

### Heat Pump Cost Background

November 4, 2022

Contact: John Hitt jhitt@masscec.com

### HEAT PUMP TYPOLOGIES

Centrally-Ducted









VRF

Ground-Source





**Distribution Type** 

2



## MASSCEC HEAT PUMP HISTORY

Program	2 0 1 3	2 0 1 4	2 0 1 5	2 0 1 6	2 0 1 7	2 0 1 8	2 0 1 9	2 0 2 0	2 0 2 1	# of Buildings (Approx)	Budget (Approx)	Description
Commercial GSHP										20	\$2M	Large Commercial
Residential ASHP										20,000	\$30M	Mostly Supplemental
Residential GSHP										600	\$5M	Whole-Home
Commercial ASHP										150	\$6M	VRF for Large Commercial
ACRE										50	\$2M	Exclusively Whole-Home (oil & propane)
Solar Access										50	\$1.7M	Supplemental
Whole-Home ASHP										150	\$0.5M	Exclusively Whole-Home (natural gas)

**Other Related Initiatives:** 

- Helping establish cold-climate heat pump spec, industry/consumer guides with NEEP
- Launching <u>Clean Energy Lives Here</u> consumer resources
- Running <u>HeatSmart</u> electrification campaigns in 15 communities

### **COSTS OF WHOLE-HOME HEAT PUMPS**

#### Limited whole-home cost data to-date:

- Whole-home pilot with 163 projects: Median project cost of \$18,000
  - Median cost for existing homes was \$21,000
- ACRE (low-income pilot) with around 40 projects: Median project cost of \$22,000
  - With installer experience and cost reduction measures costs came down to \$15-\$18k for ductless & \$12-\$15k for ducted

#### Factors that influence heat pump cost:

- Size of the building
- Layout (i.e., open floor plan or small rooms)
- Does the building have existing duct work that is reusable for heat pumps?
- Can the owner avoid replacing a legacy system?
- Did the owner want to add cooling where none previously existed?



### GENEROUS MASS SAVE $^{\ensuremath{\mathbb{R}}}$ incentives are available

Air Source Heat Pump Rebates									
Equipment Type	Rebate Type	Efficiency Requirements	Rebate Amount						
Air Source Heat Pumps	Whole-Home	Refer to the <u>MassSave</u> .com/HPQPL	\$10,000 per home						
	Partial-Home		\$1,250 per ton <sup>1</sup> , up to \$10,000						

Ground Source Heat Pump Rebates									
Equipment Type	Efficiency Requirements	Rebate Amount							
Ground Source Heat Pumps	Refer to the ENERGY STAR Certified List <sup>1</sup>	\$1 <i>5,</i> 000 per home							

#### Federal Tax Credits

- Investment Tax Credit (ITC) for GSHP
  - 30% through 2032 for residential
  - 30%+ through 2034 for commercial

# WHOLE-HOME HEAT PUMPS COST MORE THAN SUPPLEMENTAL SYSTEMS

Whole-home pilot median total project costs:

- Existing buildings: \$21,000\*
- New construction/gut rehab: \$14,000\*
- \*Pilot projects are smaller than average MA homes

Costs look higher than expected based on MassCEC's previous rebate program. Why?

- Mostly more expensive distribution (e.g., more indoor heads, ductwork)
- More expensive design due to contractor inexperience/uncertainty?
- Customers selects more expensive features (e.g., wi-fi thermostats, floor mount units)?

#### Are Integrated Controls a Possible Compromise?

- Maybe but some big questions remain.
- We don't yet have data on costs (i.e., Are they cheaper?) and performance (i.e., Do they actually get used for substantial heating hours?)
- Longterm, homeowner has to maintain and replace two systems



### CURRENT ENERGY COST TRENDS

- •Costs for all heating fuels have increased in 2022
- Geopolitical impacts on fossil fuel markets and inflation contributing to cost spikes
- Long-term supply price outlooks are more in line with historical fuel prices











MA Winter Propane Price (\$/gal)



Source: DOER Analysis

### CURRENT HEATING COSTS

•Costs of heat have increased proportional to fuel prices

•Relative costs of heating fuels generally consistent with previous years



#### Figure 2: Cost to Produce Heat this Winter (2022/23) for Different Technologies

Source: DOER Analysis

#### Figure 3: Winter Season Average Residential Household Space Heating Expenditures

### AVERAGE HOME HEATING COSTS

- •Home heating costs depend on home size, efficiency, usage, etc.
- •All fuel types contribute to significantly higher costs of heating
- Air-source heat pump heating costs would be similar to heating oil home if same square footage



Winter





Winter

Estimated Electric Resistance Heat Expenditures (Average Square Footage: 1,272)





Estimated Propane Heating Expenditures (Average Square Footage: 2,013)





Source: DOER Analysis

### FUTURE OF GAS

•In future years where less gas is burned in buildings, utilities anticipate increasing gas distribution costs per customer (from DPU 20-80 Future of Gas Proceedings)

•This will influence consumer costs and decision making with regard to heating system choices

	Gas distribution system (MA)											
Pathway	Annual gas throughput (Tbtu)	LDC customers (millions)	Embedded system costs <sup>1</sup> (\$bln)	Annual Revenue Requirement per customer (\$k)								
Efficient Gas Equipment	307 211	1.6 22	6 14	1.4 1.7								
Hybrid Electrification	307	1.61.8	6 12	1.4 1.8								
Low Electrification	307	1.6 1.1	6 12	1.4 2.6								
Networked Geothermal	307	1.6 1.8	6 13	1.4 2.0								
Targeted Electrification	307	1.6 0.9	6 7	1.4 2.2								
High Electrification <sup>2</sup>	307 49	1.6	6 11	18.4								
Interim 2030 CECP <sup>2</sup>	307 46	1.6	6 11	30								
100% Gas Decommissioning <sup>2</sup>	3070	1.6 0.9	6	1.4 3.83								
	2020 2050	2020 2050	2020 2050	2020 2050								
Natural g	as Renewable	gas Gas system	n Geothermal system	Gas + Geotherma RR/all customer								

### CONCLUSIONS

- •Heat pump economics vary significantly with existing fuel type, heat distribution system, presence of A/C, type of heat pump
- •Heat pump transitions impact a consumer's upfront and/or operating costs
- •Whole-home heat pump electrification is not yet commonplace and there is variability in upfront costs
- •Near-term cost-effectiveness of heat pumps varies significantly, but:
- Natural gas heating is generally lowest cost heat source today
- Electrifying buildings with oil heating can sometimes be cost-effective when current incentives included
- $\bullet$  For consumers adding A/C but without ductwork, heat pumps may be the most cost-effective option
- Heat pumps are a superior economic choice for consumers with traditional electric heat
- 2022 incentives can make upfront costs of heat pumps acceptable
- •Heat pumps with weatherization are the lowest cost approach to societal decarbonization in next 3 decades
- •Heat pump costs may decline based on technology and installation improvements, increased installer volume/familiarity, and economies of scale



### HEAT PUMP OPTIONS & CASE STUDIES

#### Residential Air-Source Heat Pump: Centrally Ducted





### MEDFORD ASHP CASE STUDY

#### Home:

- Built in the 1940s
- 1,449 square feet
- Weatherization measures: Blown in attic insulation, maybe some insulation in walls, 11.9 kW solar
- Heat load: 32,581 btu/hr (at 13°F)

#### Customer experience:

- Since the heat pump was installed on February 9th, 2020 they have not needed the natural gas boiler, although there has not been extreme cold weather.
- Met expectations for heating and cooling.
- It does increase electric bills. Solar PV defrayed the additional costs for this customer.

<u>Previous HVAC:</u> Natural gas hot water boiler and central A/C

#### Heat Pumps:

- Mitsubishi PUZ-HA36NHA5 (centrally ducted) with PVA-A36AA7 air handler (38,000 btu/hr at 5°F)
- Replaced old central A/C
- Installed February 2020
- Heat Pump Cost: \$12,458 (included some new duct insulation)
- Estimated Alternative Cost: \$17,300 for replacement boiler and single stage A/C





#### Residential Air-Source Heat Pump: Ductless



Multi-head

Single-head



### NORTHAMPTON CASE STUDY

#### Home:

- New construction, built 2019
- 3,100 square feet (including an unfinished basement)
- Weatherization measures: High levels of insulation in the roof, walls, and basement slab, plus triple pane windows and HRV
- Peak heat load: 23,103 btu/hr at 0°F

#### Heat Pumps:

- Three Fujitsu AOU9RLS3 single-head units (45,000 btu/hr at  $5^{\circ}$ F)
- House occupied September 2019
- Cost: \$13,750 (including markup from general contractor)



#### Customer experience:

- Overall, heat pumps do their job without being noticeable, very easy to live with.
- Units are quiet, no noise or vibrations from the wallmounted outdoor units
- Winter 2019/20, household only ran the first-floor heat pump to heat the entire house.
  Bedrooms were slightly cooler, but that matched his family's preference.
- During hot periods of the summer, they ran the upstairs unit for cooling, overall this unit cooled the house well, but the bedrooms stayed slightly warmer, especially with the doors closed. Would consider more distribution upstairs.
- With a 10kW solar array, the home has been producing more energy than it consumes

Residential Air-Source Heat Pump: Mix of ductless & ducted





#### <u>Previous HVAC</u>: Natural gas steam boiler and window A/C units Heat Pump:

- Mitsubishi MXZ-4C36NAHZ (42,444 btu/hr at 5°F) with three 9 kbtu wall mounted units downstairs and one mini-duct upstairs
- Installed August 2019
- Heat Pump Cost: \$19,500 (estimated price, homeowner paid less because he did some of his own labor)
- Estimated Alternative Cost: \$21,700+ for replacement boiler and new A/C (new duct work could be significantly more)

### BOSTON ASHP CASE STUDY

#### Home:

- Built in the 1930s
- 1,296 square feet
- Weatherization measures: Double pane windows, wall insulation, sprayfoamed the attic
- Heat load: 38,798 btu/hr at 12°F





#### Customer experience:

- No issues heating during the coldest days. When the thermostat broke on his gas boiler, he removed this back up heating source altogether.
- For ducted upstairs units he has a wireless temperature sensor which he can move around (e.g., with a guest or working in the office)
- Very happy with wall mount units. Would more seriously consider a ductless unit in every room.
- Much easier to cool the upstairs once the attic was spray foamed (i.e., ductwork was put inside the home's envelope).
- Outdoor unit was mounted against the kitchen wall and it does transmit some noise, just into the kitchen.

Residential Ground-Source Heat Pump: Centrally Ducted





#### <u>Previous HVAC:</u> Oil boiler with baseboard distribution <u>Heat Pumps:</u>

- Hydron Module HBT024 (1<sup>st</sup> unit) & Hydron Module HYT036 (2<sup>nd</sup> unit)
- Added ductwork to home
- Installed 2019
- Heat Pump Cost: \$76,000 (before incentives, including new duct insulation for both units, which was about a third of the cost)
- Estimated alternative cost: \$52,900 for replace boilers and new A/C with new ductwork

### ARLINGTON GSHP CASE STUDY

#### <u>Home:</u>

- 1920s two-family
- 2200 square feet total
- Other clean energy measures: Weatherization, solar PV, solar hot water, and electric vehicle
- Total heat load: 42,720



#### **Customer experience:**

- New system is quieter and the house is less humid.
- Estimate a 12-17 year payback period for replacing the oil heat even with duct work.



Commercial Air-Source Heat Pump: VRF





<u>Previous HVAC:</u> Gas-fired Modine heat exhangers 10-ton direct exchange air handler units with cooling coils

#### Heat Pumps:

- 12 Daikin VRV system (97 tons) with 2/3rds of air handlers (remaining 1/3<sup>rd</sup> of air handlers were a separate phase)
- Reused the existing ductwork
- Installed 2019
- Heat Pump Cost: : \$209,406
- Estimated Alternative Cost: Not available, but traditional HVAC would have cost more due to required infrastructure modifications



### LOWELL VRF CASE STUDY

- Built in the 1940s
- 19<sup>th</sup> century textile mill complex
- 143,000 square feet
- 50 commercial tenants (including conference center, café, fitness center, & university research facility)



- VRF equipment was more flexible than alternatives for a space-constrained project, with cheaper, faster, less invasive installation.
- Modular heat pumps offer flexibility as tenants change



