VRF Market Conditions

NEEP ASHP Workshop

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Motivation for Clean Heating Programs

MA GHG reduction targets vs. 1990:
- 25% by 2020
- 80% by 2050

HVAC systems typically replaced every 15-20 years
- Often during major renovations
- Only two chances to go renewable by 2050
VRF Market Barriers & Opportunities

When evaluating which technologies to support, and what type of support to provide, MassCEC considers the following factors:

<table>
<thead>
<tr>
<th>Factors for technology success</th>
<th>VRF Status</th>
<th>MassCEC Level of Influence?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Cost-Effective vs. Alternatives</td>
<td>Varies</td>
<td>High</td>
</tr>
<tr>
<td>Reputation for High Performance</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Attractive Business Opportunity</td>
<td>Yes</td>
<td>Moderate</td>
</tr>
<tr>
<td>Implementation Hurdles</td>
<td>Low</td>
<td>Limited</td>
</tr>
</tbody>
</table>

*Projects that follow best practices perform effectively, but poorly performing systems have raised questions about the technology. MassCEC’s program addresses this through requirements for designer/installer training, system startup, and third-party inspections.*
## VRF Installation Costs

### Estimated Installation Cost

($ per 12 kBTU/hr of heating capacity @ 17F)

<table>
<thead>
<tr>
<th>System Type</th>
<th>No Heat Recovery</th>
<th>Heat Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Cost</td>
<td>$5,900</td>
<td>$7,100</td>
</tr>
<tr>
<td>Premium vs. Gas Boiler + VAV</td>
<td>+$900</td>
<td>+$2,100</td>
</tr>
</tbody>
</table>

- Moderately more expensive than other efficient alternatives (gas-fired boiler + rooftop A/C with VAV distribution).
- There are significantly cheaper alternatives (e.g. four-pipe system).
- If you include heat recovery capability, that increases the cost further.
- Contractors with prior VRF experience often offer lower bid prices after their first 1-2 projects.
- MassCEC is collecting cost data and may be able to provide better estimates in the future.
GHG Savings from Heating

Notes:
- Assumes system perform as rated 47°F and 17°F; interpolation for other temperatures
- Based on Hartford, CT temperature data (design temp. = 7°F)
- Rated capacity matches load at 10°F, which may overstate savings.
- Heating only; does not include cooling or heat recovery
Efficiency Specifications

• **ASHRAE 90.1** (2016 building code)
  – Relies on AHRI test data
  – Establishes performance requirements for EER, IEER, COP\(_{47}\), COP\(_{17}\)
  – Tiered minimums, based on unit capacity (65-135 KBTU/hr, 135-240, 240+)

• **Consortium for Energy Efficiency**
  – Aligns with 90.1, but moderately more stringent

• **MassCEC**
  – VRF rebate program requires ASHRAE 90.1
## Efficiency Metrics

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<th>Notes</th>
</tr>
</thead>
</table>
| Energy Efficiency Ratio (EER)                               | • Helps utilities estimate peak summer demand impact  
• Commercial system sizing often dictated by cooling load  
• Commercial customers often have demand component (kW) in efficiency bills in addition to energy (kWh) |
| Integrated Energy Efficiency Ratio (IEER)                   | • Best indicator of overall energy savings from cooling (similar to SEER)                                                                                                                                 |
| Coefficient of Performance (COP_{47} / COP_{17})            | • No seasonal efficiency rating (like HSPF)  
• No NEEP data available (max/min; no data at 5°F)  
• COP_{17} may be best measure of efficiency below 32°F  
• Low-temperature performance is important.  
  ➢ VRF often (usually?) a sole source of heating  
  ➢ Impacts customer’s winter electricity demand charge (kW)  
  ➢ Winter gas shortages causing spiking electricity prices across New England; if gas is the alternative, the “break-even” COP to reduce that shortage about 2.0* |
| Simultaneous Cooling and Heating Efficiency (SCHE)          | • Measures efficiency of heat recovery                                                                                                                                                         |

*Assumes VRF relies on 45%-efficient gas-fired peaking plant; replacing 90%-efficient gas-fired condensing boiler
Efficiency Metrics

Legend

X-axis: cooling capacity (BTU/hr)
Y-axis: efficiency metric
## VRF vs. “Mini-Splits”

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mini-splits</th>
<th>VRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test standard</td>
<td>AHRI 210/240</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td>Level of customization</td>
<td>Low*</td>
<td>High (&quot;Applied product&quot;)*</td>
</tr>
<tr>
<td>Unit capacity (BTU/hr)</td>
<td>Up to 65,000**</td>
<td>65,001** to 500,000*</td>
</tr>
<tr>
<td>Indoor heads per outdoor compressor</td>
<td>Up to 8*</td>
<td>Up to 60*</td>
</tr>
<tr>
<td>Variable speed inverter</td>
<td>Not required by AHRI (required by MassCEC)</td>
<td>Required by AHRI</td>
</tr>
<tr>
<td>Typical thermostat/control location</td>
<td>On indoor unit*</td>
<td>Central*</td>
</tr>
<tr>
<td>Expansion valve location</td>
<td>Outdoor unit*</td>
<td>Indoor unit*</td>
</tr>
<tr>
<td>Power type</td>
<td>Single-phase*</td>
<td>Three-phase*</td>
</tr>
<tr>
<td>Pipe configuration</td>
<td>Separate pipe for each indoor head</td>
<td>Single pipe network with branches for indoor heads</td>
</tr>
<tr>
<td>Simultaneous heating &amp; cooling (&quot;heat recovery&quot;)</td>
<td>Not available</td>
<td>Available</td>
</tr>
</tbody>
</table>

*Not required by AHRI standard but reflects actual market

**AHRI classifies all units with <65,000 BTU/hr in single category; manufacturers sees some of these as VRF
Ensuring Project Quality

To ensure project quality, MassCEC’s rebate program established the following measures:

- **Sizing**
  - Systems must meet 100% of both heating and cooling block loads
    - Ensures sufficient capacity for both summer and winter comfort
    - Minimizes use of backup heat, especially electric resistance
    - Applies only to zones conditioned by VRF system; other zones can use alternate HVAC systems

- **Controls**
  - Central Internet-connected controller for systems >240 kBTU/hr

- **Manufacturer-Assisted Start-up**
  - Required for all projects

- **Designer/Installer Training**
  - **Designer Training**: PE license or manufacturer letter recommending that MassCEC waive the PE requirement for the individual designer.
  - **Design and Installer Training**: At least 8 hours of manufacturer training in past five years (prior to application) on models being installed
  - Each designer/installer will undergo at least one third-party design review/inspection
  - Designer/Installer is an individual but may meet requirements by designating others from project team
Commercial CH&C Awareness Campaign

• Collaborate with key channel partners to promote CH&C technologies (air-source and ground-source heat pumps, biomass heating, and solar thermal):
  – Utility efficiency programs
  – Architecture and engineering firms/trade groups
  – Building owners/developers (public and private)
  – Facilities, energy, sustainability managers and consultants

• Supporting tools we’d like to develop
  – Financial modeling tool
  – Reference guide or case study for exploring CH&C technologies
  – VRF course certified by AIA, ASHRAE, or others so participants can receive continuing education credits

• Outreach venues
  – Meetings, events, conferences
  – Mass communications (newsletters, ads, websites, social media)