VRF Technology
Variable Refrigerant Flow

Mitch Watson | Commercial Area Sales Manager | Mitsubishi Electric Cooling & Heating
Comfort
First Cost
Efficiency
Maintenance
Architectural Impact

Variable Refrigerant Flow
What is VRF?

End User Experience

Case Studies

Architectural Impact

VRF Energy Profile

Take-Aways
Commercial System
Heat Pump with Heat Recovery

Condensing Unit

Simultaneous
- Cooling
- Heating

Refrigerant Piping

Indoor Units

Branch Circuit Controller

Cooling

Heating

Up to 50 indoor units per system
Commercial System

Heat Pump with Heat Recovery

Condensing Unit

Simultaneous

Cooling

Heating

Refrigerant Piping

Geothermal System or Cooling Tower

Indoor Units

Up to 50 indoor units per system
Controls
Factory plug & play control systems

• Zone controllers
• Central controllers
• Web based
• Integrate with Building Automation Systems
Heat in Cold Climates

Air Source

Heating Season

Heat Economics

VRF heat: lower utility cost

GAS heat: lower utility cost

Electric rate: $0.10 / kwh
Gas rate: $1.00 / therm
Commercial System
Simultaneous Heating and Cooling Applications

- Multi-family
- Senior living centers
- Schools
- Student housing
- Hotels
- Offices
- Retail
- Medical facilities
What is VRF?

End User Experience

Net Zero Take-aways

Architectural Impact

Net Zero Case Studies

VRF Energy Profile
Eliminate hot and cold spots

- Individual control
- No season restriction
  - Heat in the summer
  - Cool in the winter
Precise Temperature Control

Traditional Compressor

Set Point Temp.

Compressor Energy Consumption

<table>
<thead>
<tr>
<th>60Hz</th>
<th>Off</th>
<th>30Hz</th>
<th>Off</th>
<th>0Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>80°F</td>
<td>77°F</td>
<td>75°F</td>
<td>73°F</td>
<td>150Hz</td>
</tr>
</tbody>
</table>

- Energy Consumption

- Precise Temperature Control
Precise Temperature Control
Inverter-driven Compressor

Set Point Temp.

Compressor Energy Consumption

On
Precise Temperature Control

- Maximum comfort
- Eliminate ON – OFF – ON – OFF annoyance
- Extends equipment life – Reduced startup amperage
- Part load dehumidification
**Quiet Operation**

- **Ducted Unit**
  - As low as 22 dB(A)

- **Indoor Unit**
  - As low as 32 dB(A)

- **PTAC Unit**
  - 50 dB(A) to 60 dB(A)

- **Residential 3-ton HVAC Unit**
  - 65 dB(A) to 75 dB(A)

- **Air-cooled Chiller**
  - 75 dB(A) to 85 dB(A)

- **Commercial Outdoor Unit**
  - As low as 61 dB(A)

- **dB(A) Levels**:
  - 20: Recording studio
  - 30: Whisper
  - 40: Library
  - 50: Large Office
  - 60: Conversation
  - 70: Vacuum cleaner
  - 80: Garbage disposal

**Recordings**
- 20 dB: Whisper
- 30 dB: Whisper
- 40 dB: Library
- 50 dB: Large Office
- 60 dB: Conversation
- 70 dB: Vacuum cleaner
- 80 dB: Garbage disposal
Maintenance

- Low Maintenance System
- Advanced electronics for auto diagnosis and safe operation
- 10 Yr. parts warranty

### Required Maintenance

<table>
<thead>
<tr>
<th>Item</th>
<th>Traditional</th>
<th>VRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water treatment</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cooling tower</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pump seals</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>10-year overhaul</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Boiler overhaul</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chiller maintenance</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Tube brushing</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Belt changes</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Strainer cleaning</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Filter changes</td>
<td>X X</td>
<td></td>
</tr>
<tr>
<td>Condenser cleaning</td>
<td>X X</td>
<td></td>
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</tbody>
</table>
What is VRF?

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VRF Energy Profile

VRF | Variable Refrigerant Flow
Modular and compact design
Location flexibility – often spread around the property
Modular and compact design
Location flexibility – often spread around the property
Modular and compact design
Location flexibility – often spread around the property

Water cooled application
- Cooling tower
- Geothermal
Eliminate Large Mechanical Rooms

Increase the usable square footage
Space Savings
Space required to deliver 20 tons of cooling

Rectangular Ductwork
- Traditional: 40" x 20"
- VRF with OA: 20" x 10"
- VRF: (not shown)

Round Ductwork
- Traditional: 30" Round
- VRF with OA: (not shown)
- VRF: (not shown)

Piping
- Traditional: 3" CHWS&R, 3" HWS&R
- VRF with OA: 1 3/8" Gas, 1 1/8" Liquid
- VRF: 1 3/8" Gas, 1 1/8" Liquid
Reduced ceiling plenum space

- Lower construction cost by design shorter building
- Add additional floor for additional leasing
Ducted Units

- Medium Static Ducted Unit
- Low Profile Ducted Unit
- High Static Ducted Unit
- Vertical Ducted Unit
Ceiling Recessed Cassettes
Ceiling Recessed Cassettes
Ceiling Mounted Units
Wall Mounted Units
Floor Mounted
VRF - Variable Refrigerant Flow

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VRF Energy Profile

Recap
Energy Usage & Utility Costs?

Part load efficiency curve

VRF
Conventional System
Annual HVAC Energy Cost ($ / SF / Year)

Hotel

<table>
<thead>
<tr>
<th>System</th>
<th>Cost ($ / SF / Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF</td>
<td>$0.70</td>
</tr>
<tr>
<td>Split System</td>
<td>$1.09</td>
</tr>
<tr>
<td>4-Pipe System</td>
<td>$1.00</td>
</tr>
<tr>
<td>WSHP</td>
<td>$1.10</td>
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</tbody>
</table>

34% less
Annual HVAC Energy Cost ($ / SF / Year)

K to 12 School

- VRF: $0.62
- Split System: $1.01
- 4-Pipe System: $0.93
- WSHP: $0.98

36% less
Annual HVAC Energy Cost ($ / SF / Year)

Typical VRF Savings Compared to Conventional HVAC Systems:

- 25% to 40%
  New vs. New
- Up to 75%
  New vs. Existing
Energy – Why is VRF so efficient?

- High part load efficiency
- VRF recovers the wasted heat in the building
- Advanced Heat Pump Cycle
- Inverter matches load & equip capacity
- ECM fan motors – 50% reduction typical
- Heat transfer rate of refrigerant
Energy around the world

- Electric rates 3-6x higher than US
- Use of VRF validates energy efficiency

Japan: 90% VRF, 7.2M Systems
Europe: 81% VRF, 7.6M Systems
China: 86% VRF, 16.7M Systems

Key Features:
- Controllability
- Energy
- LEED
- Maintenance
- Cost
- Expandability
Liberty Memorial Central Middle School
Lawrence, KS

• 272 Tons VRF – Heat Recovery

• Budget & Timeline Challenges (75 Days)

• 13 Heat Recovery Systems & 147 Indoor Units
Saline County Authority Bldg.
Salina, KS

- 295 Tons VRF – Heat Recovery
- Budget & Occupancy Challenges
- 13 Heat Recovery Systems & 232 Indoor Units
Kansas City Streetcar Maintenance Facility
Kansas City, MO

- 28 Tons VRF – Heat Recovery
- High solar load and architecture challenges
- Controls integration
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Recap – VRF Benefits

- Precise temperature control
- Elimination of hot & cold spots
- Reduced utility bills
- Quiet operation
- Reduced maintenance
- Lifecycle costs savings
- Flexibility
Thank you for your time!

Questions?

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