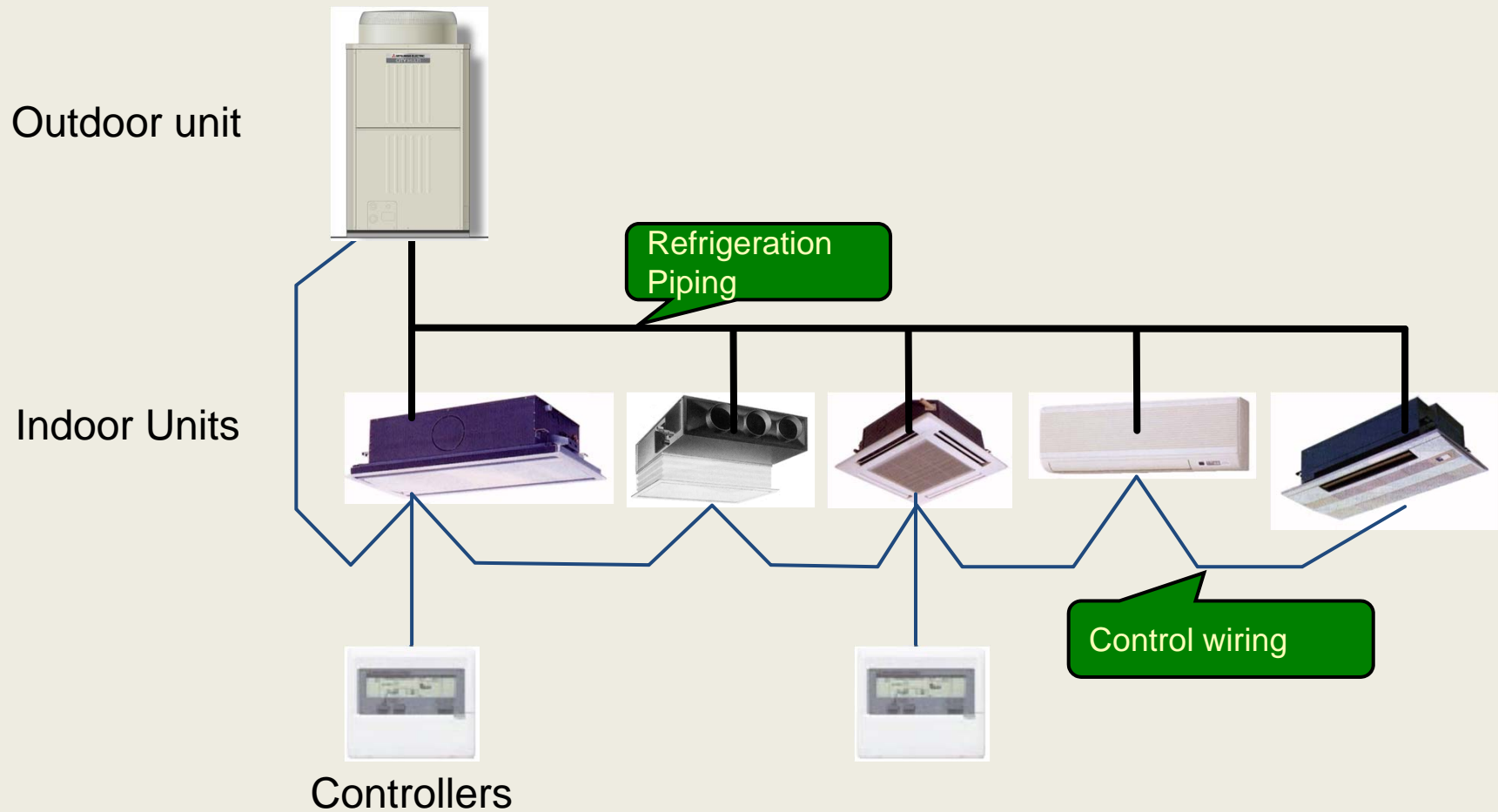
Indoor unit
capacity
control



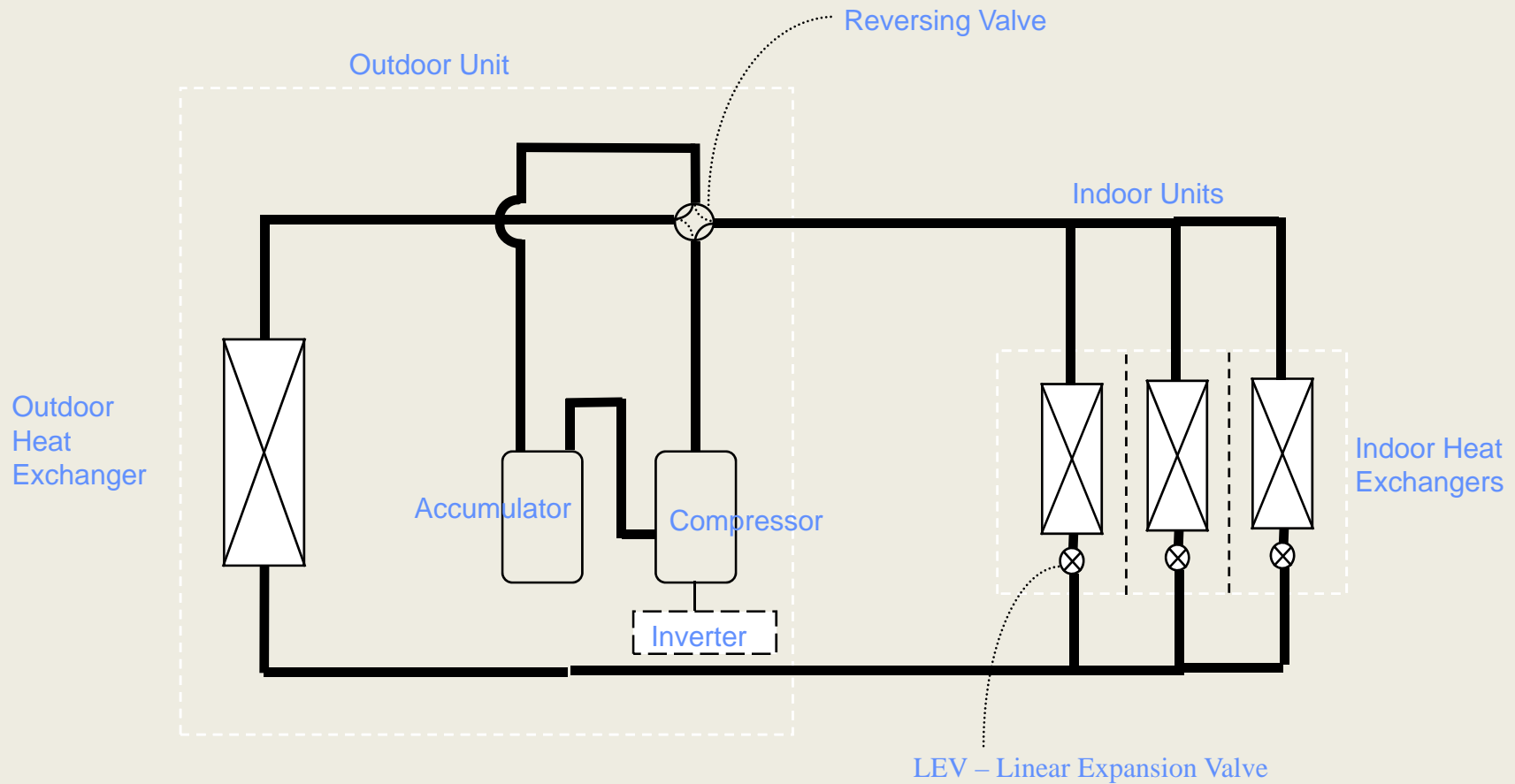
Why do we use VRF Systems?

- Decentralized System – Zone Comfort
- Efficiency – Pay for what you use
- Flexible
- Simple to design
- Easy to install and commission
- Good value

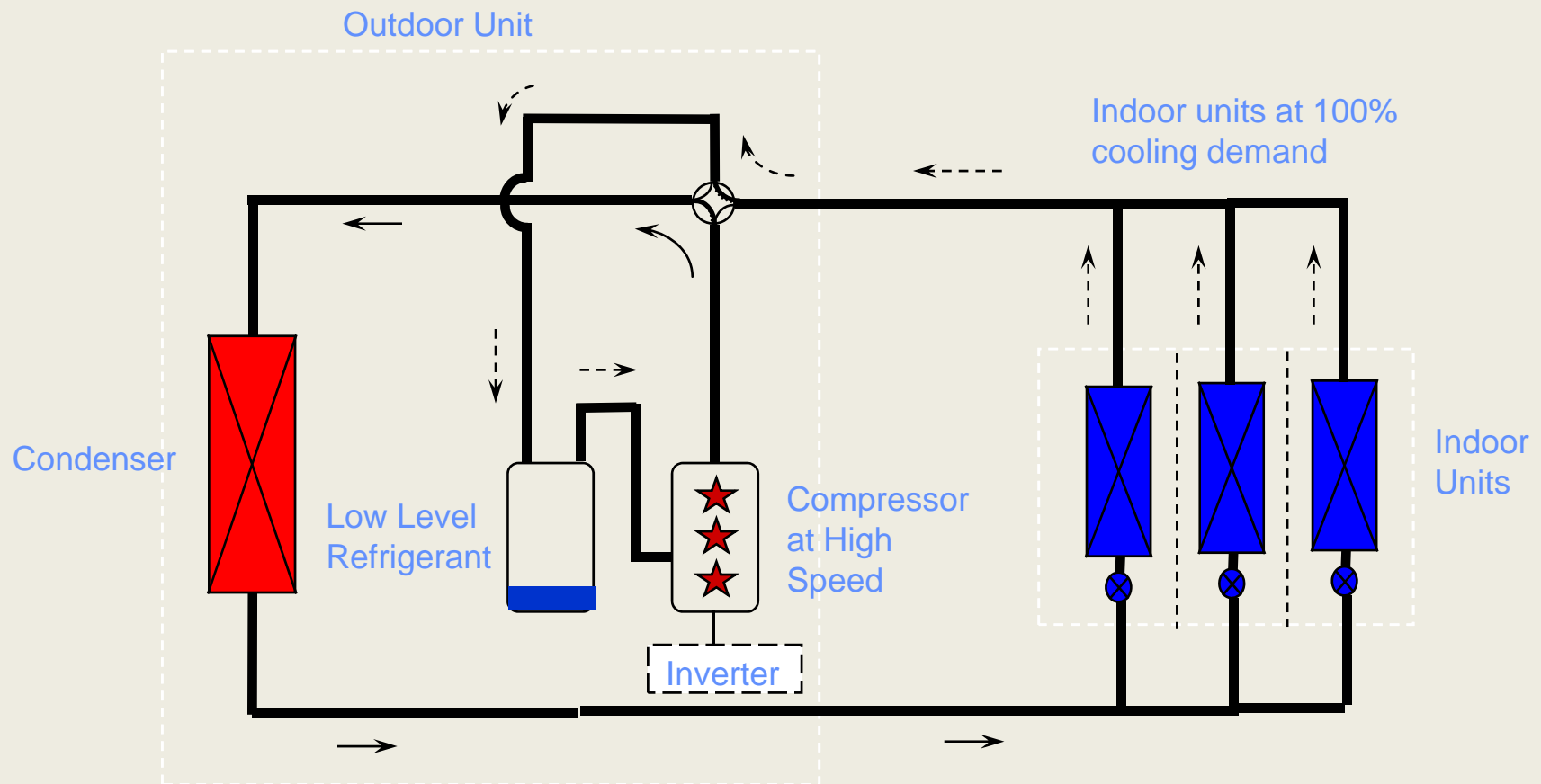
How does VRF work?



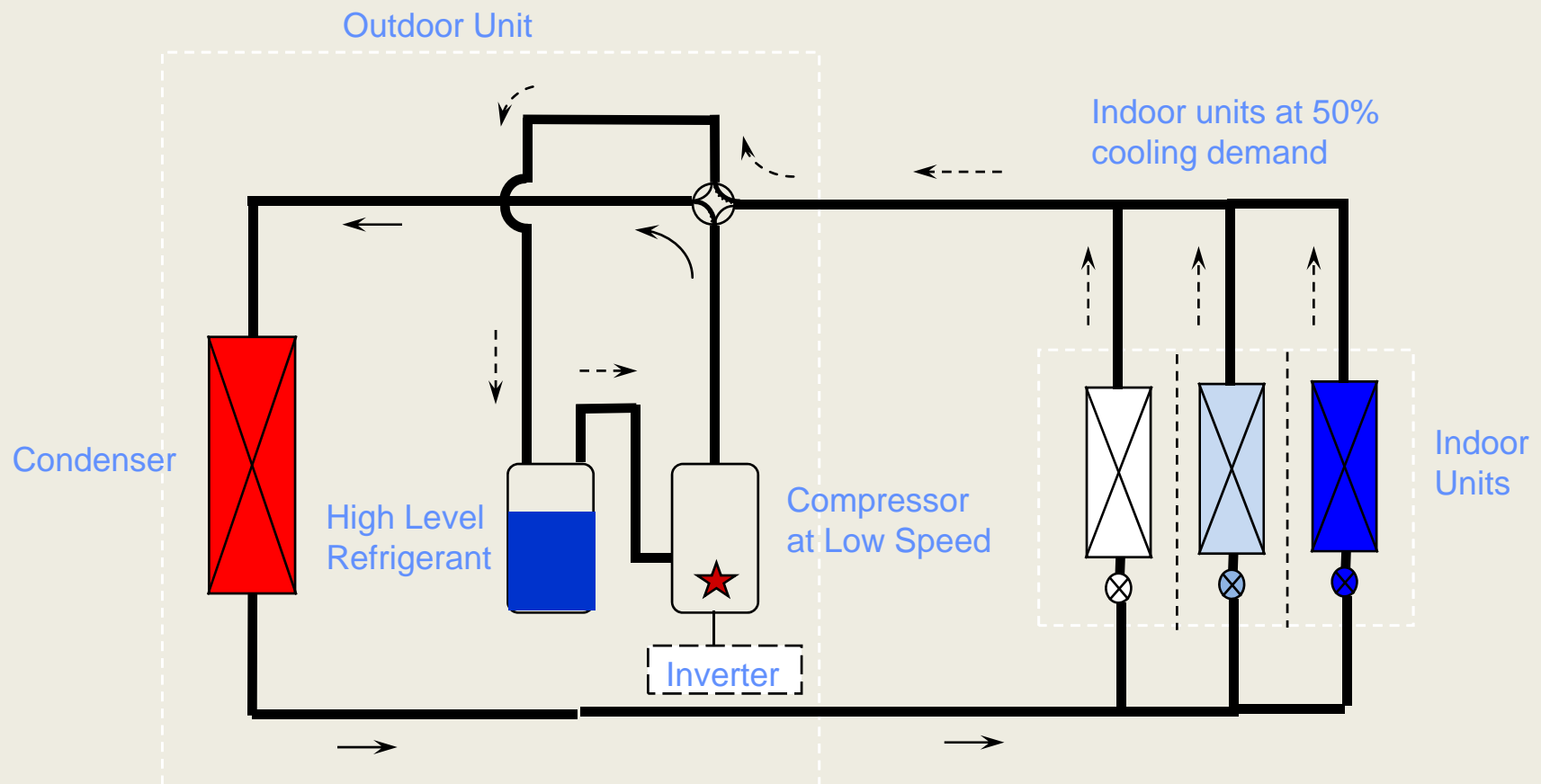
How does VRF work?



100% Cooling Demand

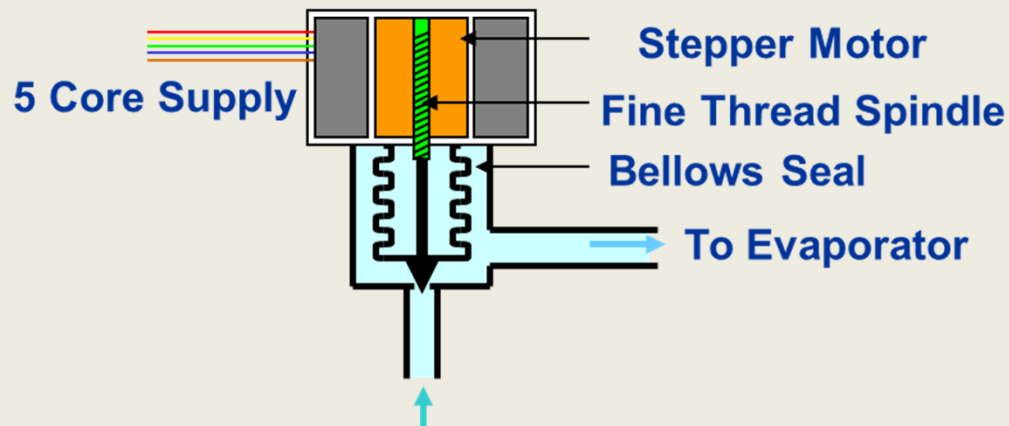


50% Cooling Demand



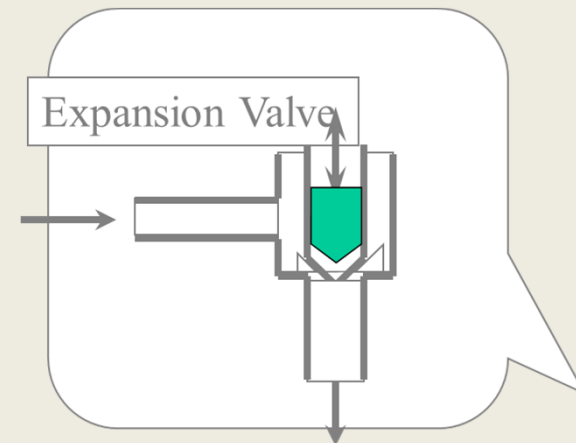
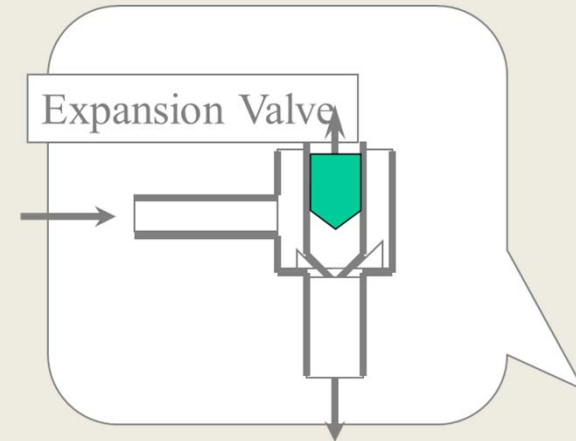
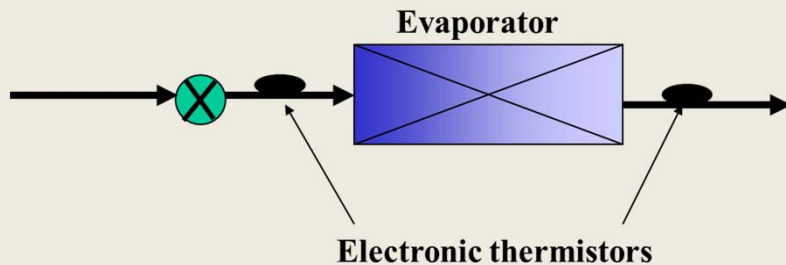
Indoor Unit Capacity Control

- Indoor units individually controlled by LEV
- LEV has 2 functions
 - Control the superheat across indoor unit evaporator
 - Acts as solenoid valve to stop refrigerant flow to indoor units that are off



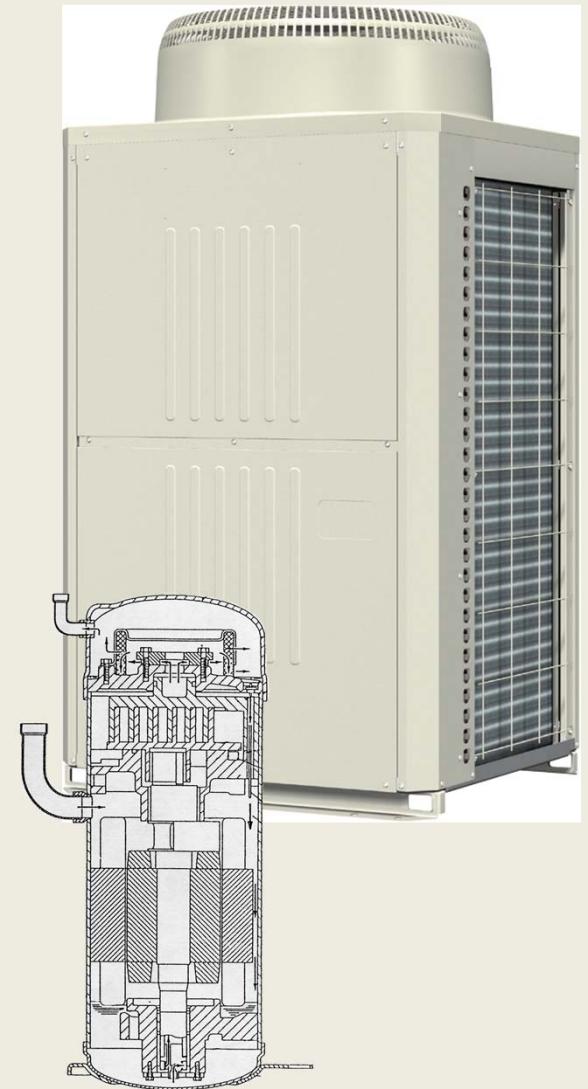
Smart Indoor Coil Design

- If superheat is high the valve will open
- If Superheat is low the valve will close



Outdoor Unit Capacity Control

- Compressor speed is controlled by a VFD based on common saturated suction temperature and capacity required
- Refrigerant volume flow is directly proportional to the compressor speed
- Power input is directly proportional to the cube of the compressor speed



Combined indoor and outdoor Capacity Control

Indoor Heat Load High all zones

1.) Superheat high

3.) Saturated suction temperature high

5.) Refrigerant pumping volume high

Outdoor Heat Exchanger

Accumulator

Compressor

Variable speed control

Zone A Zone B Zone C

Indoor unit
Heat Exchangers

Indoor units

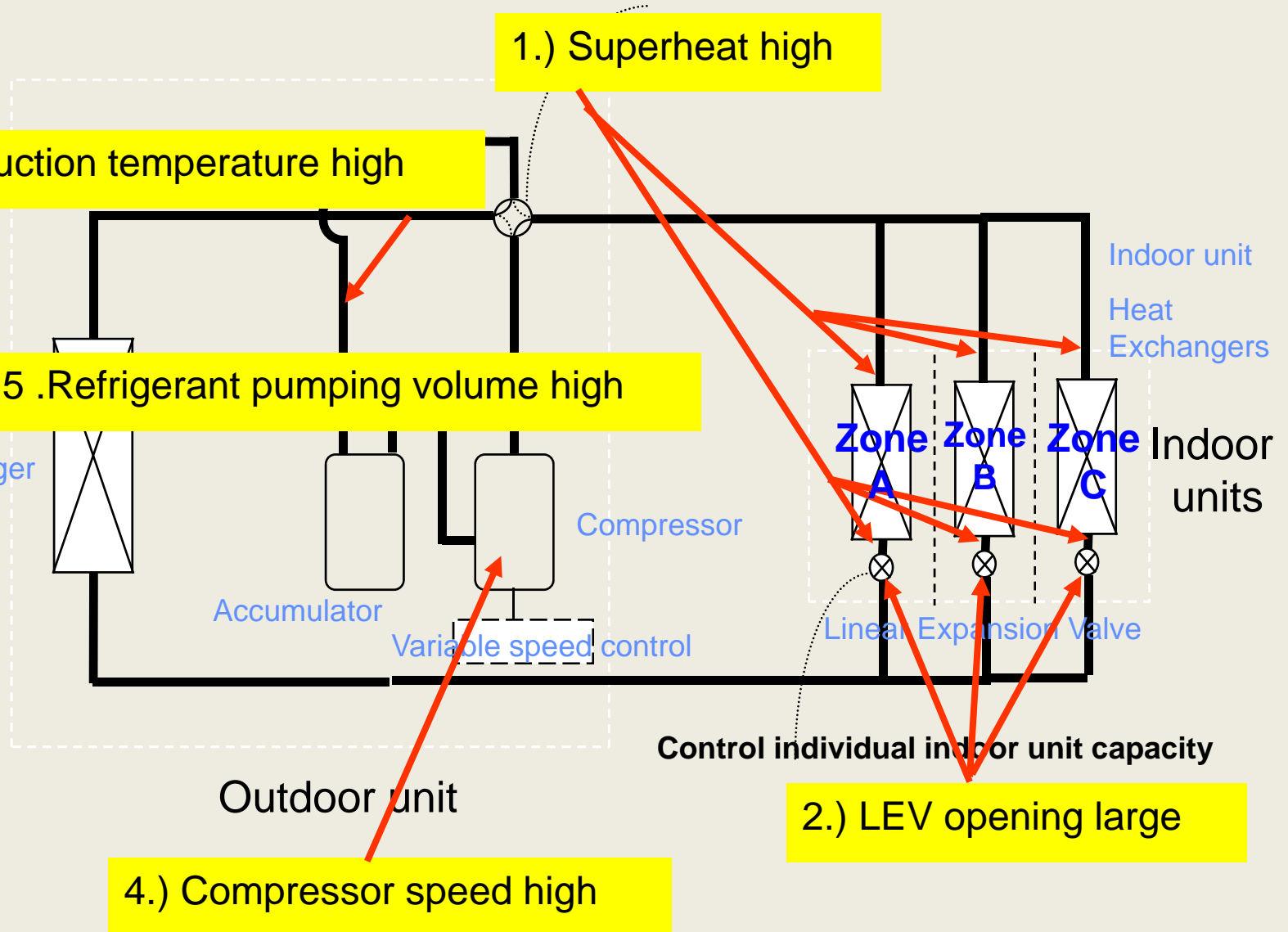
Linear Expansion Valve

Control individual indoor unit capacity

2.) LEV opening large

4.) Compressor speed high

Outdoor unit



Combined indoor and outdoor Capacity Control

Indoor Heat Load : Zone A High
Zone B Medium
Zone C Zero

6.) Saturated suction temperature lowers

1.) Superheat high

3.) Superheat Lower

8.) Refrigerant pumping volume lowers

Outdoor Heat Exchanger

Indoor unit
Heat Exchangers

Zone A Zone B Zone C Indoor units

Compressor

Accumulator

Variable speed control

Linear Expansion Valve

2.) LEV opening large

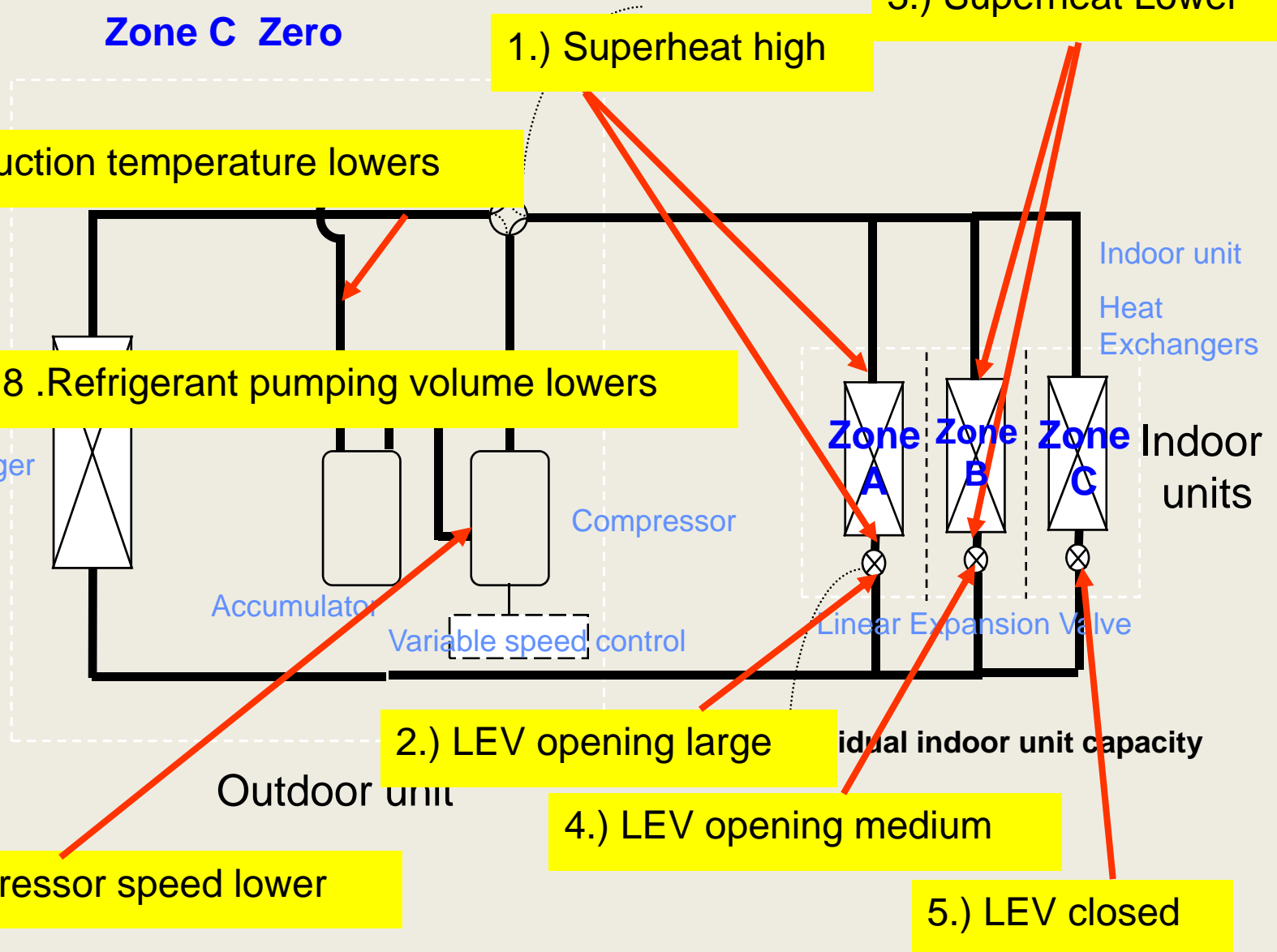
Individual indoor unit capacity

4.) LEV opening medium

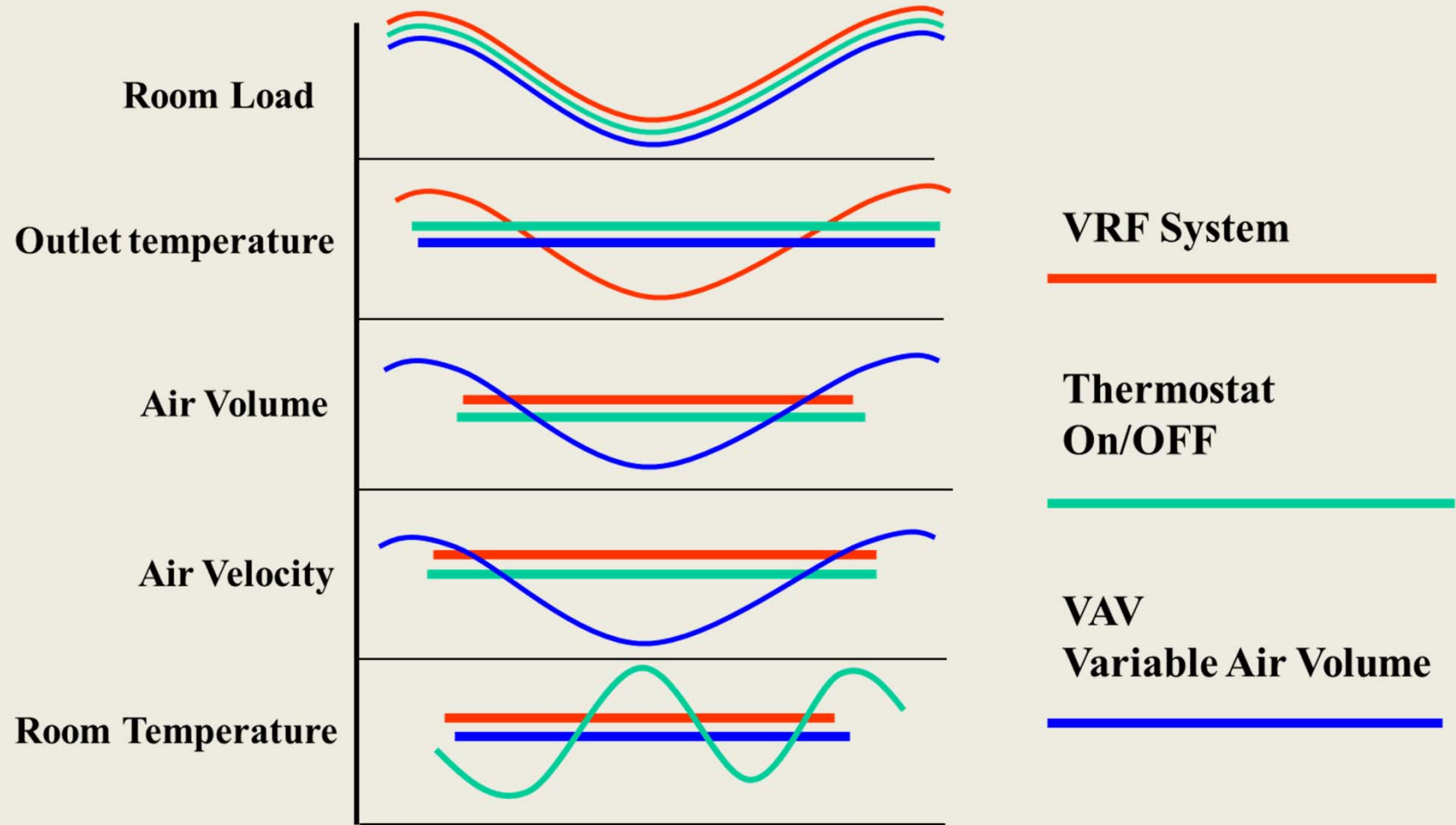
7.) Compressor speed lower

5.) LEV closed

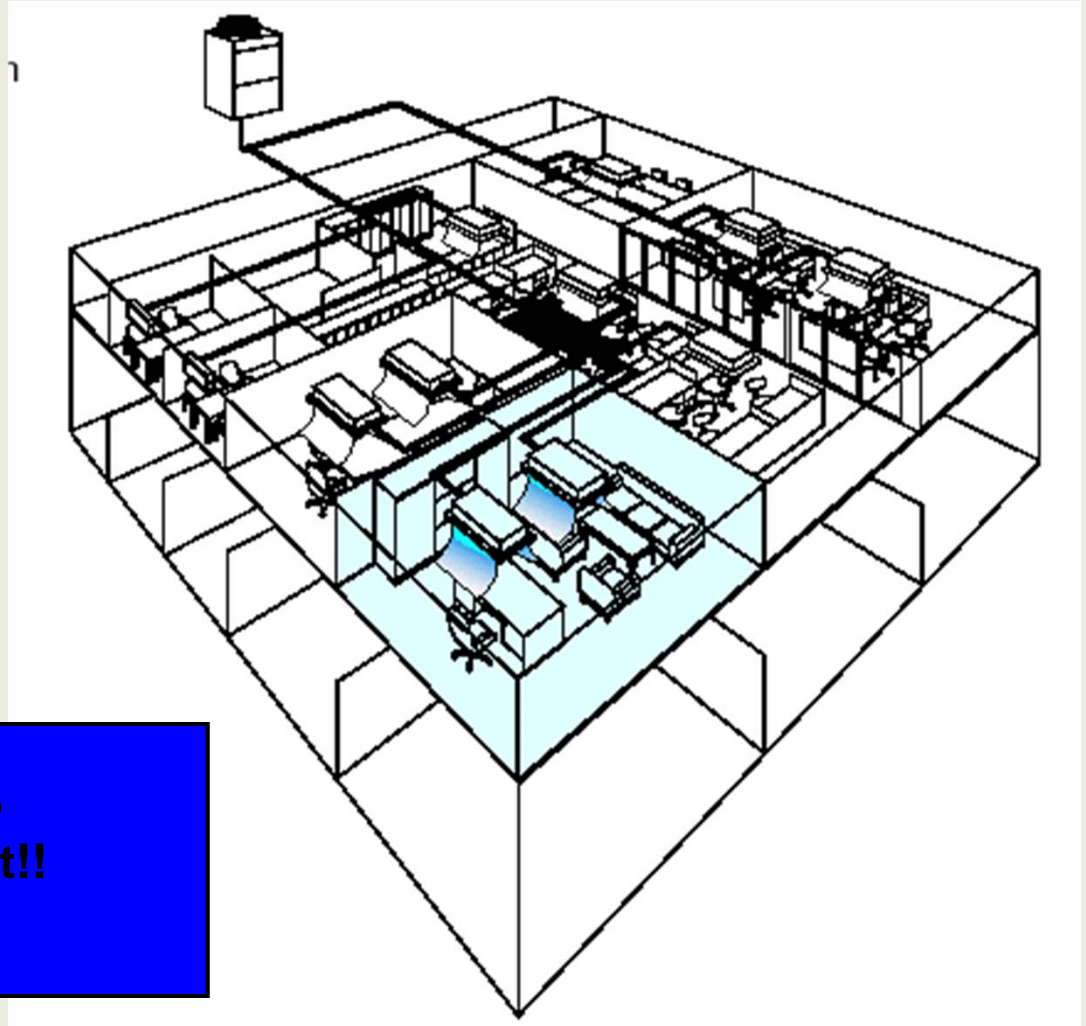
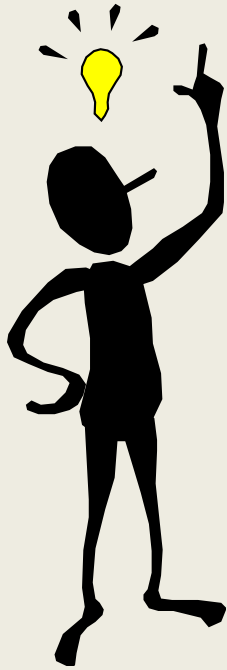
Outdoor unit



VRF control compared to conventional systems



Comfortable and Efficient Operation in each zone

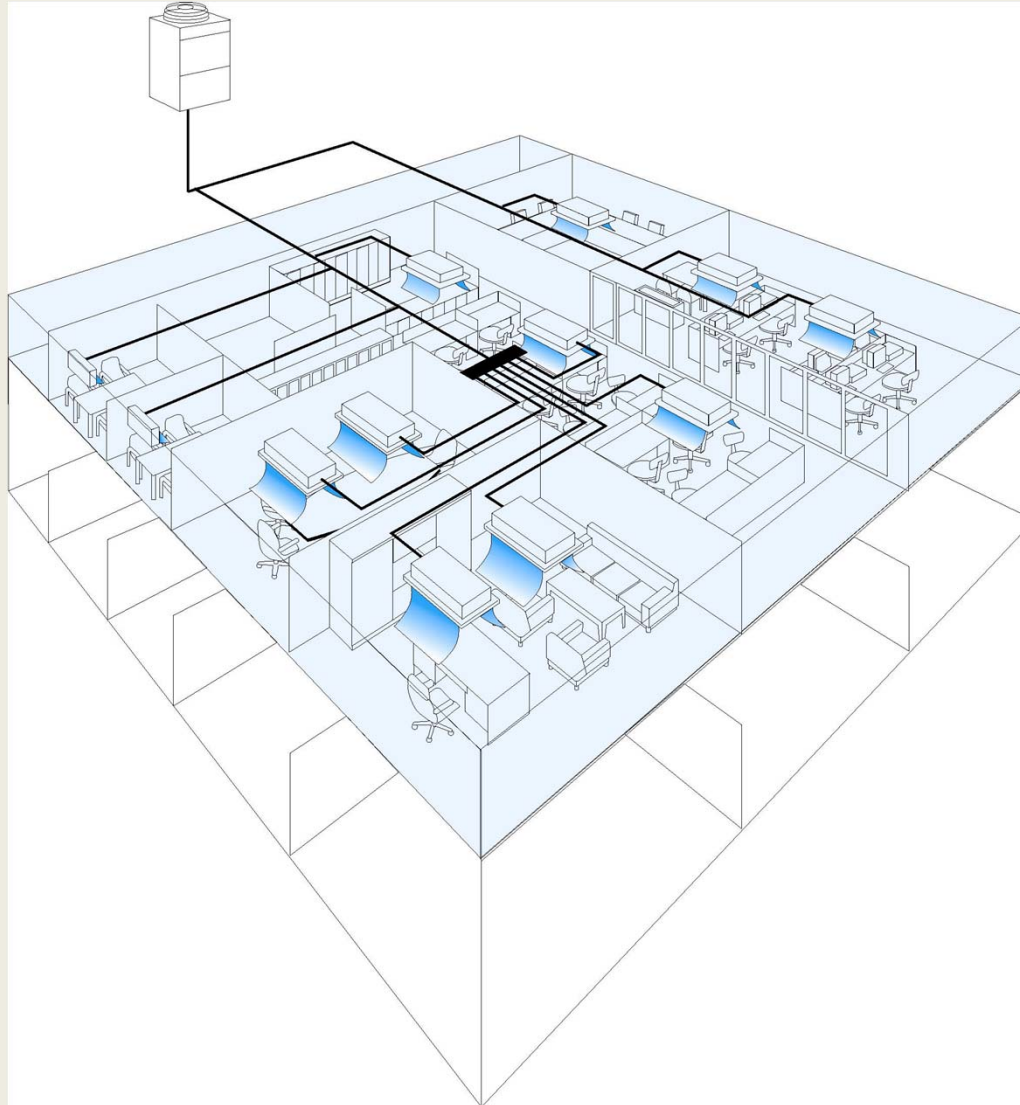


**ZONE Air Conditioning to
meet individual requirement!!
< Only 1 room >**

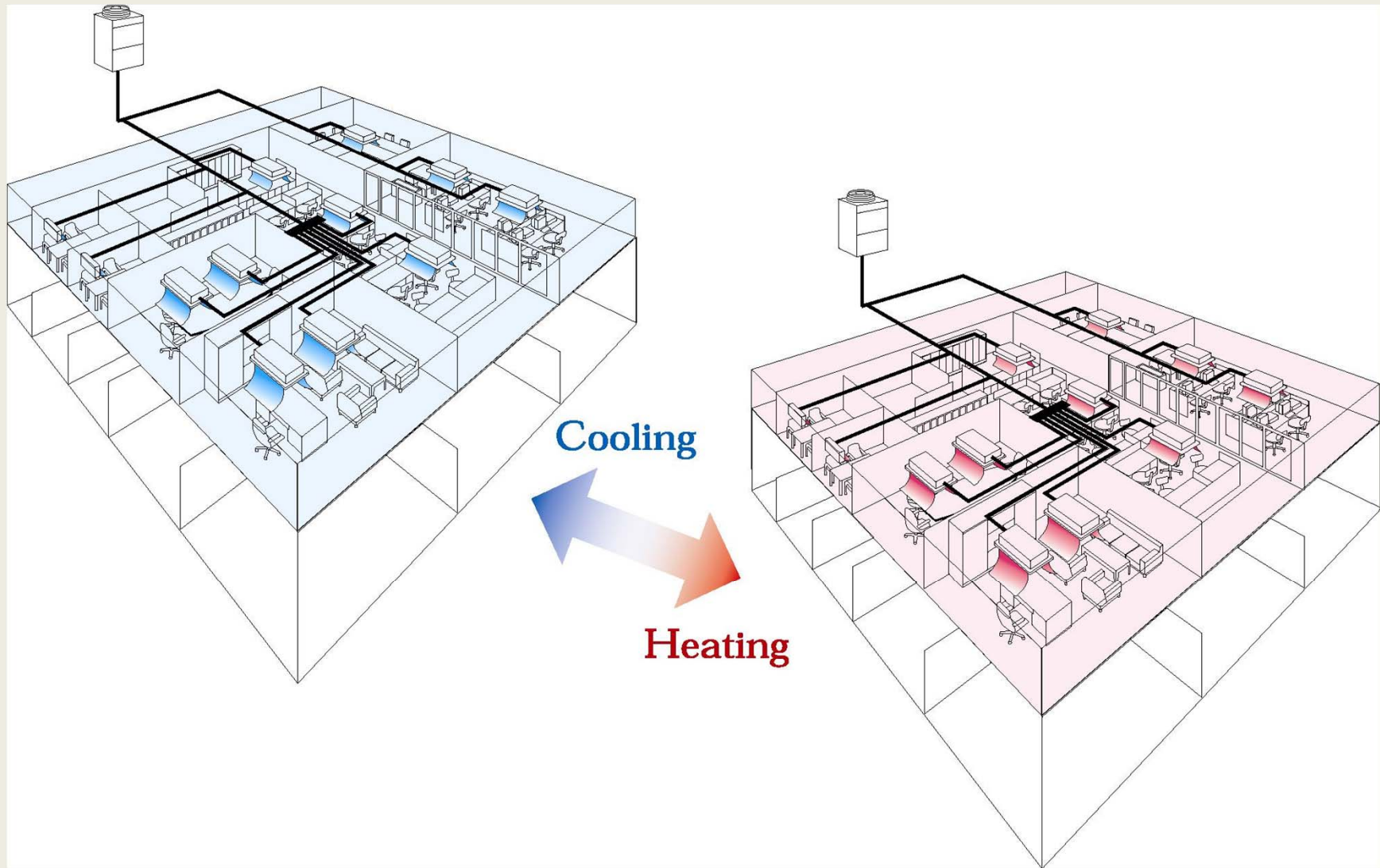
Different VRF Systems

- 2 Pipe System cooling only
- 2 Pipe System heat pump cooling or heating
- 3 Pipe System simultaneous cooling and heating
- 2 Pipe System simultaneous cooling and heating – air cooled
- 2 Pipe System simultaneous cooling and heating – water and geothermal application

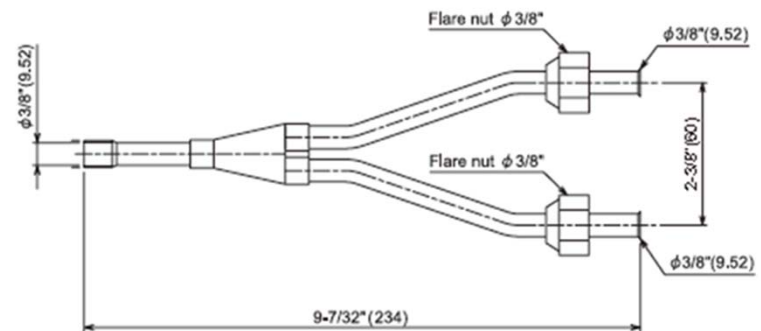
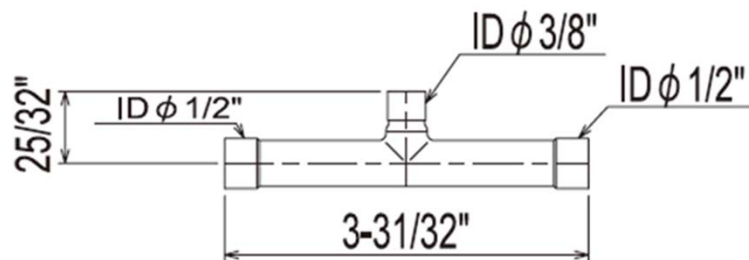
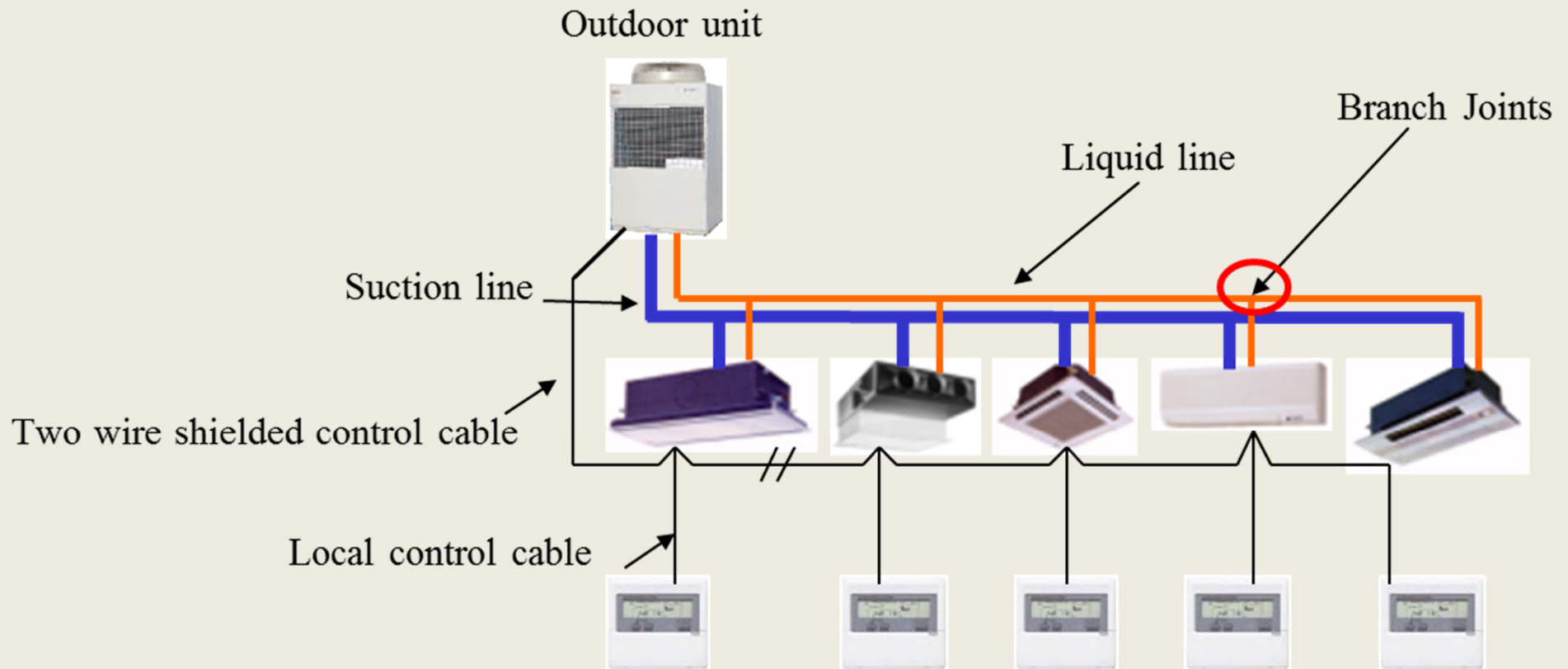
2 Pipe System cooling only



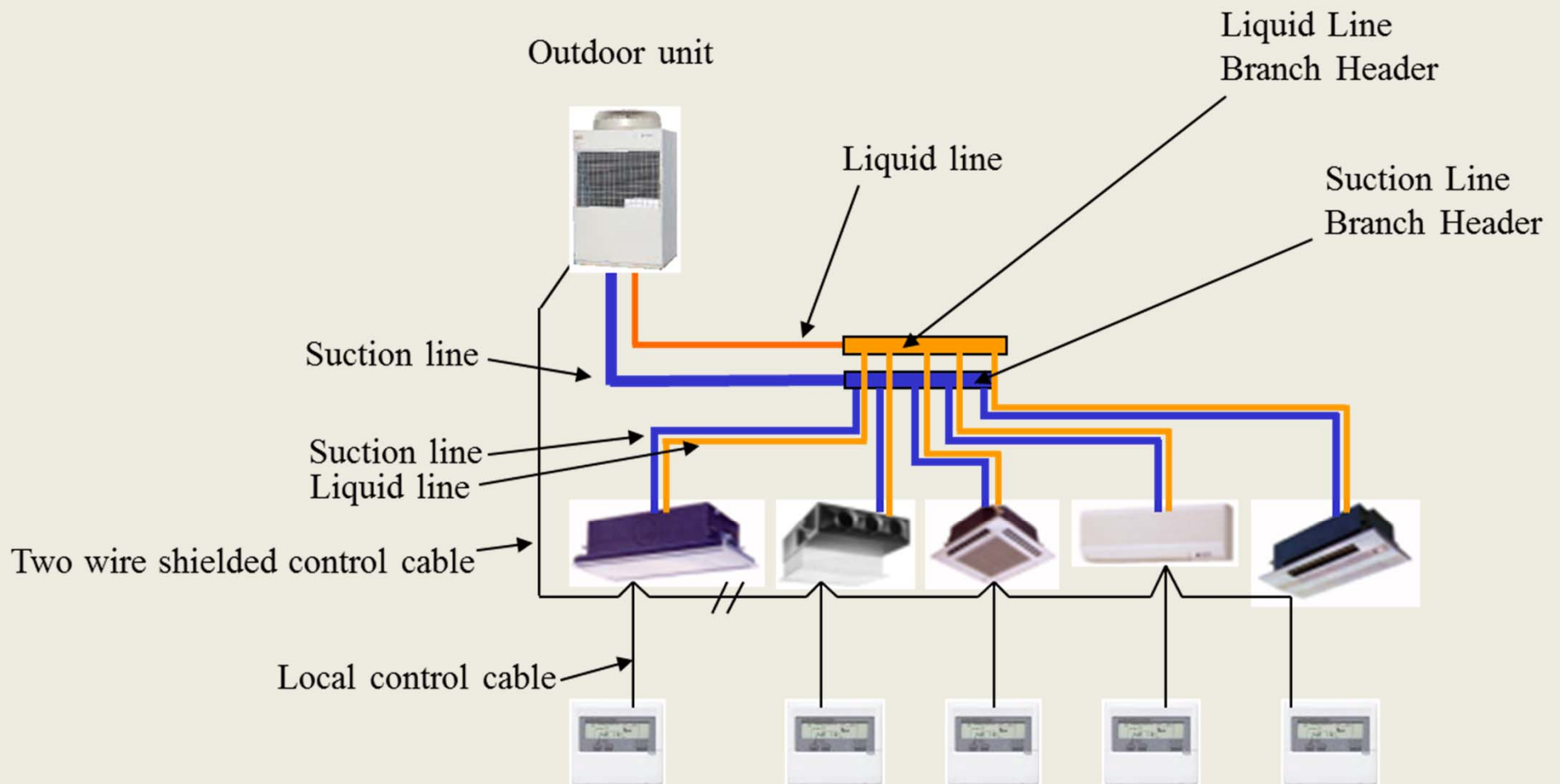
2 Pipe System cooling or heating



2 Pipe System using branch joints



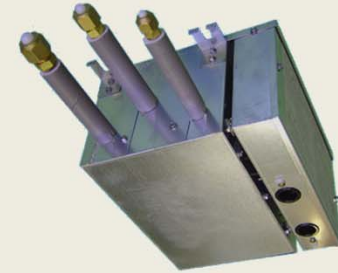
2 Pipe System using branch header



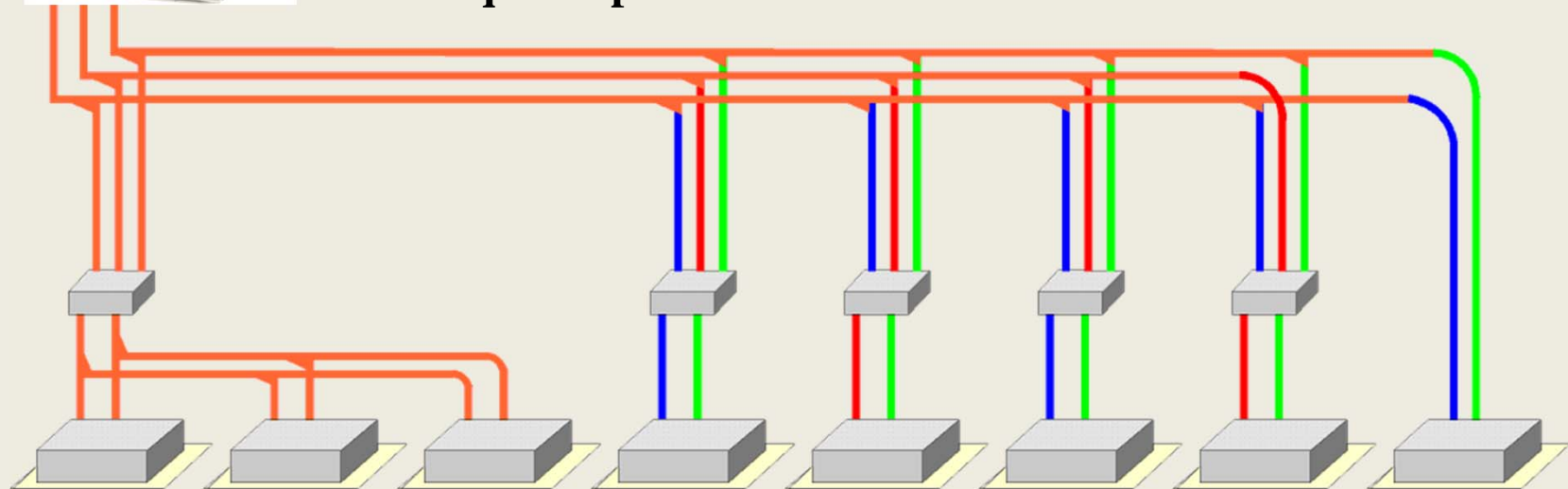
3 Pipe simultaneous cool and heat



- 1. - Suction Pipe
- 2. - Hot gas Pipe
- 3. - Liquid Pipe



Branch selector

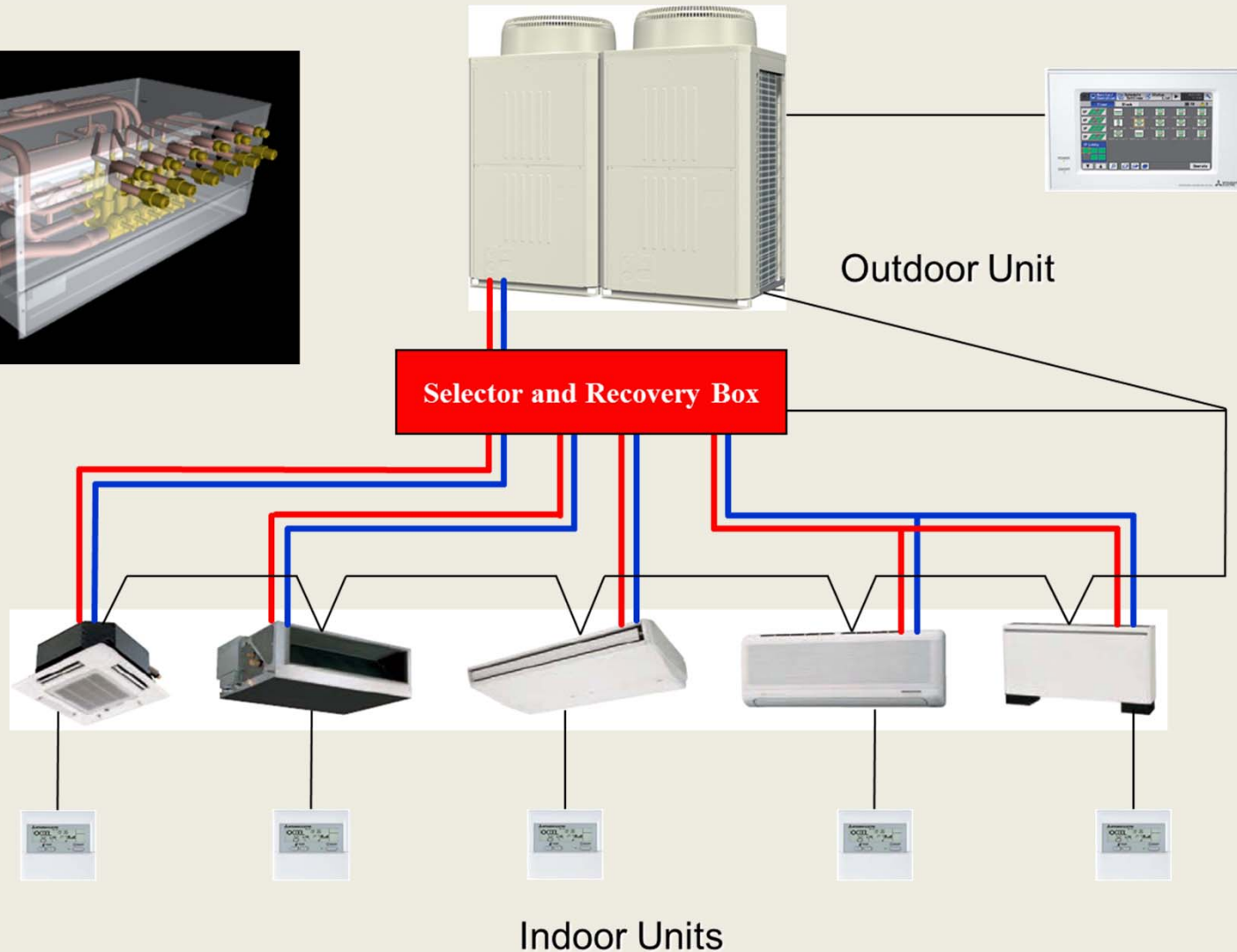
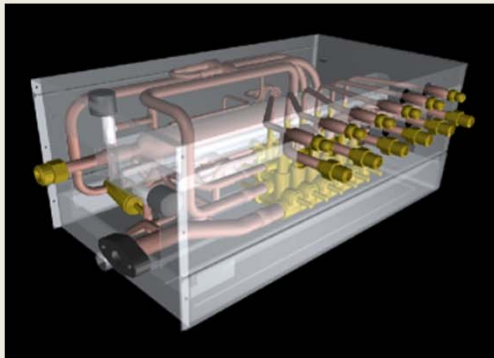


Same Operation mode
but individual control

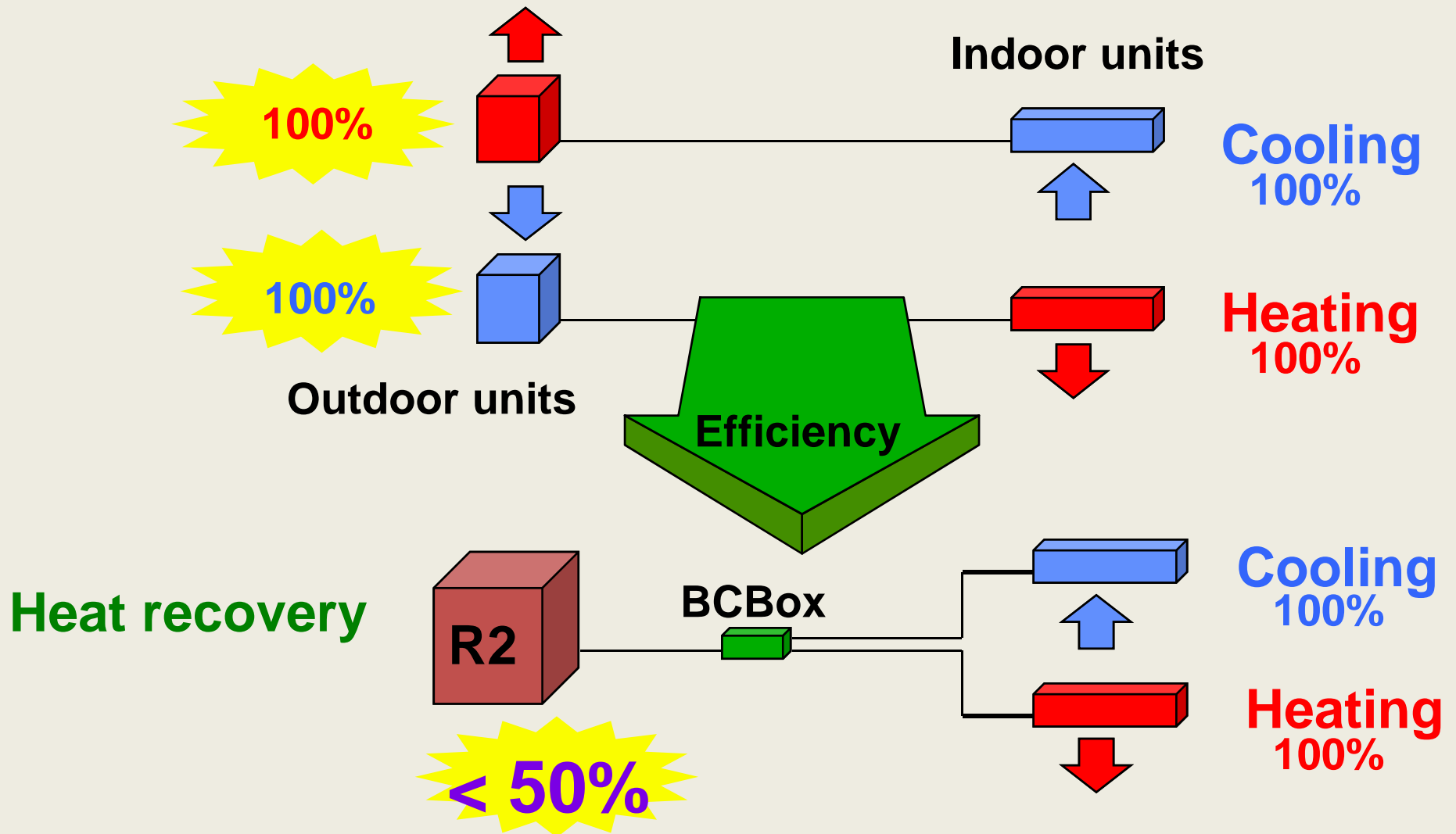
Cooling
Only

2 Pipe simultaneous cool and heat

Air cooled

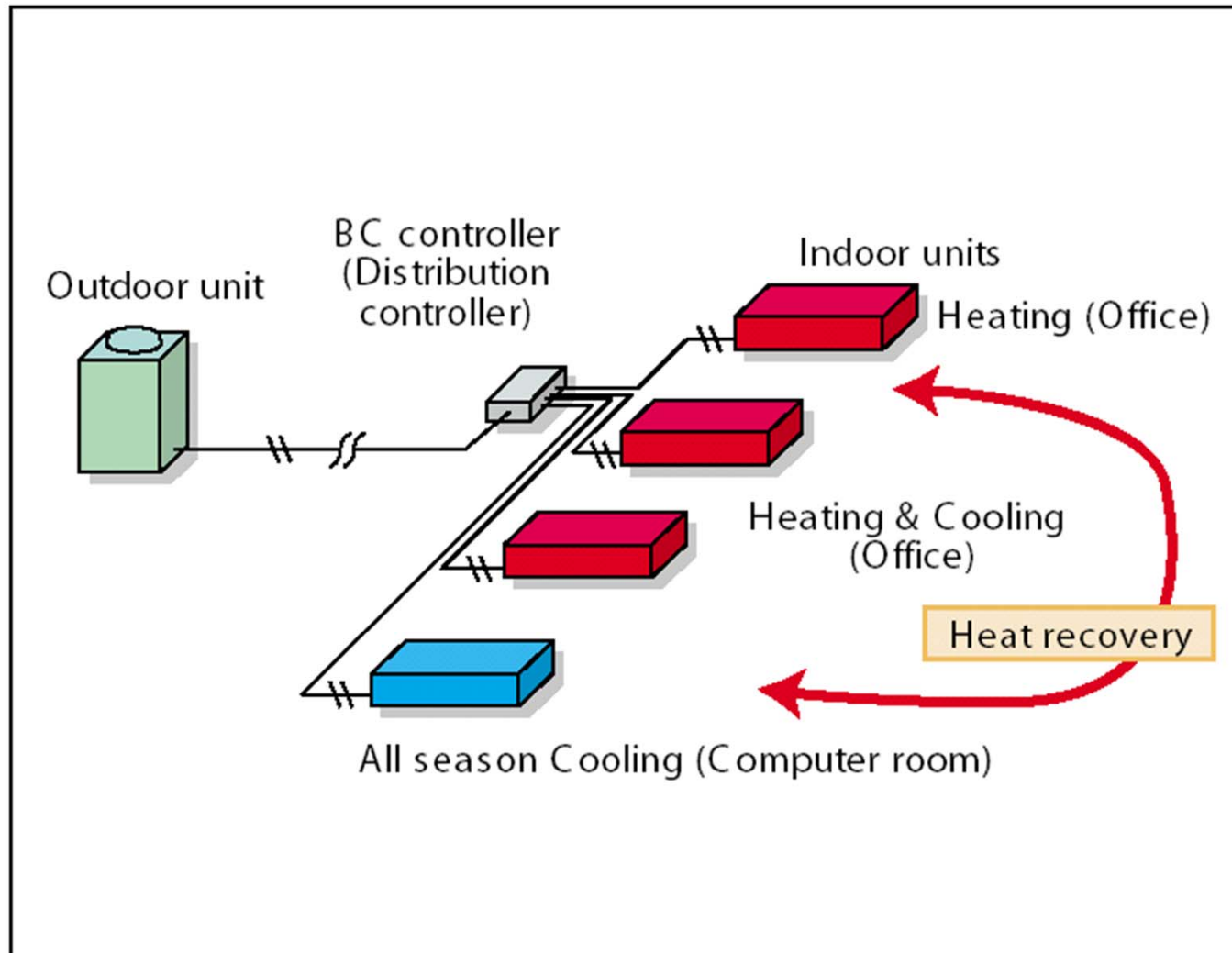


Efficiency of simultaneous heat/cool



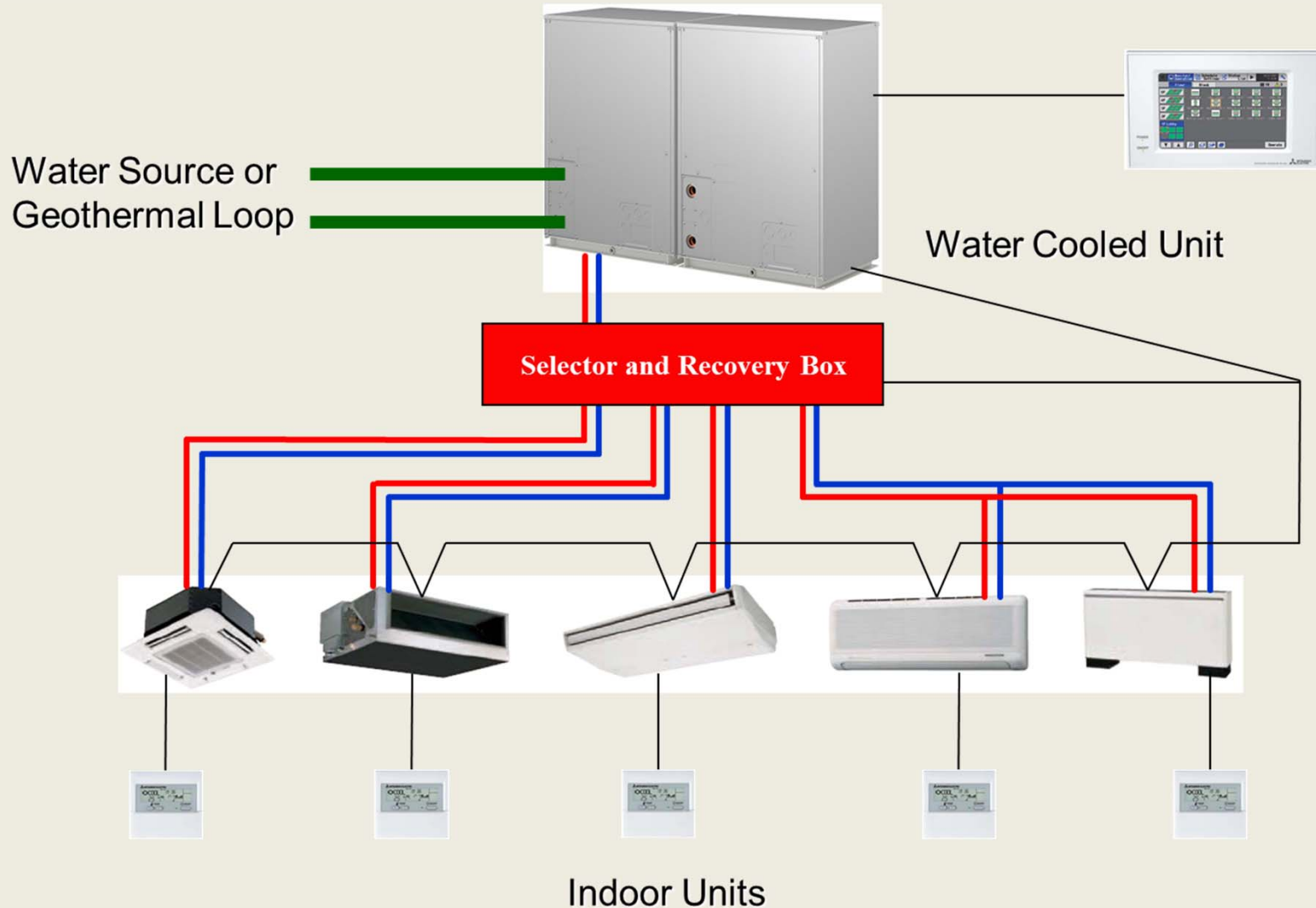
Heat Recovery – 2 Pipe system

Two-pipe simultaneous cooling / heating sysytem (R2)



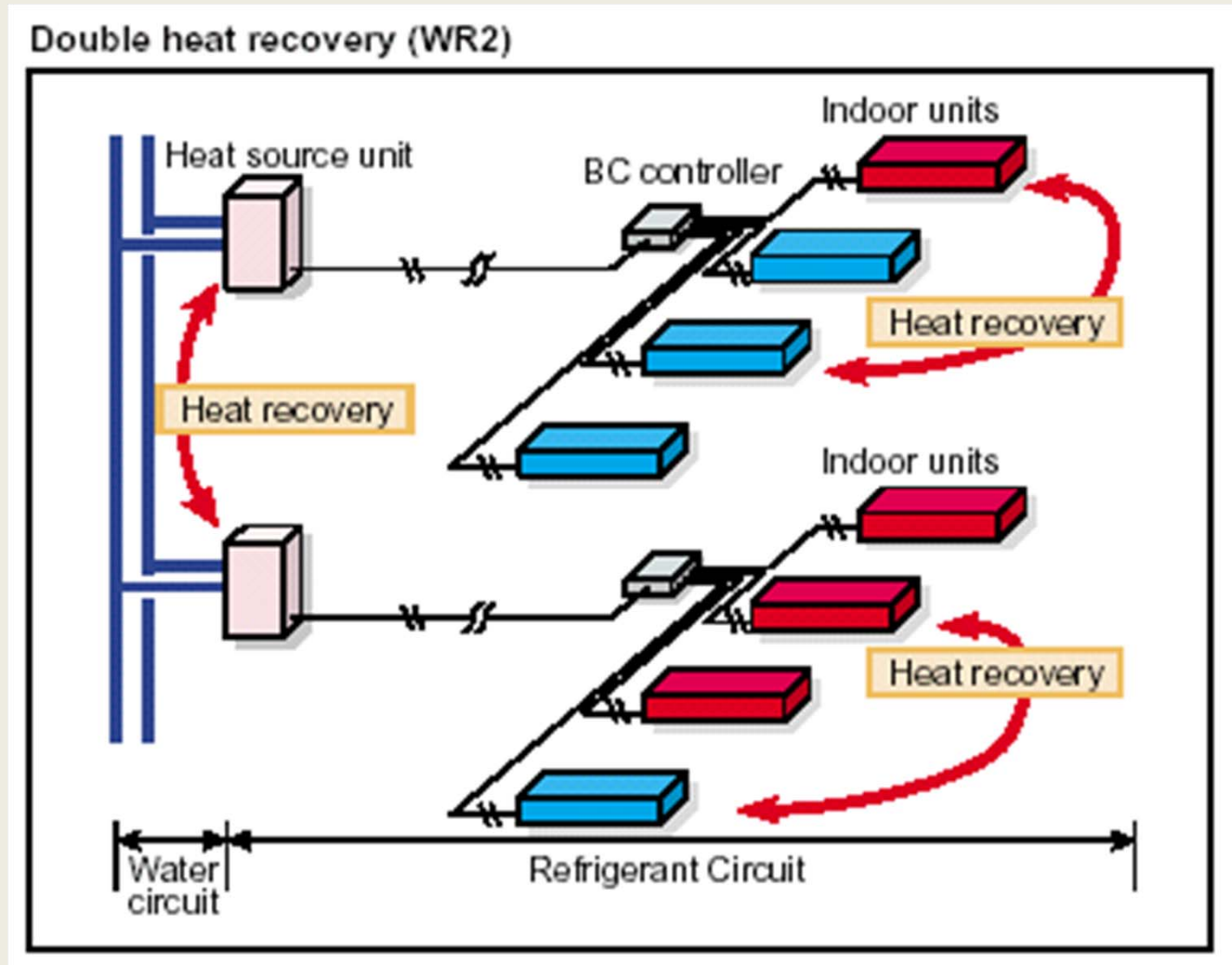
2 Pipe simultaneous cool and heat

Water source or geothermal loop



2 Pipe heat recovery

Water source or geothermal loop

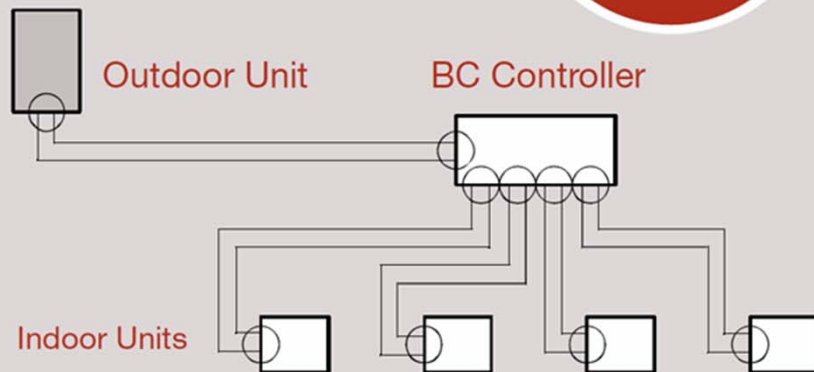


2 Pipe VS 3 Pipe simultaneous cool and heat

CITY MULTI

Two-Pipe Heat
Recovery System

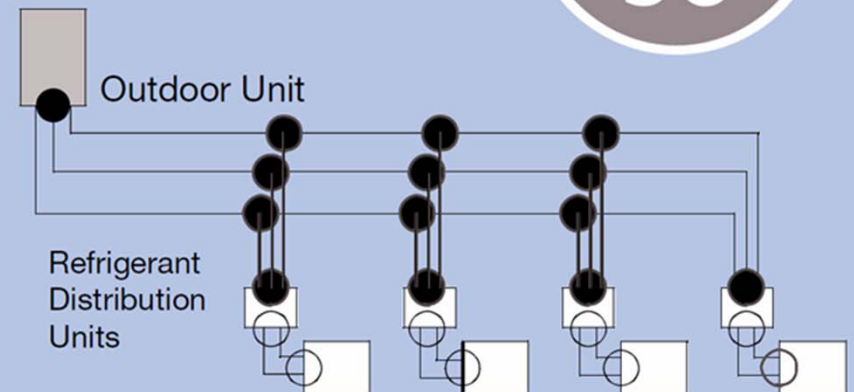
Total
connections
20



MITSUBISHI ELECTRIC

3 Pipe System

Total
connections
58



○ = 2 connections

● = 3 connections

DIVERSITY

1. Time of Day
2. Heating & Cooling
3. Occupancy

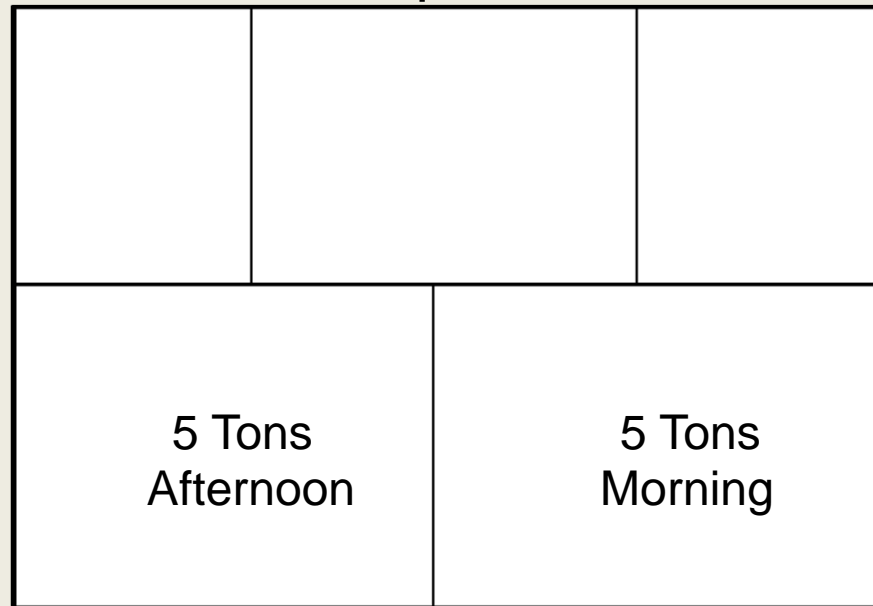
Time of Day



3 Tons Afternoon	5 Tons Afternoon	



Time of Day



Both zones peak at 5 tons

Do we need 10 tons of cooling???

Time of Day

5 Tons	3 Tons	

Afternoon

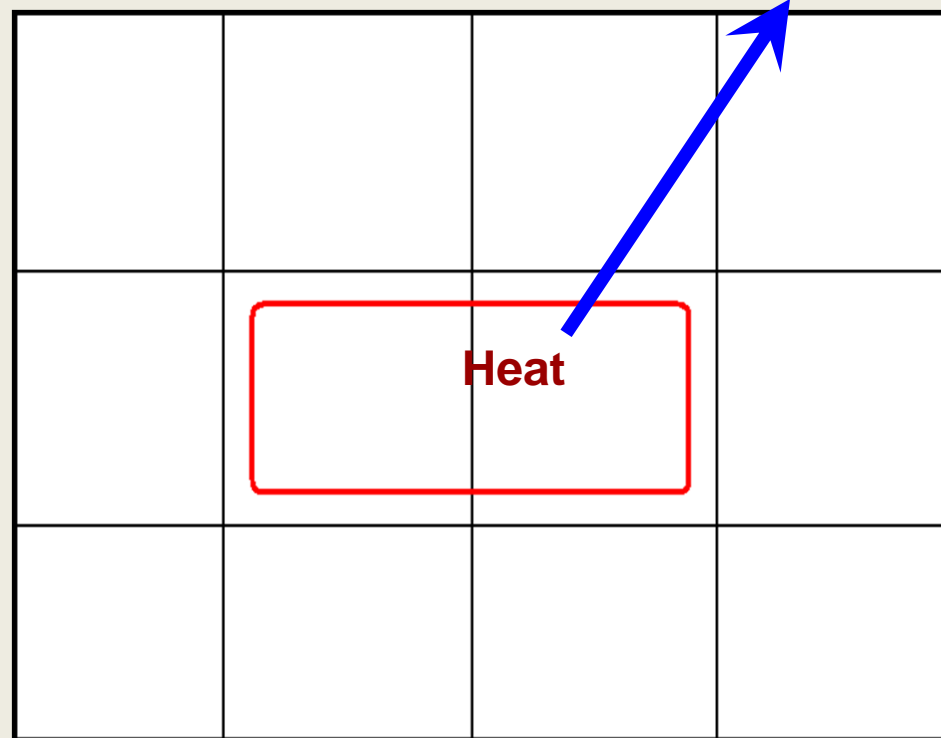
3 Tons	5 Tons	

Morning

With VRF, only 8 tons of cooling are required!!

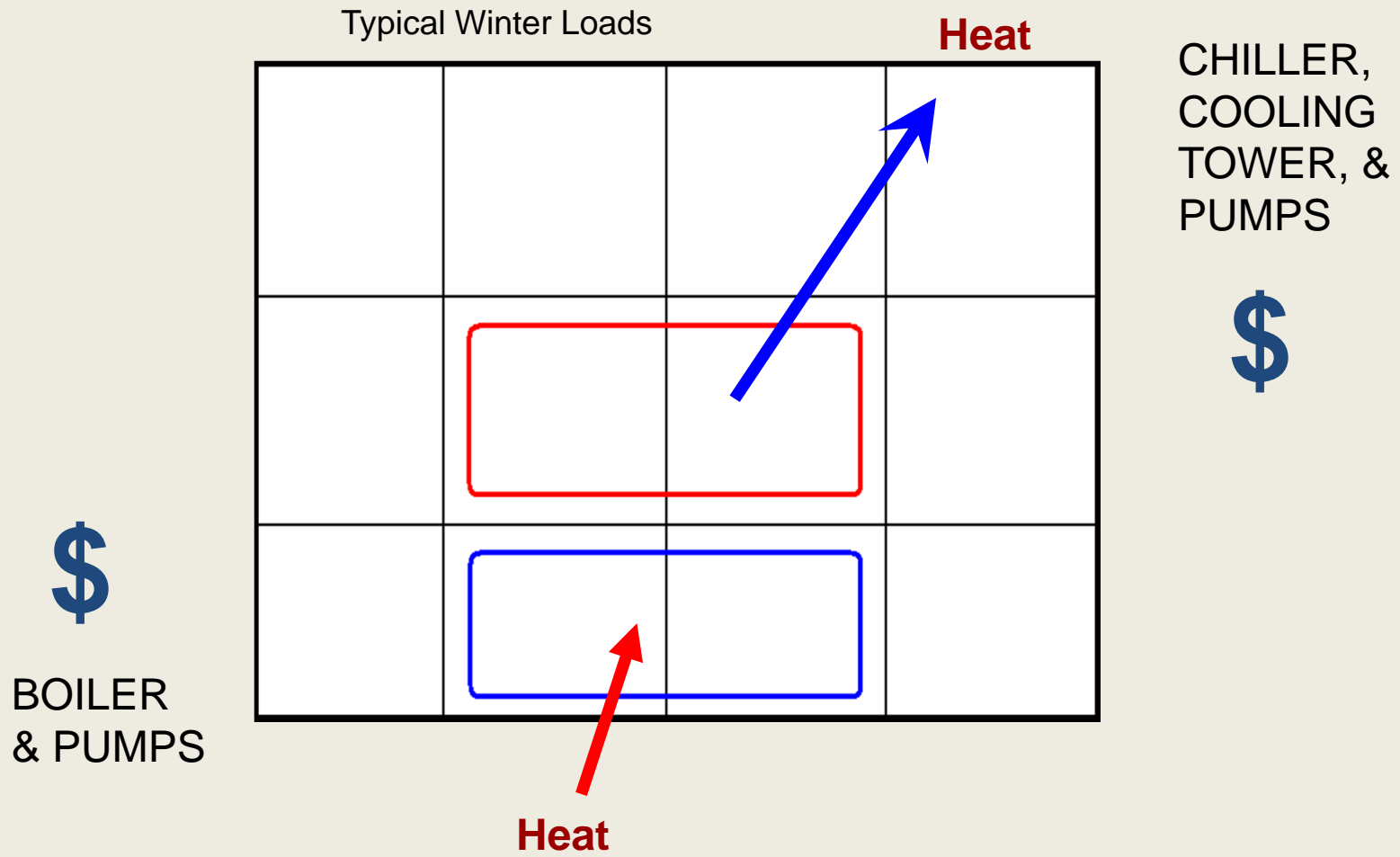
Heating & Cooling

Typical Winter Loads



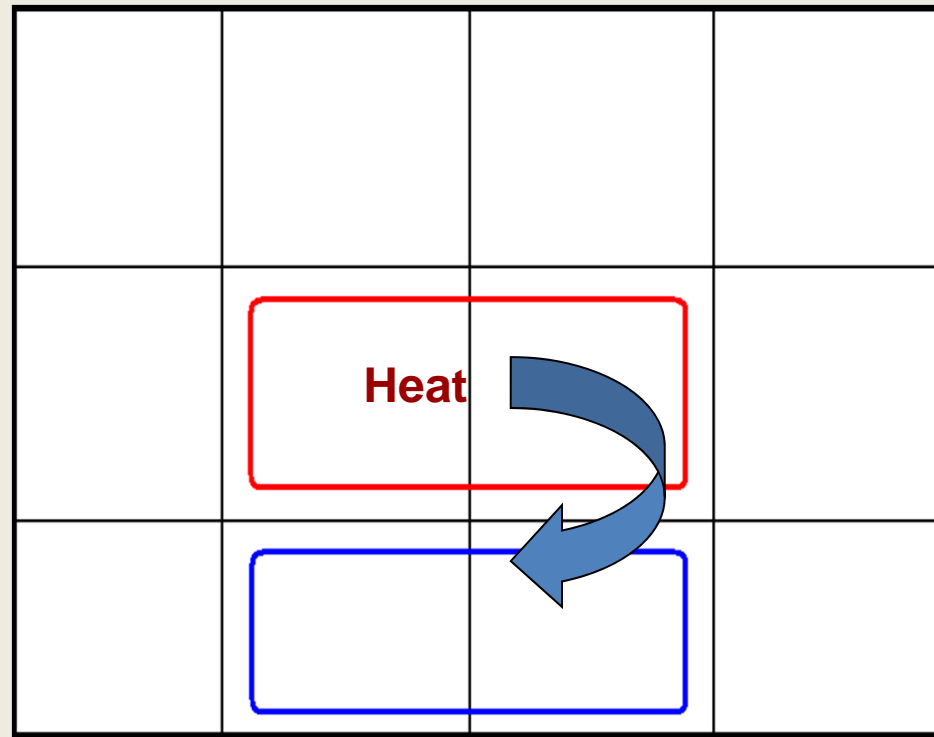
CHILLER,
COOLING
TOWER, &
PUMPS

Heating & Cooling



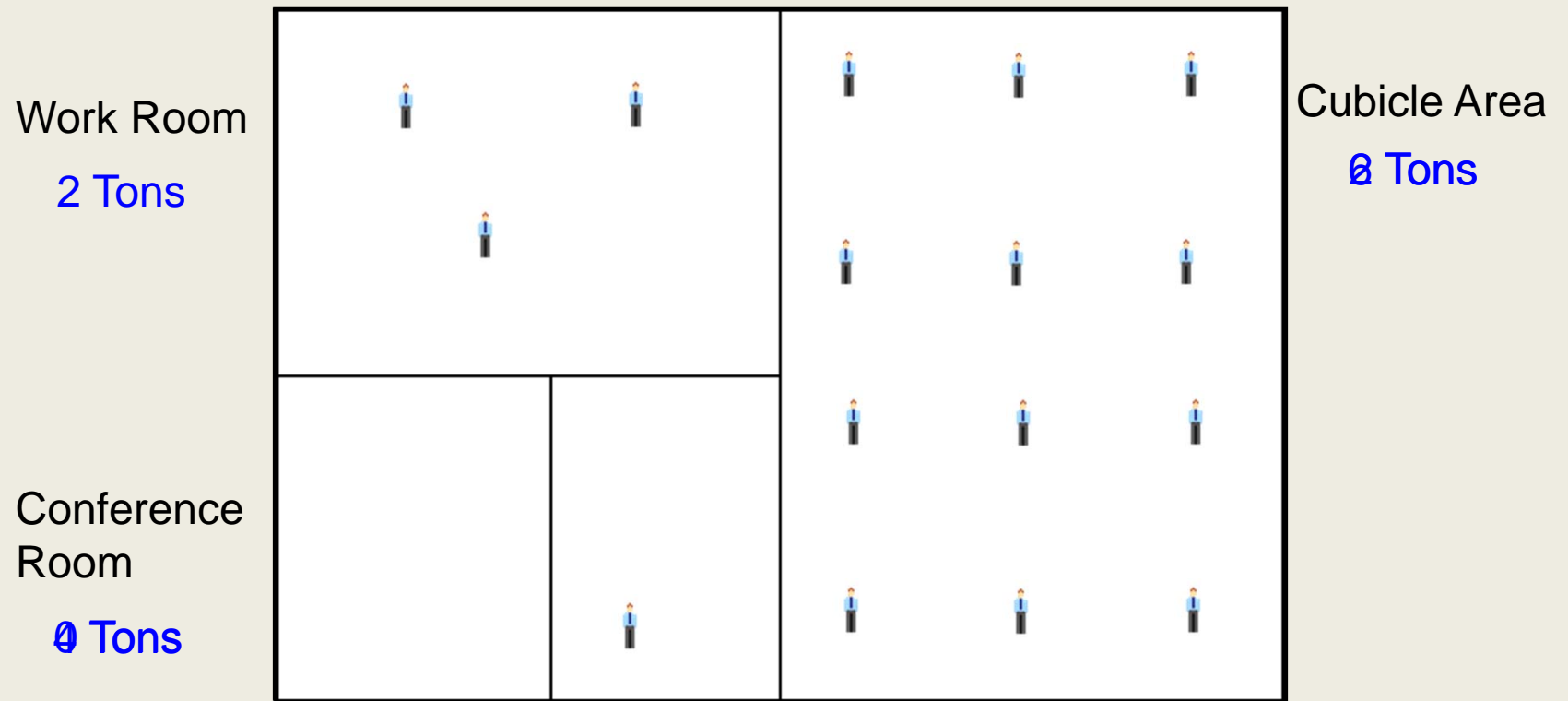
Heating & Cooling

Typical Winter Loads



With
VRF Systems

Occupancy



8 Tons Total Cooling

DIVERSITY

1. Time of Day

VRF System can efficiently distribute cooling capacity to keep up with changing solar loads

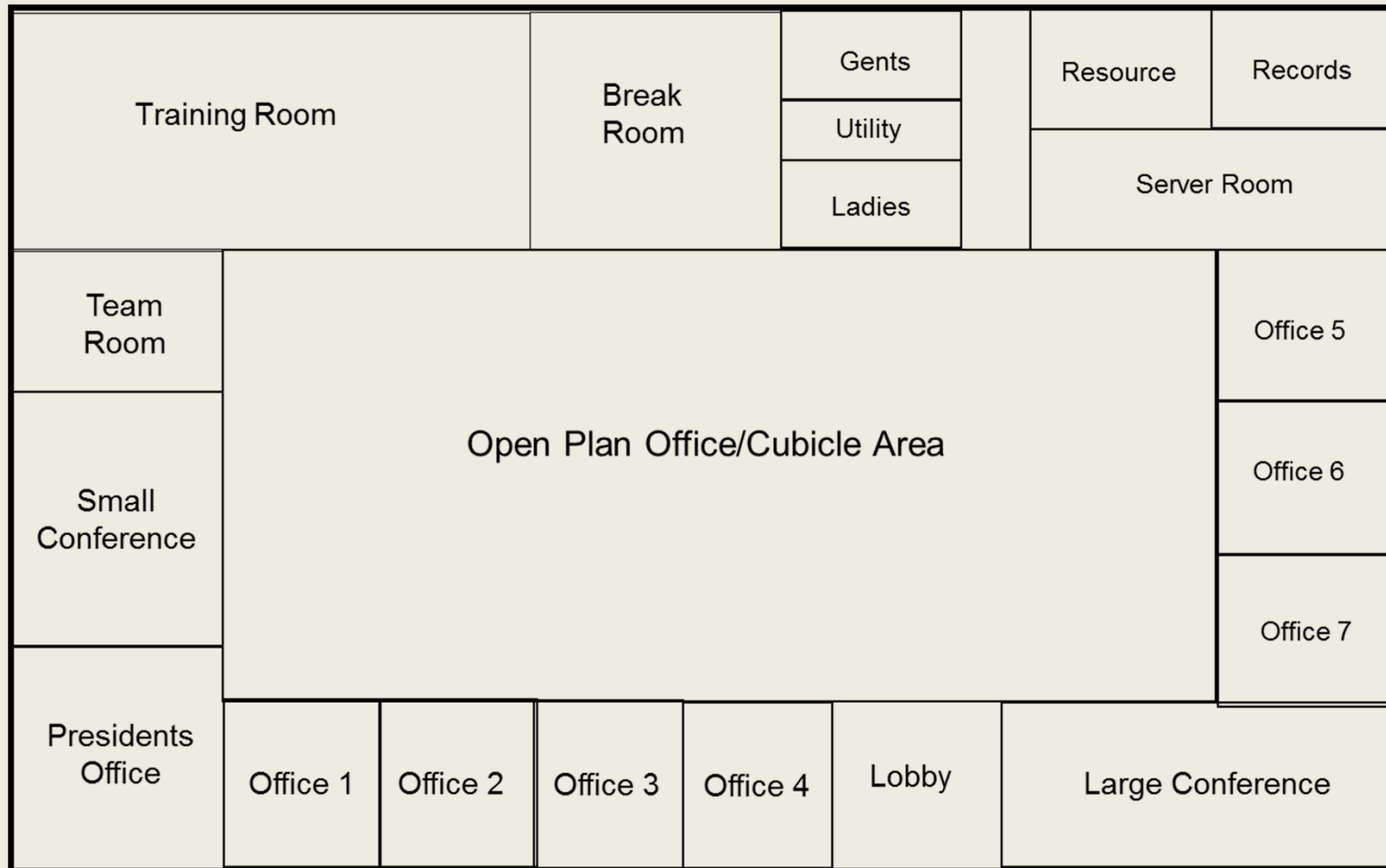
2. Heating & Cooling

VRF System can heat and cool simultaneously

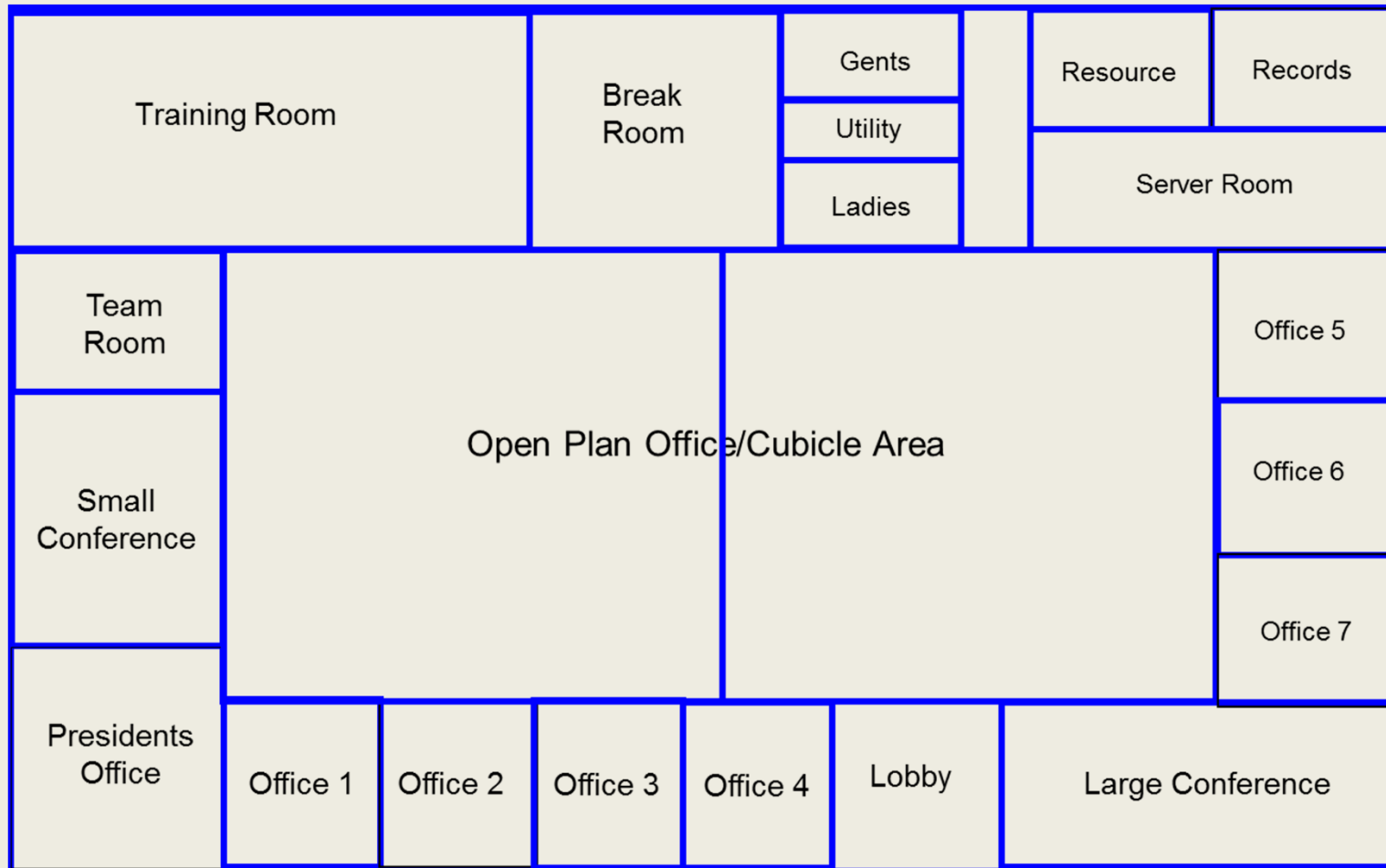
3. Occupancy

As people move throughout a building, **VRF System** can move energy around to maintain comfort levels within setpoint

10,000 ft² Office Application

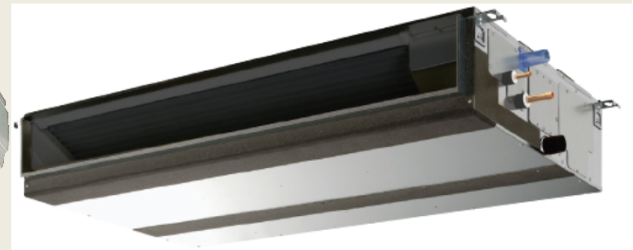


10,000 ft² Office Application



VRF Indoor Unit Overview

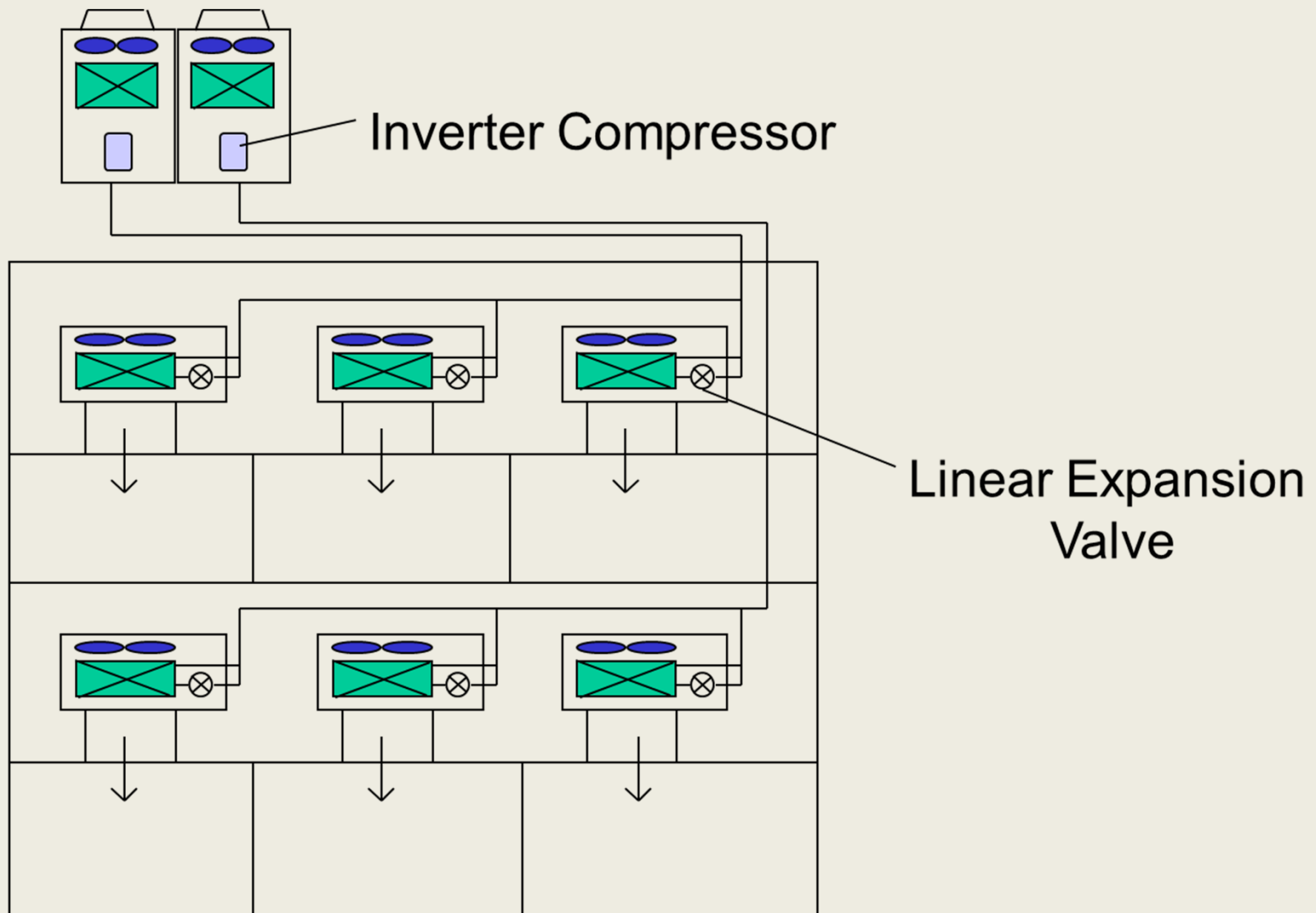
- 1, 2 & 4 Way Cassette
- Ducted horizontal
- Ducted vertical
- Ceiling Suspended
- Wall Mounted
- Floor Standing
- Water heating modules



Comparing VRF to « Conventional System »

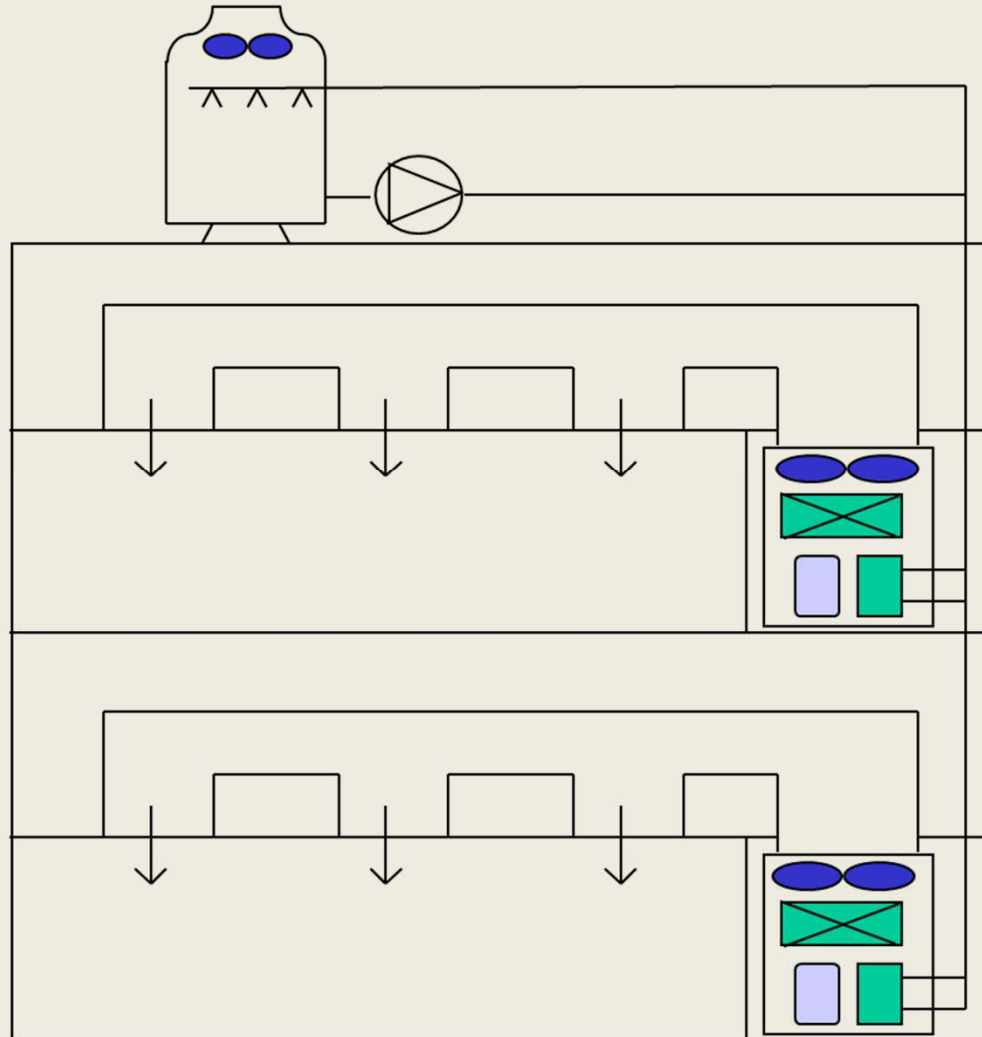
- **Total System is stopped during night time**
- **If one person is working overtime, the complete system must operate**
- **Unevenly Air Conditioned space**
- **Possibility of Water Pipe Corrosion**
- **Maintain Water Quality**
- **Lots of Piping & Wiring**
- **Lots of Space Required for Machines**
- **Time Consuming Design**

VRF SYSTEM



Water Cooled Packaged A/C

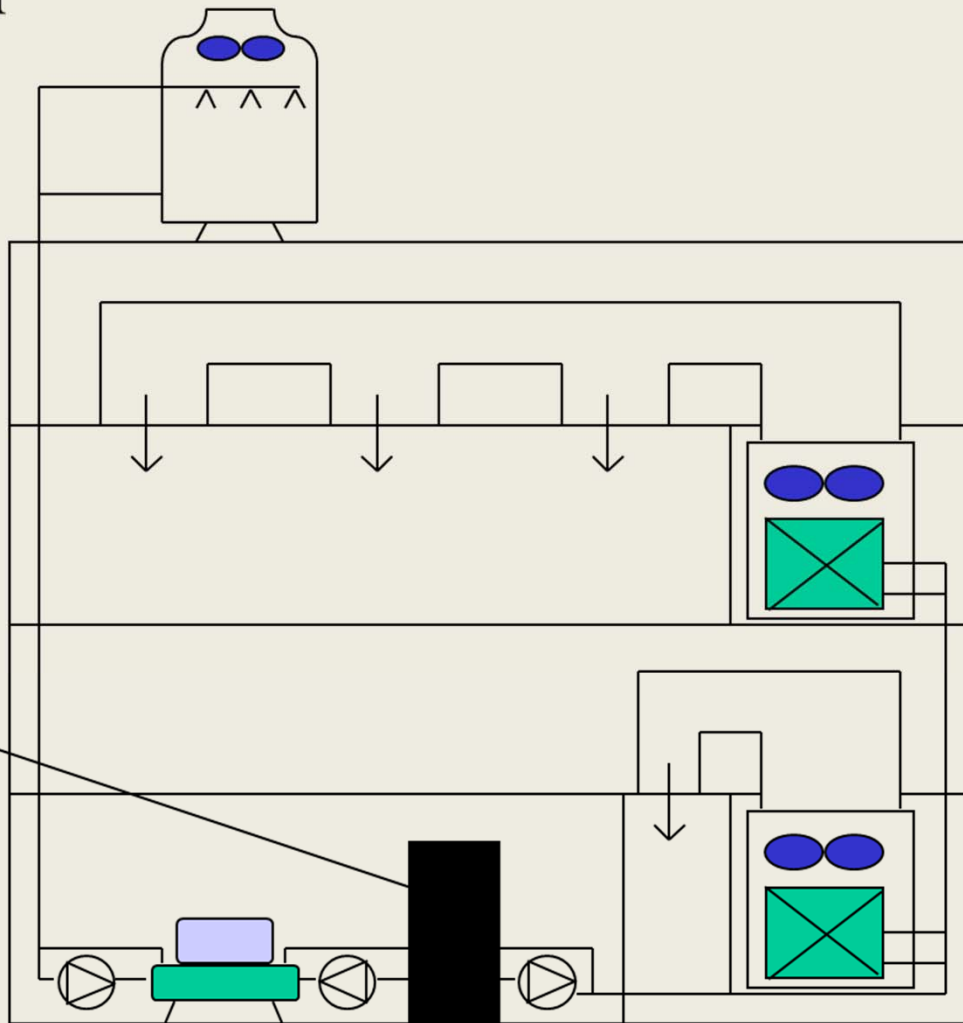
cooling tower



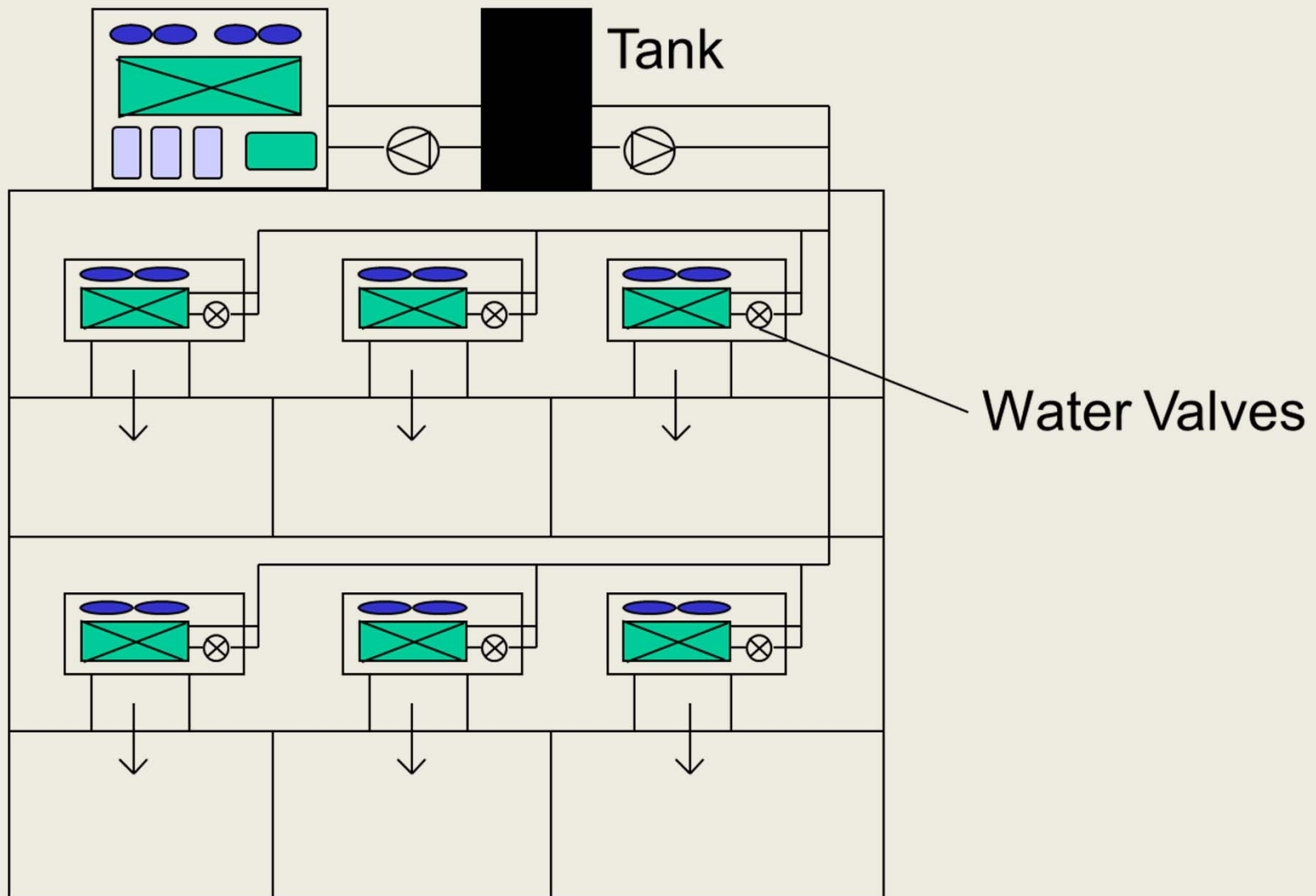
Water Cooled Chiller & AHU

cooling tower

water tank

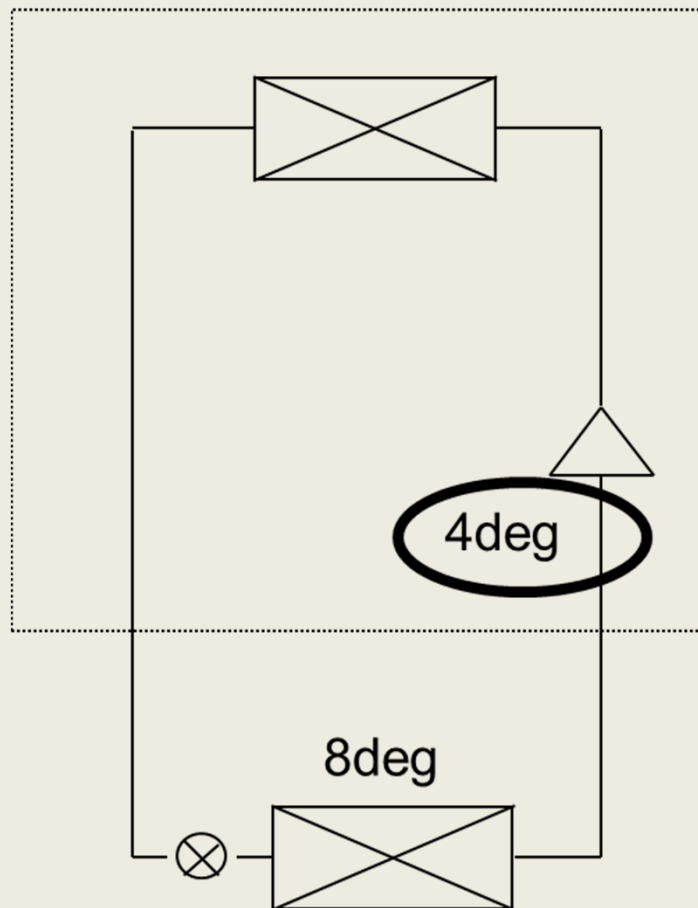


Air Cooled Chiller & Fan Coil Units

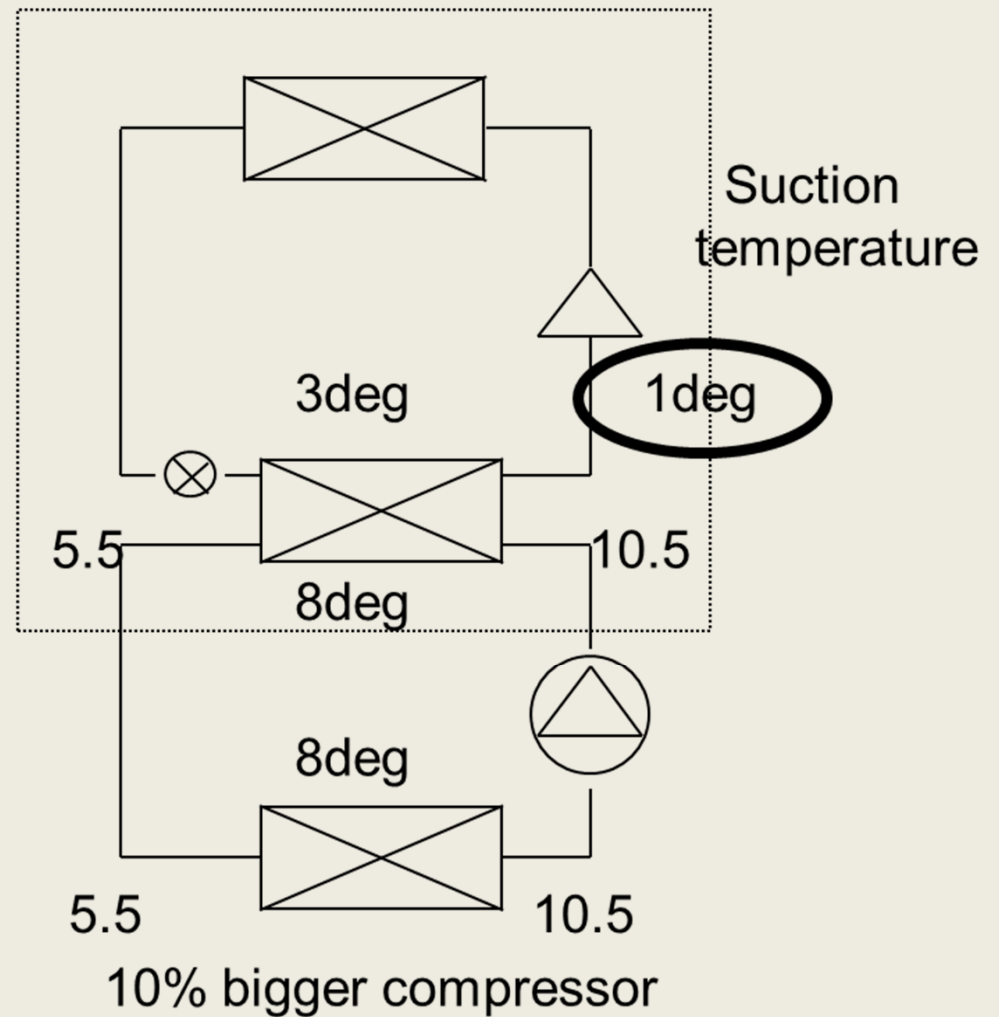


Water Chiller & AHU

VRF



Chiller



Operation and Comfort

A ; good
 B ; normal
 C ; bad

	“VRF”	C-PAC	Chiller +AHU	Chiller +FCU
Individual use at night or holiday	<u>A</u>	<u>B</u>	C	C
			All building	
Control temperature Individually	<u>A</u>	C	C	<u>A</u>
		Common duct		
Start quickly	<u>A</u>	<u>A</u>	C	C
			All building	
Quiet (outdoor area)	<u>A</u>	C	C	C
		Noisy unit & pump		
Quiet (Indoor area)	<u>A</u>	C	B	<u>A</u>
		Comp	Big fan	

Operation and Comfort

A ; good
 B ; normal
C ; bad

	“VRF”	C-PAC	Chiller +AHU	Chiller +FCU
Individual use at night or holiday	<u>A</u>	<u>B</u>	C	C
			All building	
Control temperature Individually	<u>A</u>	C	C	<u>A</u>
		Common duct		
Start quickly	<u>A</u>	<u>A</u>	C	C
			All building	
Quiet (outdoor area)	<u>A</u>	C	C	C
		Noisy unit & pump		
Quiet (Indoor area)	<u>A</u>	C	B	<u>A</u>
		Comp	Big fan	

Management and Architecture

	“VRF”	C-PAC	Chiller +AHU	Chiller +FCU
Maintenance water quality, pipe corrosion	<u>A</u>	B	B	C
		Cooling Tower		All
Possibility of water leakage in the room	<u>A</u>	<u>A</u>	<u>A</u>	C
				FCU
Machine space (heat source)	<u>A</u>	<u>A</u>	C	<u>A</u>
			Chiller	
Machine space (Indoor unit)	<u>A</u>	C	C	<u>A</u>
		Floor standing		
Future Add unit for increasing A/C load	<u>A</u>	<u>A</u>	C	C
			Change All	

Initial Cost

	“VRF”	C-PAC	Chiller +AHU	Chiller +FCU
Equipment (main unit)	B	<u>A</u>	B	B
Equipment (sub parts)	<u>A</u>	B	B	B
System controller	<u>A</u>	<u>A</u>	<u>A-C</u>	<u>A-C</u>
Engineering time	<u>A</u>	<u>A</u>	B-C	B-C
			variety	

Operating Cost – Full Load

	“VRF”	C-PAC	Chiller +AHU	Chiller +FCU
Total Cost	<u>A</u>	B	C	B-C
pump(main)	<u>A</u>	<u>A</u>	C	C
pump(cooling tower)	<u>A</u>	C	C	<u>A</u>
fan(outdoor)	B	B	B	B
fan(indoor)	<u>A</u>	C	C	<u>A</u>
		Big fan, duct loss		
Transfer loss from refrigerant to water	<u>A</u>	<u>A</u>	C	C

Operating Cost – Part Load

	“VRF”	C-PAC	Chiller +AHU	Chiller +FCU
Total Cost	<u>A</u>	B	B-C	B
pump(main)	<u>A</u>	<u>A</u>	B-C	B-C
			Inv-No inverter	
pump(cooling tower)	<u>A</u>	C	C	<u>A</u>
fan(outdoor)	<u>A</u>	C	C	<u>A</u>
fan(indoor)	<u>A</u>	C	B-C	<u>A</u>
		Big fan, duct loss		
Transfer loss from refrigerant to water	<u>A</u>	<u>A</u>	B	B

Benefits of VRF

- **For Property Owners**

- Can be adapted to meet various applications in buildings due to multiple style and capacity indoor units
- Creates Added Value to the building due to:
 - Comfort Levels (Space temperature controlled individually)
 - Operation only required in zones used
 - Power consumption can be reduced by up to 30%
- Provides advanced space efficiency at a good price

Benefits of VRF

- **For Consultants / Contractors / Installer**
 - ✦ Easy to design
 - ✦ No Zoning considerations with heat recovery
 - ✦ Short design period compared
 - ✦ Easy to install
 - ✦ No need for expensive controls
 - ✦ Easy to maintain
 - ✦ All system components supplied by one vendor

Benefits of VRF

- **For Users**

- ✦ Can be operated to suit individual needs
- ✦ Exact temperature control for each office/ zone
- ✦ Comfortable working space improves productivity.

QUESTIONS ?