Residential Heat Pumps:
Technology, Current Market, and Program Opportunities

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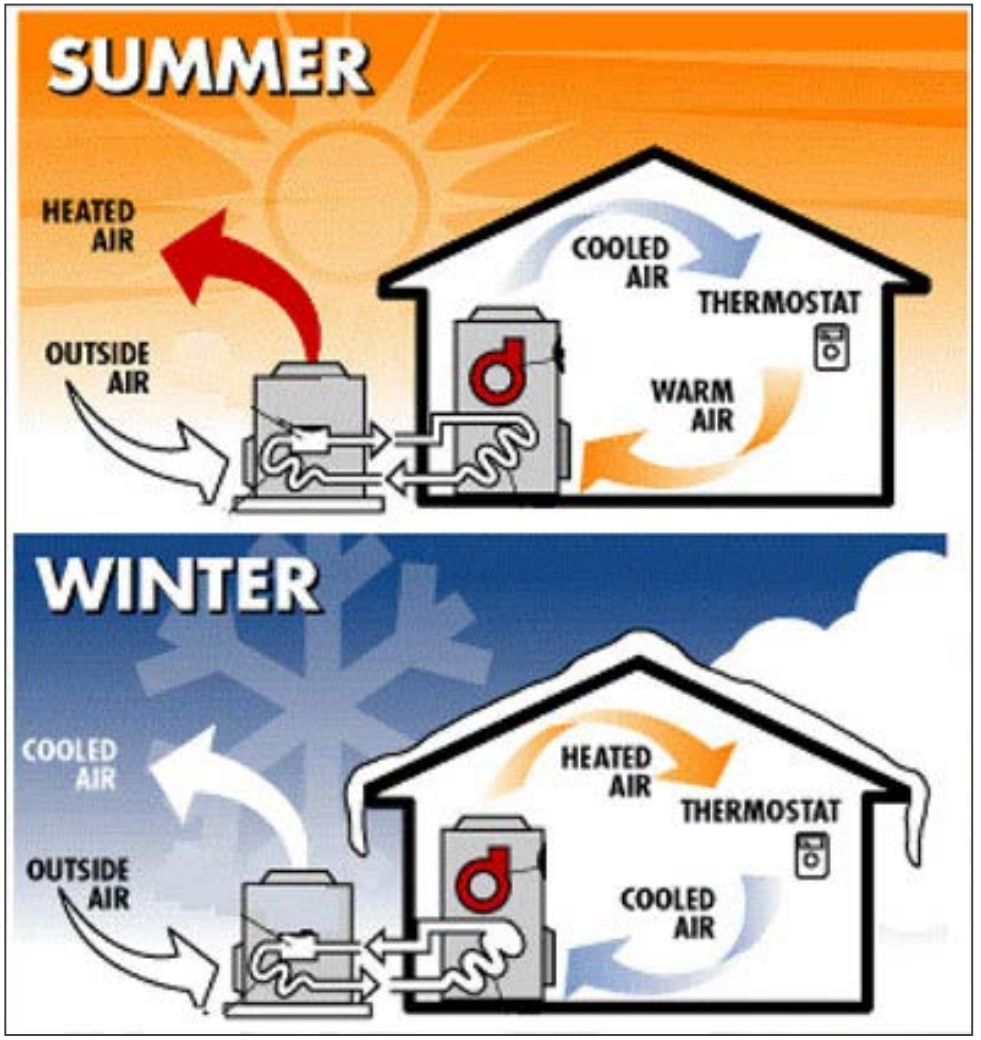
Outline

- Heat Pump (HP) Technology
- HP Program Savings and Participation
- Key Evaluation Findings
- Program Design Changes

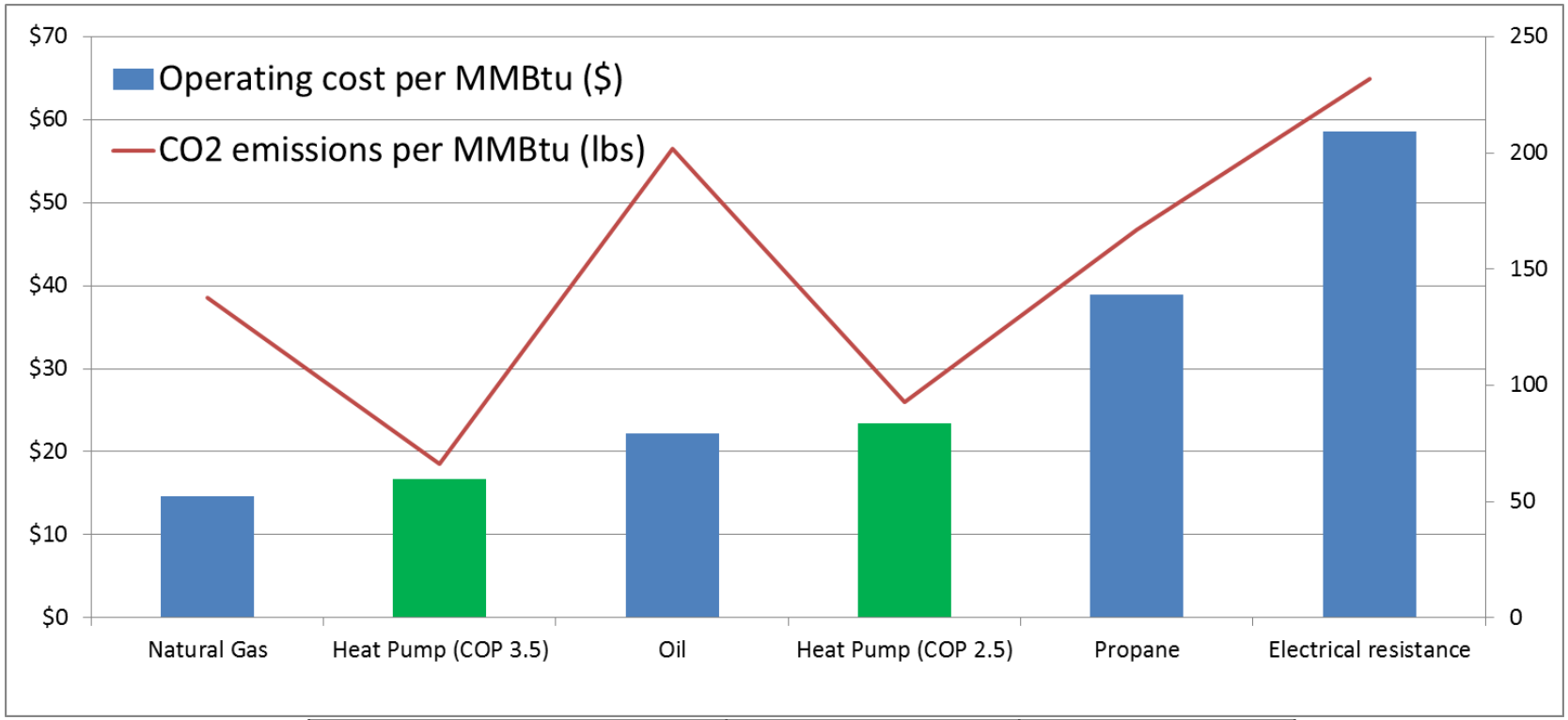
What Is a Heat Pump (HP)?

- Uses electricity to ***transfer*** ambient heat at a higher temperature from or to the home
  - Instead of ***converting*** electricity (directly through a resistor heating element) or ***burning*** fossil fuels to produce heat
- Efficiency is a function of outdoor temperature



Source: http://celticgreenenergy.co.uk/how-a-heat-pump-works

Heat Pumps Generally Have Low Operating Costs and Emissions (Heating)



Fuel	Cost	Efficiency
Heat Pump	$0.20/kWh	2.5/3.5
Electrical Resistance	$0.20/kWh	1.0
Natural Gas	$1.28/therm	0.85
Oil	$2.47/gallon	0.80
Propane	$2.96/gallon	0.85

PA internal analysis. Costs for oil and propane are the average retail prices for the 2016-17 winter season published by MA Executive Office of Energy and Environmental Affairs. Emissions factors (CO_2) from MA Department of Environmental Protection.

Heat Pump Program Savings
2016-2018 Three-Year EE Plan TRM

HP Technology	Estimated Maximum Energy Savings/Year and Load Reduction (Standard Efficiency to High Efficiency)	
Central heat pumps (ducted systems)	1,080 kWh 0.65 kW (2.8-ton unit)	
Mini-split heat pumps (**MSHPs**)	330 kWh 0.45 kW (1.0-ton unit)	
Heat pump water heaters (**HPWHs**)	<u><55 gallons</u> 1,650 kWh 0.34 kW	<u>>55 gallons*</u> 344 kWh 0.14 kW

* New offering introduced in 2017.

Photo sources: https://www.oregon.gov/energy/At-Home/Pages/Ducted-Heat-Pumps.aspx, http://www.justminisplits.com/products/dual_zone_mitsubishi_mini_split.php, http://www.ecosmartinc.com/catwheat21.php.

Heat Pump Program Rebate Volume

Equipment Type	2014	2015	2016
Central HPs	691	902	700
MSHPs*	6,520	6,050	7,484

* Number of outdoor units.

Source: https://www.energystar.gov/products/heating_cooling/ductless_heating_cooling

How Are Customers Using MSHPs?

MA customer survey

- 430 participants from 2013-2014
- More than half got an energy audit
- For comfort (68%), not for energy savings
- For A/C and as supplemental/secondary heat

Source: http://www.trueblueheatandair.com/services/mini-split-ductless-air-conditioners/

Source: The Cadmus Group, Inc. *Ductless Mini-Split Heat Pump Customer Survey Results*, August 2014.

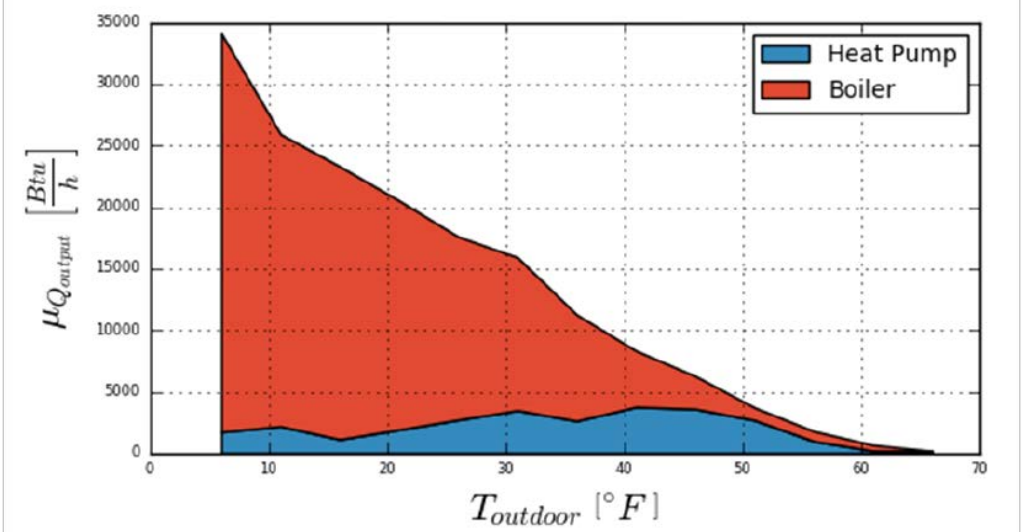
How Are Customers Using MSHPs?

2016 MA impact study affirms that MSHPs are being used intermittently year-round and secondarily with existing heating systems (comfort over savings)

Equipment Type	Equivalent Full Load Hours per Year	
	Cooling	Heating
MSHPs (Study Average)	**218**	**451**
MSHP (Study Top 25th percentile)	499	1,117
Central A/C and HPs (TRM)	360	1,200

Source: The Cadmus Group, Inc. *Ductless Mini-Split Heat Pump Impact Evaluation*, December 30, 2016.

Figure 61. Site M0198, Heating System Interaction

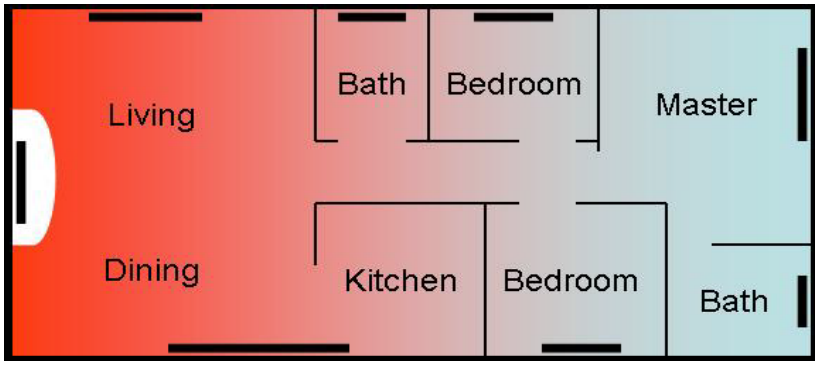


MSHP is not being used as a primary source of heat

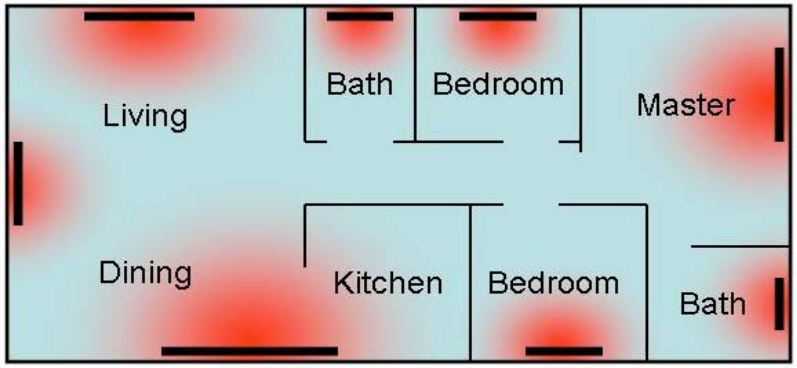
Boosting MSHP Savings without Sacrificing Customer Comfort

- Maximize MSHP usage for heating as the key driver of savings
- Optimize configuration and operation so MSHPs better complement existing heating systems and reduce overall heating costs
  - But customer concerns over cost and aesthetics
  - Also not a very compelling case at current fuel prices (next slide)

One MSHP -
Turn down primary/existing heat



Zoned System -
Match, size, and integrate with existing zone(s)



Managing Both Primary and MSHP Systems to Maximize Savings

A function of primary fuel type, the current cost of that fuel, MSHP efficiency, and outdoor temperature

Primary Heating Fuel	Assumptions (Winter 2016-2017) (1)	Outdoor Temperature Above Which It is More Cost Effective to Operate MSHP System	
		All Units	Cold-Climate Units
Electric Resistance	$0.20/kWh	All	All
Propane	$0.20/kWh $2.96/gal	-11°F	-13°F
Oil	$0.20/kWh $2.47/gal	30°F	22°F
Natural Gas	$0.20/kWh $1.28/therm	70°F	60°F (2)

(1) Also assumes fossil-fuel heating system efficiencies of 80%, inclusive of duct losses, and furnace fan and boiler pump energy use.

(2) Would decrease to about 40°F at $1.50/therm and 30°F at $1.70/therm.

Source: Figures ES-6 and ES-7 from Cadmus' *Ductless Mini-Split Heat Pump Impact Evaluation*, December 30, 2016.

Program Design

Changes to Incentives

- Increased HSPF
- Incentive per indoor unit

2016	2017
≥ 9 HSPF ≥ 18 SEER $250/outdoor unit	≥ ***10*** HSPF ≥ 18 SEER $100/***indoor*** unit
≥ 11 HSPF ≥ 20 SEER $500/outdoor unit	≥ ***12*** HSPF ≥ 20 SEER $300/***indoor*** unit

Customer/Contractor Education

Additional info on rebate forms and website, highlighting:

- Whole-house heating
- Crossover temperatures for use with existing systems
- No setbacks
- Proper refrigerant charge
- Sizing
- Zoning

Future Possibilities

- Currently lost opportunity measure - from standard efficiency (SEER 14.5, HSPF 8.2) to higher efficiency units (386, 338 kWh/yr)
  - May claim higher level of savings (~475 kWh) through the successful promotion of whole-house heating
- Possible retrofit of electric resistance
  - Marginally cost-effective due to high MSHP total installation cost (would have to claim highest level of savings to be cost-effective)
  - Need to verify displacement of existing ER heat all winter long
- Unlikely retrofit of fuel-fired heating systems
  - Cost effectiveness concerns – total installation costs, baselines, current cost of natural gas/oil

Thank you