



# Variable Refrigerant Flow (VRF) Systems for Commercial HVAC

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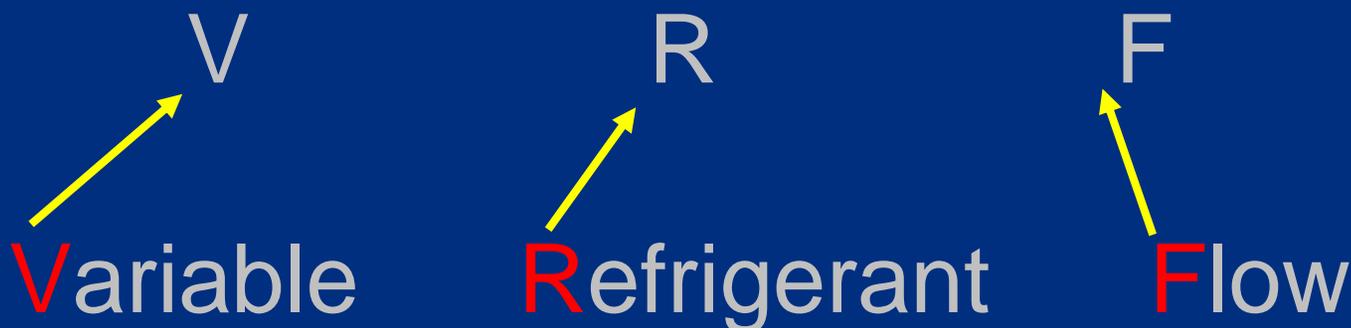


**GovEnergy**  
[www.govenergy.gov](http://www.govenergy.gov)



# Background

## What is VRF?



- In Japan, VRF is used in half of medium-sized commercial buildings (<70,000 ft<sup>2</sup>) and ~ 1/3 of larger buildings
- Very popular throughout Asia and Europe
- Numerous suppliers worldwide:
  - Daikin, Mitsubishi Electric, Hitachi, Sanyo, Fujitsu, Panasonic, Toshiba-Carrier, LG, MHI, Samsung
  - At least 5 manufacturers selling in the U.S.



# Technology Overview

VRF competes most naturally with a chiller

## Outdoor Unit

## Indoor Units

Key Attributes:-

- Energy Efficient
- Individual, tight temperature control
- Very Quiet
- Numerous zones
- Large capacity but modular
- Centralized plant with long refrigerant piping
- Wide range of units
- Advanced BAS control
- Premium Price





# Technology Overview

## VRF Concept – System Design



**With proper engineering, code compliance with ASHRAE Standard 15 and Standard 62.1 is not a problem. Europe & Japan have analogous codes**



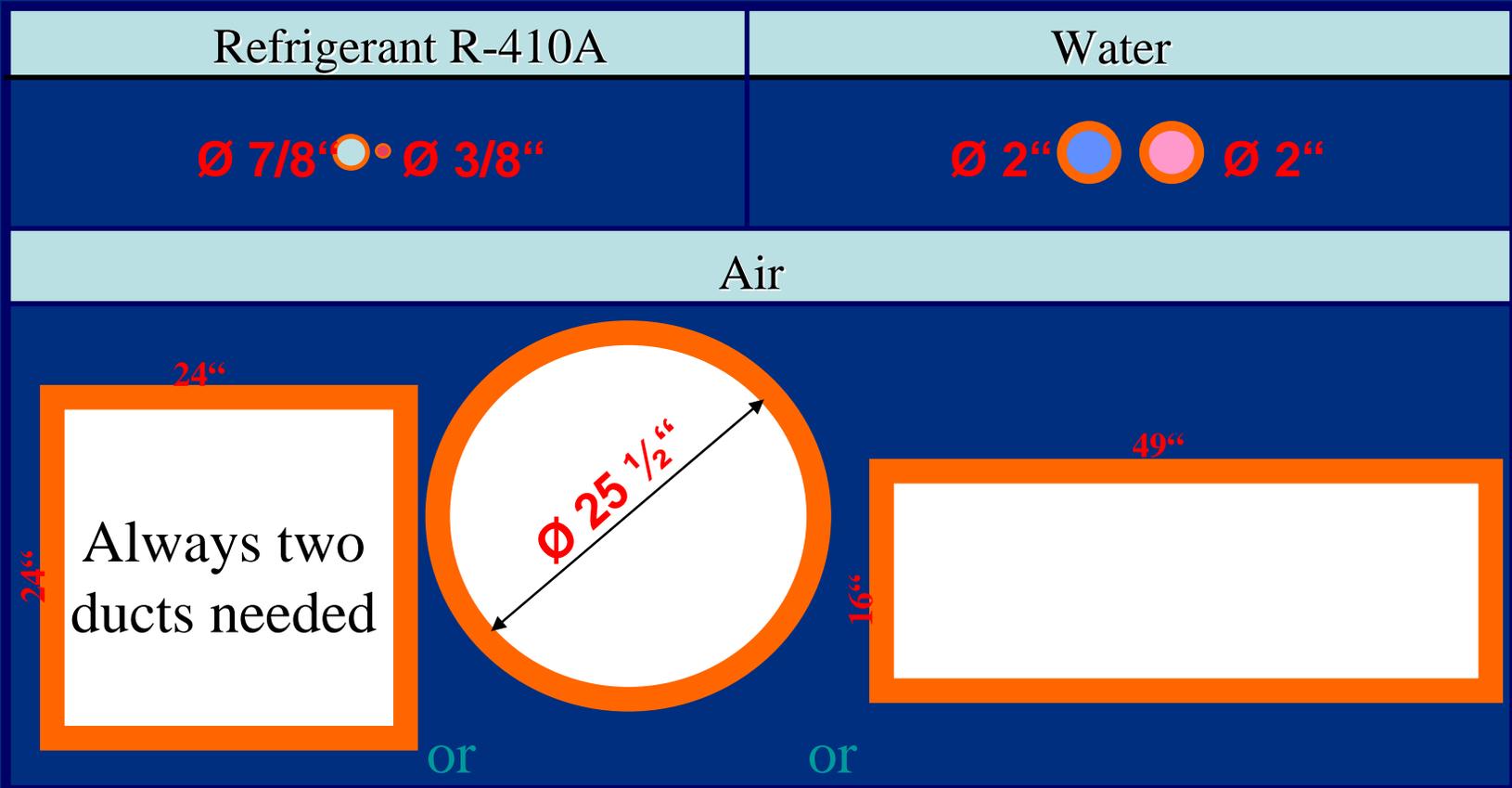
- Single Outdoor Unit With Multiple Indoor Units
- Individual Control
- Modular Build-up

- Energy Saving especially @ part-load
- Cost Effective
- Low Noise



# Technology Overview

## VRF Concept – Heat Transfer Media (8 ton example)



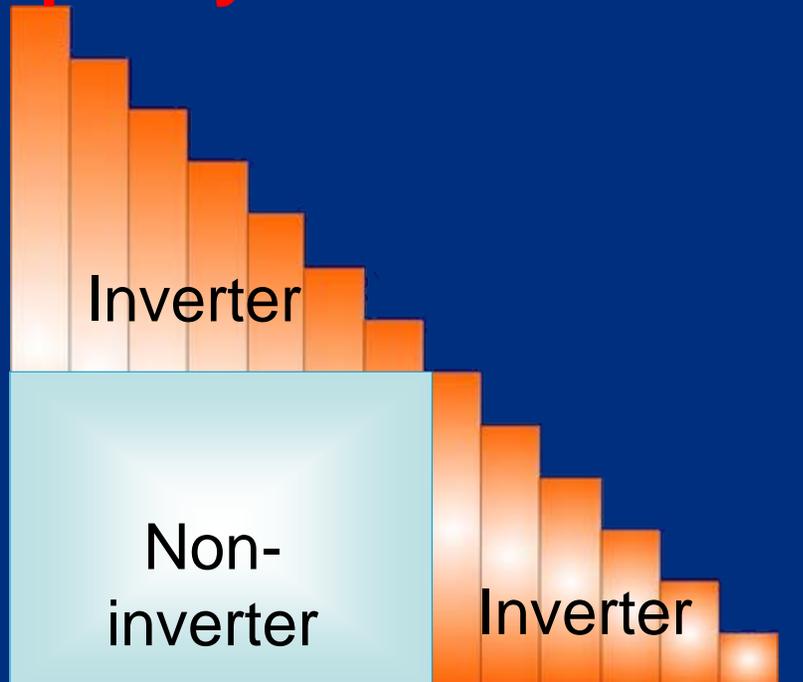
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# Technology Overview

VRF Concept – How does it operate?

## Capacity Control



100%

Compressor  
Capacity  
Control

14%

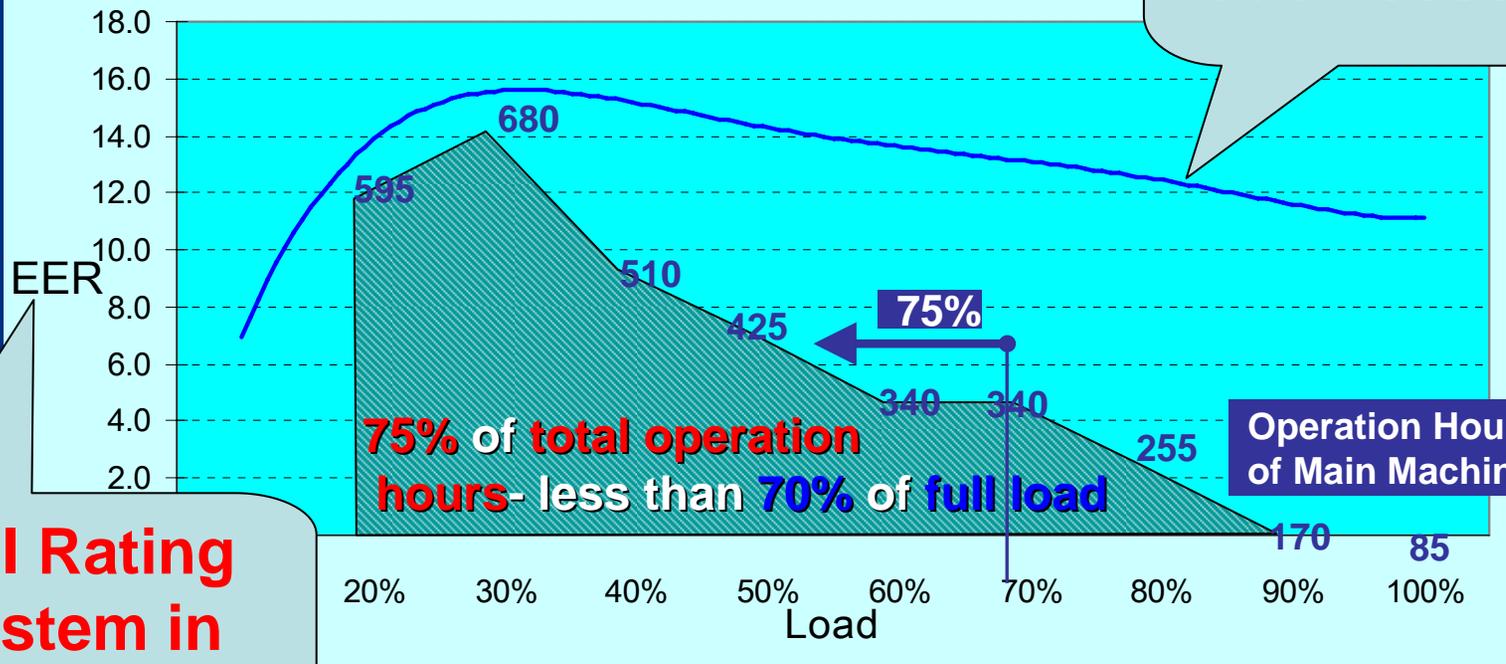
Large ← Load → Small



# Benefits

## Energy Efficiency

### Partial Load Performance



**And Virtually Eliminates duct losses**

**ARI Rating System in Development**

**75% of total operation hours- less than 70% of full load**

**Operation Hours of Main Machine**

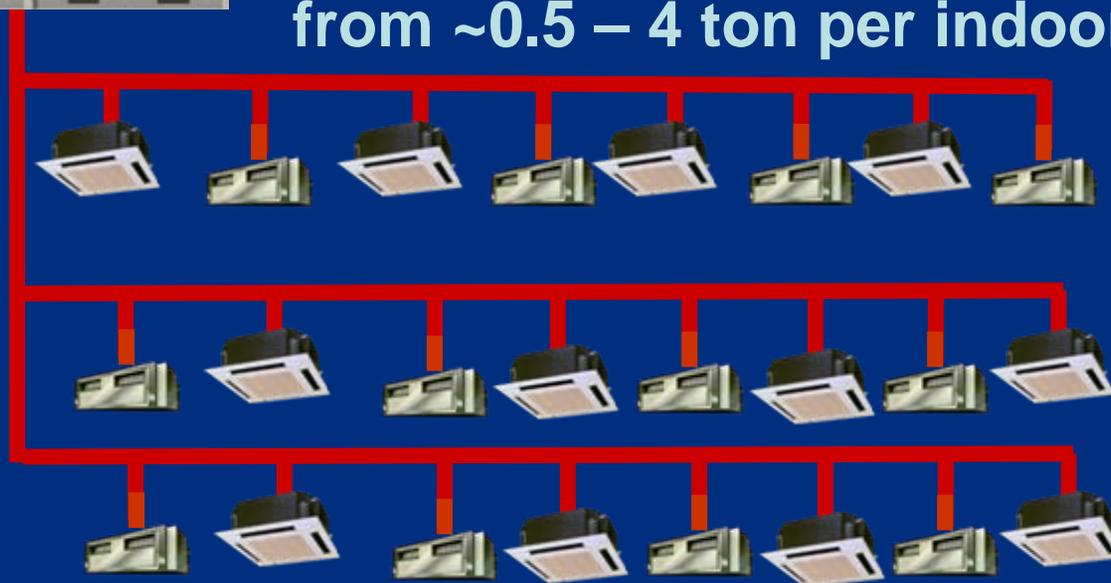


# Benefits

## Flexible Configurations



On a single refrigerant piping network, up to 41 indoor units, including ducted and ductless, with varying capacities from ~0.5 – 4 ton per indoor unit.



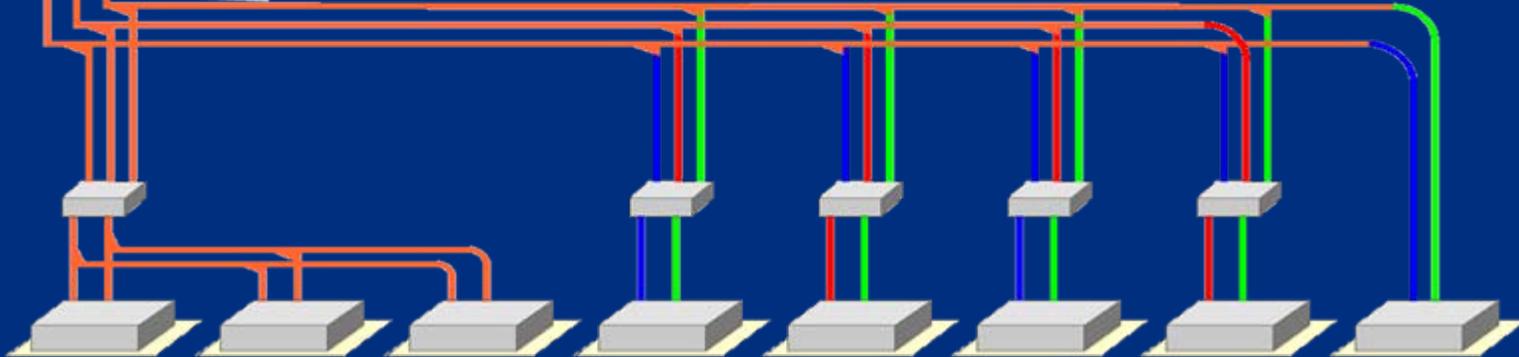
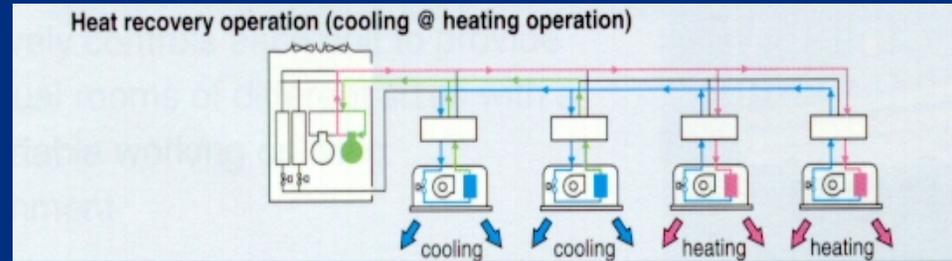


# Benefits

## Heat Recovery for Simultaneous Heating & Cooling



Heat absorbed by indoor units in cooling mode is used in areas that require heating.



Same Operation mode  
but individual control

Individual Cool/Heat  
Changeover

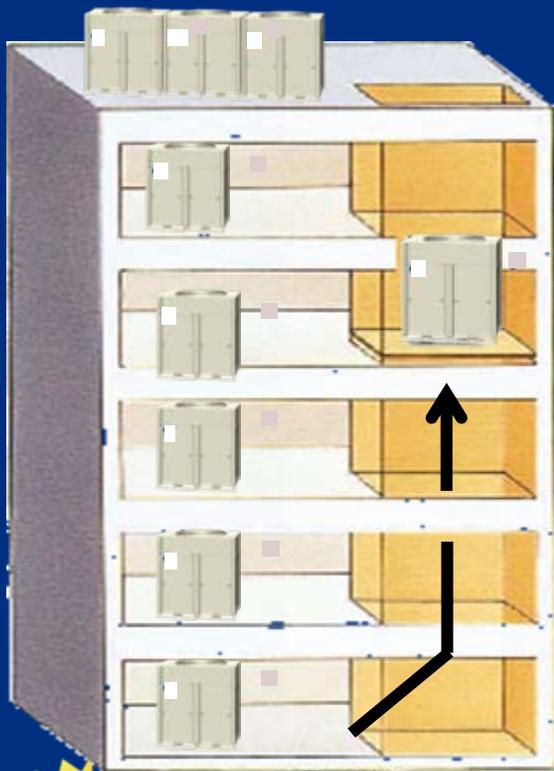
Cooling  
Only



# Technology Overview

Ease of Installation:

Modularity, Size & Weight, fits in an elevator



**Small footprint for rooftop, balcony, or machine room installation**

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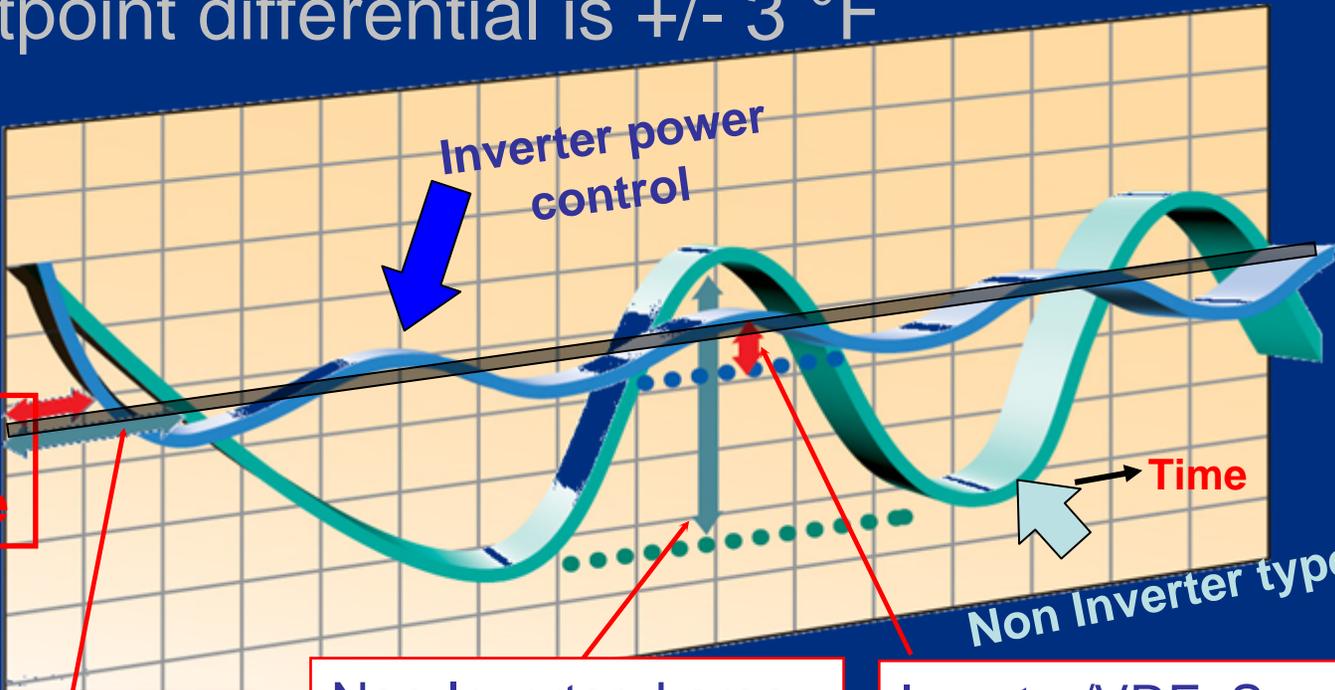
August 3-6, 2008



# Benefits

Comfort- Uses PID logic for tight control when room to setpoint differential is  $\pm 3^\circ\text{F}$

Temp.



Set point temperature

Inverter Cools a room quickly

Non-Inverter: Large Temp. Difference

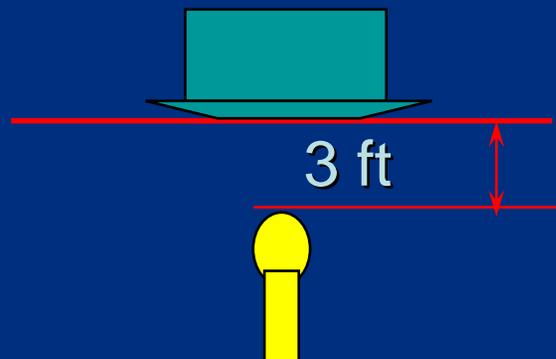
Inverter/VRF: Small temp. difference



# Benefits

## Extremely Low Sound Levels

Indoor units



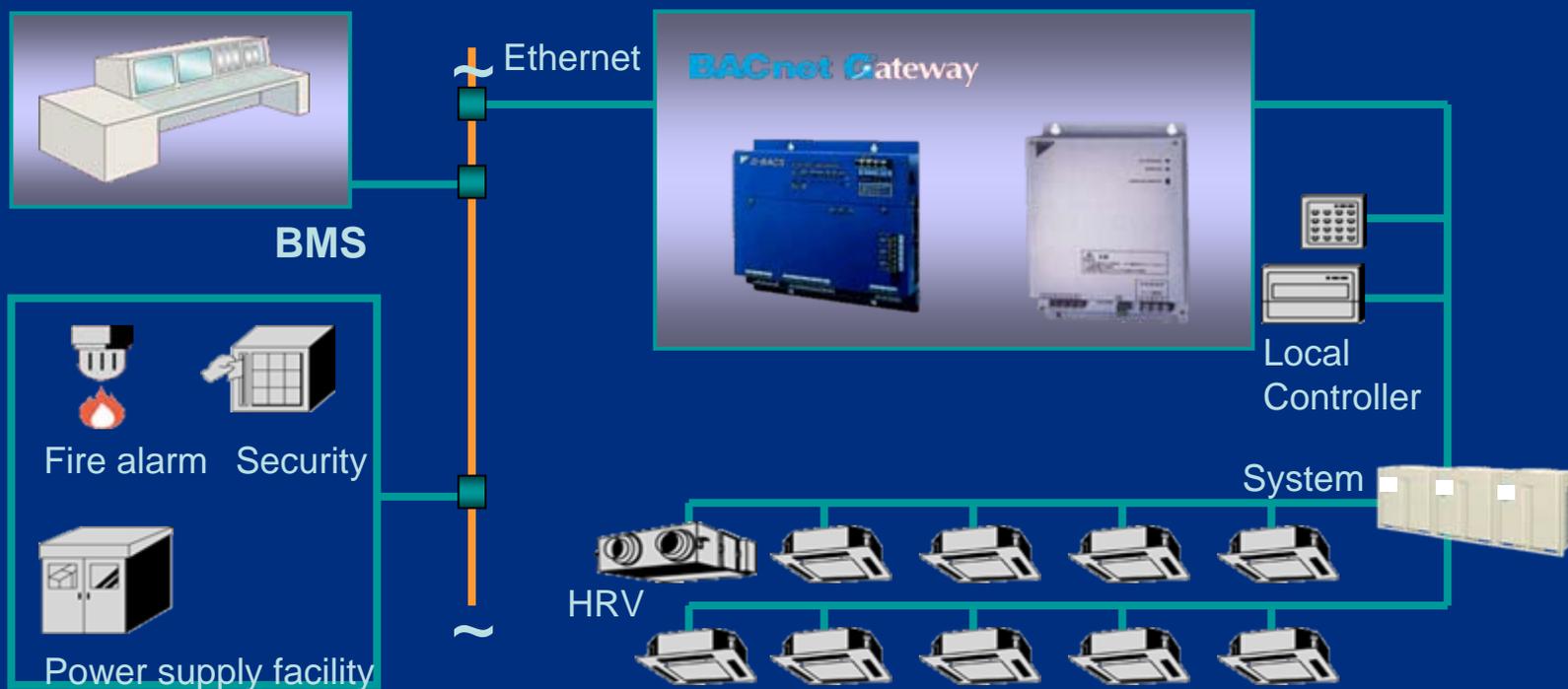
Indoor Unit Tonnage	1	2	3
Sound level db (A) at low speed	28	29	33



# Benefits

## Sophisticated Controls & Diagnostics

**BACnet™** and **LONWORKS®**





# Benefits

## Flexible, Advanced Controls & Diagnostics



Full color LCD Touch screen

Max 64 groups

Max 10 Outdoor Units

Simple operation

Power Proportional Distribution (Hourly data)

Self-Diagnostics: 66 malfunction codes

Multi language

Web enabled



# Sample Installations

Lille, France: Historic building- hotel built in 1460



- 71 ducted indoor units installed
- Provide heating and cooling to guest rooms and central areas
- All piping totally concealed
- Outdoor units must not be seen or heard
- 9 VRF Heat Pump outdoor units in sound proofed machine room
- 75 Tons of fully modulating and zoned air conditioning capacity

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# Sample Installations

Dalian, China: 32 story, 500,000 ft<sup>2</sup> office building

- 212 Heat Pump outdoor units
- 539 indoor units
- 1,753 tons of cooling
- Access panel behind each unit so that service can be done from the inside of the building





# Types of VRF

## Types of VRF Systems Available

- Air-Cooled (vs. small – large chillers)
- Water-cooled (vs. medium – large chillers)
- 208-230V/3-phase (renovation)
- 460V/3-phase (new construction)
- Heat Pump (vs. 2-pipe chiller)
- Simultaneous heating & cooling (vs. 4-pipe chiller)



# Ongoing Challenges

- Completion of ARI Rating Standard and certification program
- Incorporation into Energy Plus, EnergyPro, E-Quest and DOE-2
- Integration of outside air with VRF
- Broadening the installer base



# Conclusions

- VRF is a viable *alternative* to chillers in many cases, but many applications are better served by chillers or rooftop DX
- Energy savings and other benefits are application-specific and must be evaluated on case-by-case basis
- 25 year operating history throughout the world
- Additional details: manufacturer websites and ASHRAE Journal article April 2007:  
[http://www.ashrae.org/doclib/20070327\\_goetzler.pdf](http://www.ashrae.org/doclib/20070327_goetzler.pdf)



# Would you like to know more about this session?

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- Don't forget to fill out and drop off your session evaluations.

