



VRF Market Conditions

NEEP ASHP Workshop

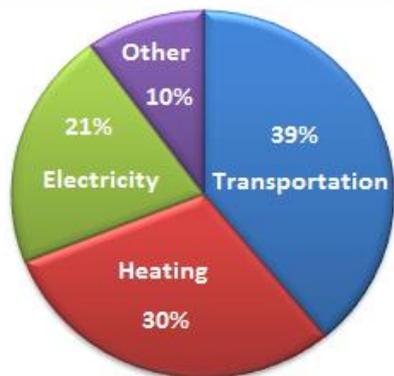
June 2017

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Motivation for Clean Heating Programs

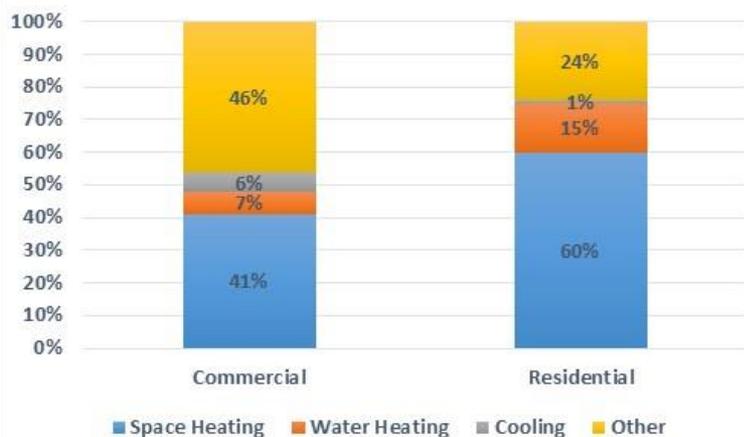
GHG Emissions (MA)



MA GHG reduction targets vs. 1990:

- 25% by 2020
- 80% by 2050

Building Energy Use (New England)



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:

| Factors for technology success | VRF Status | MassCEC Level of Influence? |
|---------------------------------|------------|-----------------------------|
| Awareness | Moderate | Moderate |
| Cost-Effective vs. Alternatives | Varies | High |
| Reputation for High Performance | Moderate | Moderate |
| Attractive Business Opportunity | Yes | Moderate |
| Implementation Hurdles | Low | Limited |

**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

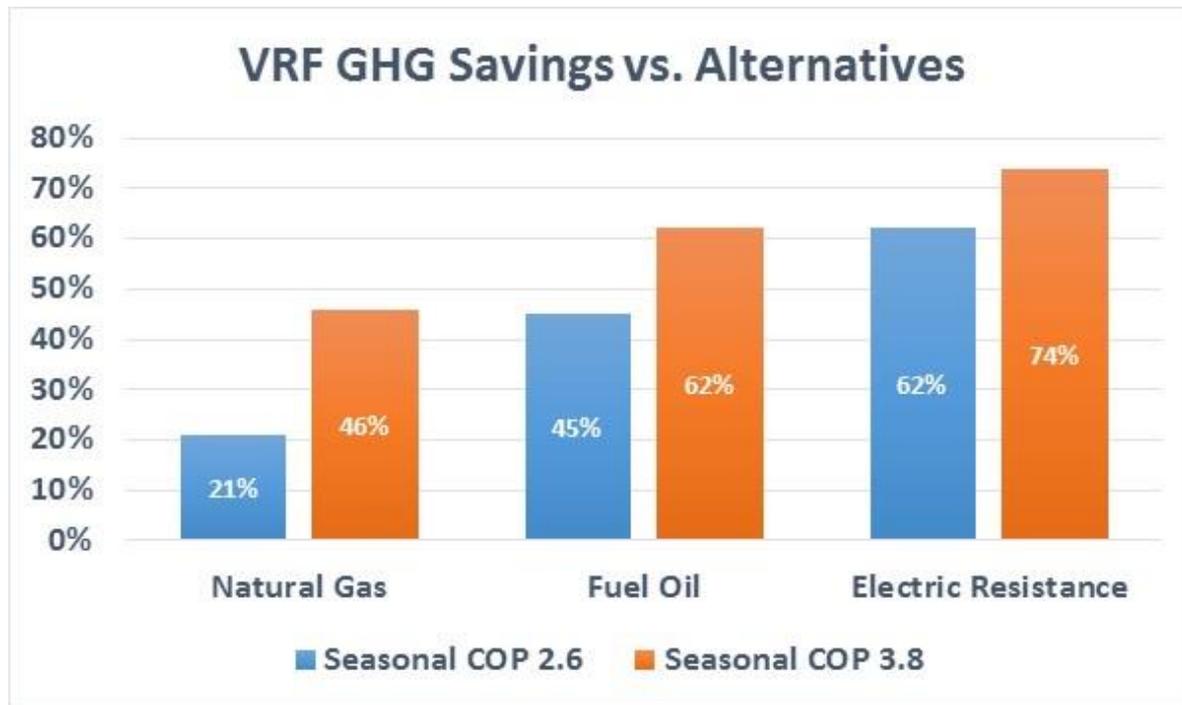
Estimated Installation Cost

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

| System Type | No Heat Recovery | Heat Recovery |
|------------------------------|------------------|---------------|
| Installation Cost | \$5,900 | \$7,100 |
| Premium vs. Gas Boiler + VAV | +\$900 | +\$2,100 |

- 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



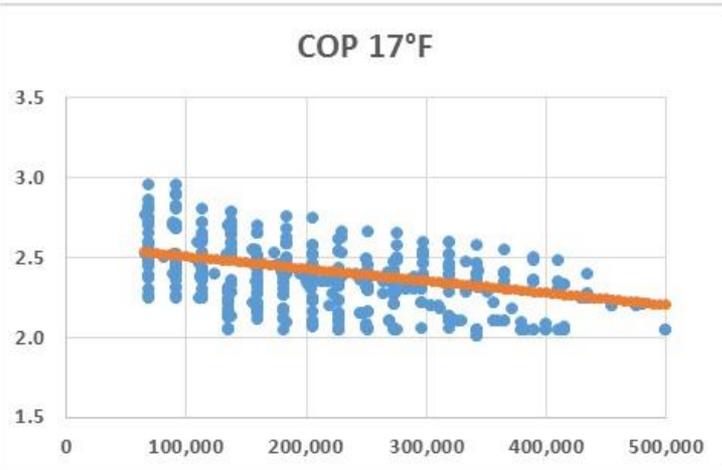
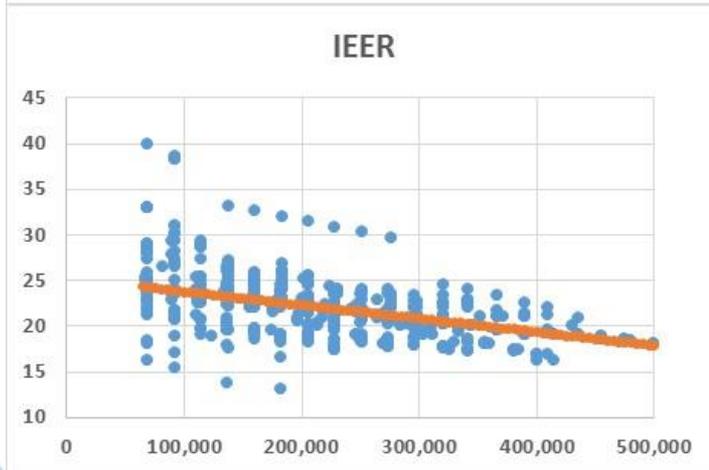
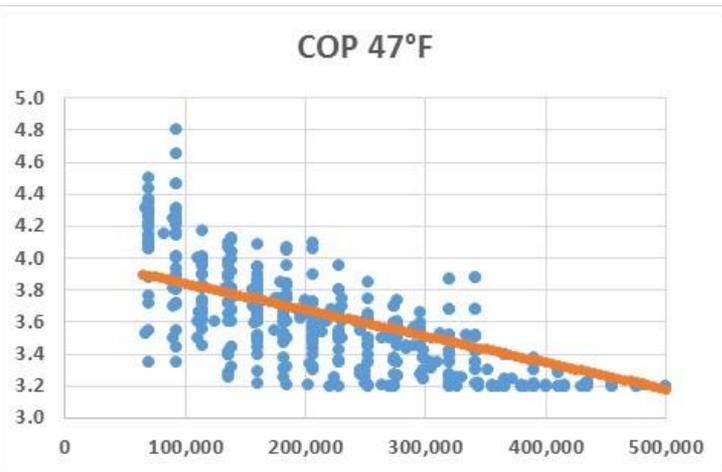
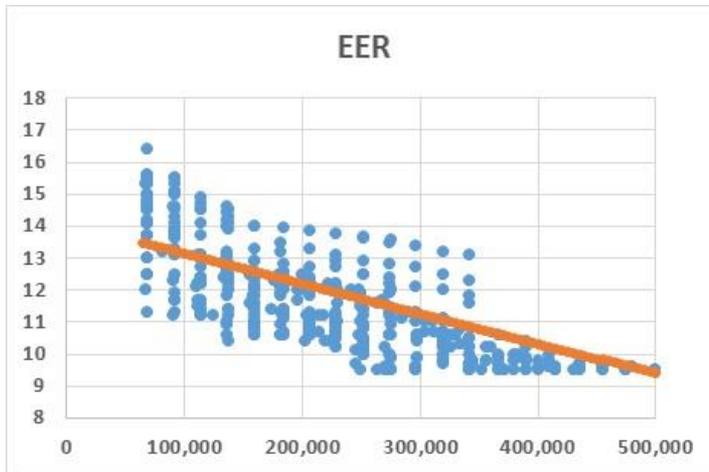
Efficiency Specifications

- **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

| Metric | Notes |
|---|---|
| Energy Efficiency Ratio (EER) | <ul style="list-style-type: none"> • 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) | <ul style="list-style-type: none"> • Best indicator of overall energy savings from cooling (similar to SEER) |
| Coefficient of Performance (COP ₄₇ / COP ₁₇) | <ul style="list-style-type: none"> • No seasonal efficiency rating (like HSPF) • No NEEP data available (max/min; no data at 5°F); • COP₁₇ may be best measure of efficiency below 32°F • Low-temperature performance is important. <ul style="list-style-type: none"> ➤ 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) | <ul style="list-style-type: none"> • Measures efficiency of heat recovery |

Efficiency Metrics



Legend

X-axis:
cooling capacity
(BTU/hr)

Y-axis:
efficiency metric

VRF vs. “Mini-Splits”

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

**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)