MASSACHUSETTS CLEAN ENERGY CENTER

VRF Market Conditions

NEEP ASHP Workshop

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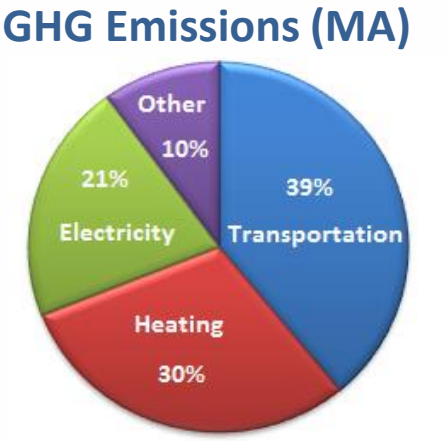
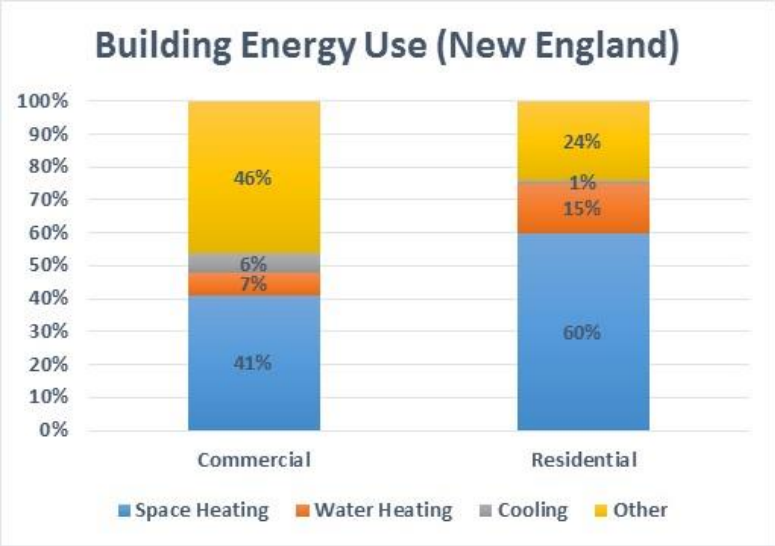
Motivation for Clean Heating Programs



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:

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.*

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VRF Installation Costs

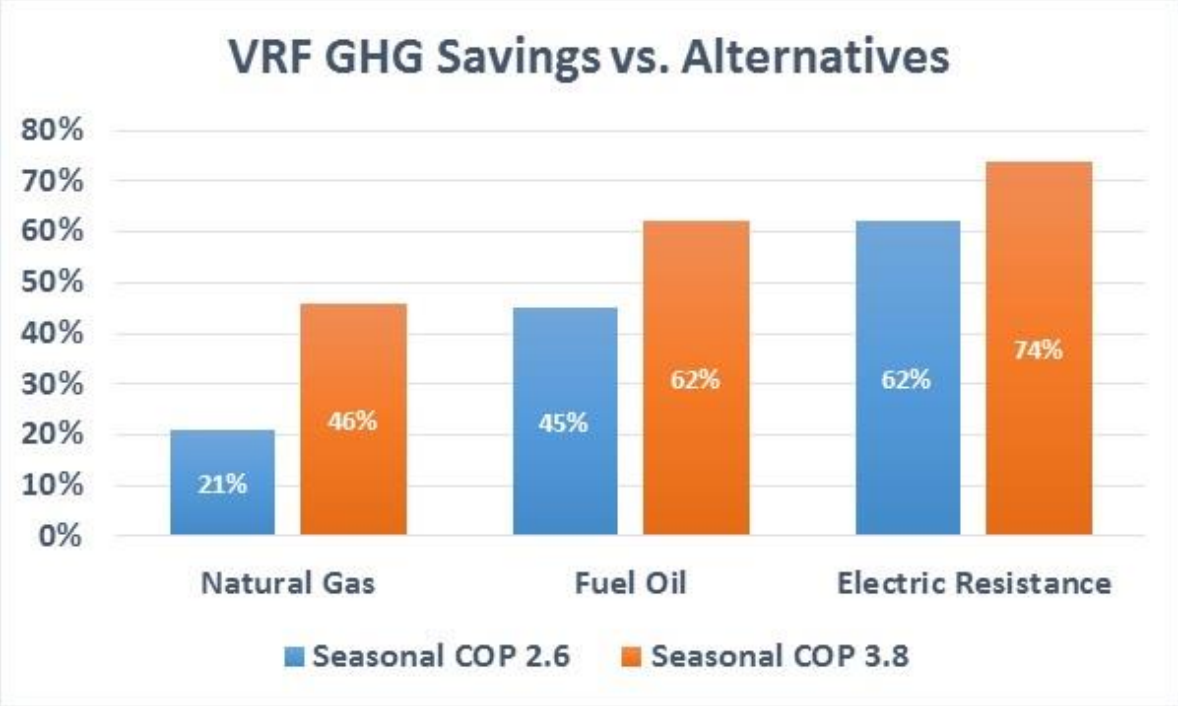
Estimated Installation Cost

($ 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

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Efficiency Metrics

Metric	Notes
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

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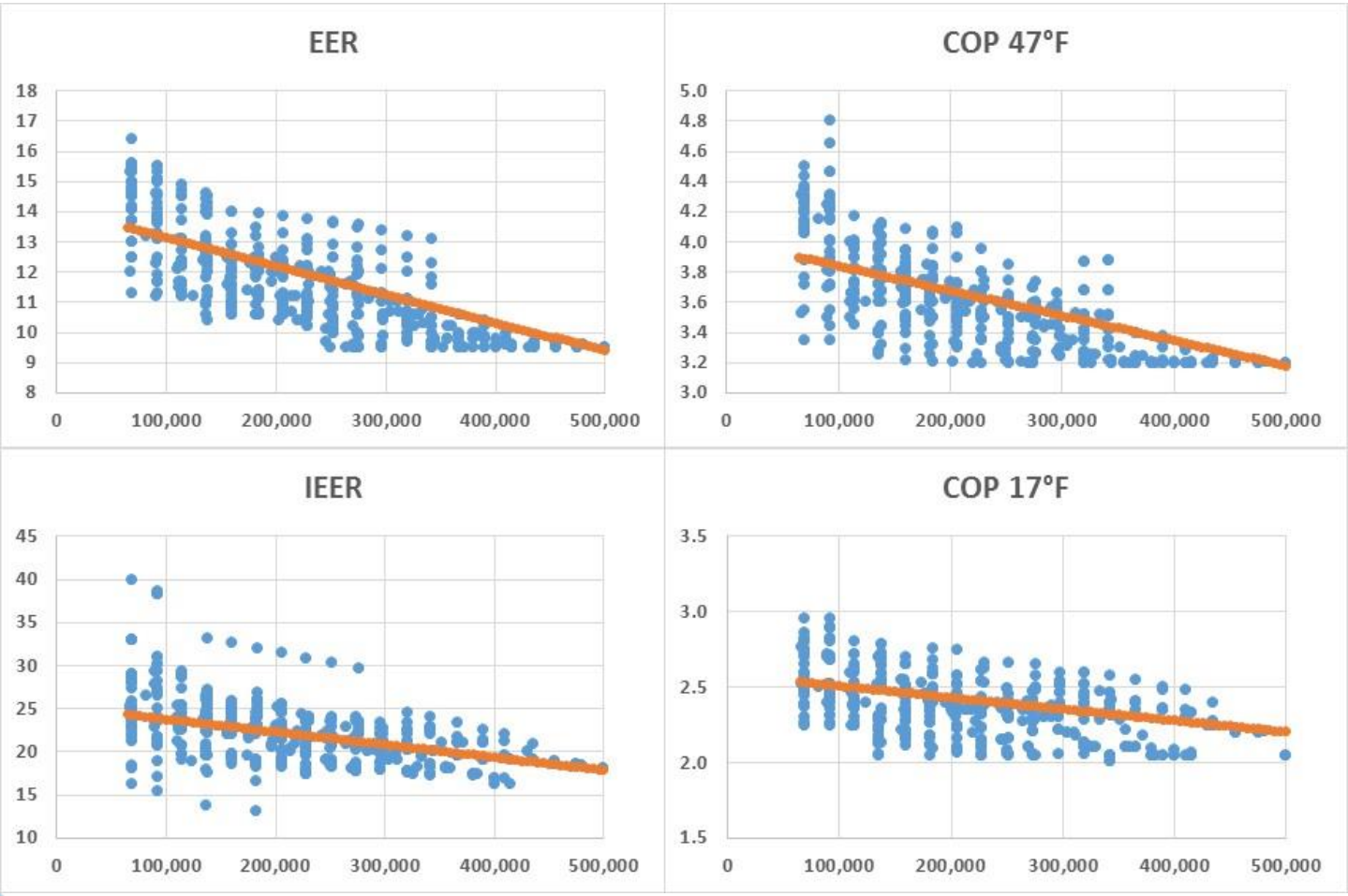
Efficiency Metrics



Legend

X-axis:
cooling capacity (BTU/hr)

Y-axis:
efficiency metric

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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)