Heat Pumps

Community Workshop – Manchester Library, Manchester

Jake Marin
Program Manager – HVAC/R
Efficiency Vermont
April 14, 2015
Our Roadmap

- Brief Technology Overview
- Heat Pump Economics
- Successful Applications
- Program Support
Benefits of Heat Pumps

- **Heating and cooling** from same piece of equipment
- **Cheaper** than most conventional heating systems
- Also **efficient cooling**
- Ductless heat pumps are a **quick and non-invasive** retrofit installation
- New construction - reduced need for **heating and cooling infrastructure**
- Can be completely **sustainable** if powered by renewables
A Quick Technology Primer
What IS a heat pump, anyway?

An air conditioner in reverse
Heat Source → Heat Sink

Heat source e.g. air, ground, water

Evaporator

Heat pump cycle

Compressor

Expansion valve

Condenser

Heat sink e.g. building
Heat Source

Air (Air Source Heat Pump)

Air source heat pump

- Outdoor coil: Refrigerant absorbs heat from air
- Compressor increases temperature and pressure of refrigerant
- Refrigerant releases heat to air and returns to a liquid state
Ground (Ground Source or Geothermal Heat Pump)

- Earth
Water

Water is pumped from the borehole to the heat pump.

Cooler water is returned, gaining heat as it passes through the ground before reaching the aquifer.

Direction of flow
Heat Sink – Space Heat

Air Delivered
Heat Sink – Space Heat

Water Delivered
Heat Sink – Domestic Hot Water
Heat Pump Water Heaters

- Air → Water
- 1/3-1/2 the electricity compared to a standard electric water heater (saves 50-66% in water heating costs)
- $550 Efficiency Vermont discount on this equipment
- New federal standards in April, 2015 will require electric water heaters >55 gal to be a heat pump water heater
What’s the Difference?

**Standard Electric Water Heater**
*Covers* heat using electricity (with a heating element)

**Heat Pump Water Heater**
*Moves* heat (energy) from one place (air) and transfers it to another (water).

Generally, it’s easier to move something, than to make something...
Heat Pump Water Heater Considerations

• Units should be installed in a space where the temperature stays above ~50°F
• Better suited to basements than living spaces
• At least 750 cubic feet of air space around the unit
• Requires a condensation drain – either pumped outside, or passively drained to a lower receptacle
A Closer Look at Space Heating with Heat Pumps
Some Equipment Terminology

**Heat Pump** – Overarching technology

**Ductless Heat Pump** – A heat pump which delivers space conditioning without ducts

**Mini-Split** – A heat pump in which the system is “split” between indoor and outdoor components

**Multi-Split** *(also, multi-port or multi-zone)* – As above but with multiple indoor units connected to a single outdoor unit

**Ductless Mini-Split** – A ductless delivery split system

**Air Source Heat Pump** – Heat pump equipment with air derived heat energy

**Geothermal (Ground Source) Heat Pump** – Heat pump equipment with ground or water derived heat energy
Efficiency Acronyms – Why 3?

(Expressed as btus/watt)

**HSPF** – Heating Seasonal Performance Factor
- **Seasonal heating** efficiency of a heat pump

**SEER** – Seasonal Energy Efficiency Ratio
- **Seasonal cooling** efficiency of a heat pump

**EER** – Energy Efficiency Ratio
- **Peak cooling** efficiency of heat pump running at 95°F
Are they efficient?

- They *Move* Heat, rather than *Generate* Heat
- Leverage heat existing in the environment (stored solar energy) rather than burn fuel to release energy
- High SEER - Cooling
- High HSPF - Heating
- COPs of 2.0-4.0+
  - What is COP???
  - COP (Coefficient Of Performance) = Energy Out/Energy In

So… A COP of 2-4 is equivalent to 200-400% efficiency!
More Out than In (COP of 3)?

Heat source:
Air, Ground or Water

1 kWh
Electricity
In to Move Heat

HEAT PUMP

3 kWh

3 kWh
Heat sink:
House

Efficiency Vermont
Cold Climate Performance

Cold Climate Heat Pump

- Maintain capacity at very cold temperatures (below 5°F)
- High efficiency at these low temperatures

How is this achieved?

- New refrigerants
- Ultra high pressure systems
- Variable speed compressors
- Sophisticated controls
Heat Pump Economics
Ductless Mini Splits
The Displacement Model

Before

100%

Central System

After

80%

Heat Pump

20%

Central System
## A Comparison of Heating Fuels

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Unit</th>
<th>Btu/Unit</th>
<th>Efficiency</th>
<th>$/Unit</th>
<th>$/MMBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>Therm</td>
<td>100,000</td>
<td>90%</td>
<td>$1.48</td>
<td>$16.44</td>
</tr>
<tr>
<td>Wood</td>
<td>Cord</td>
<td>22,000,000</td>
<td>60%</td>
<td>$227.00</td>
<td>$17.20</td>
</tr>
<tr>
<td>Pellets</td>
<td>Ton</td>
<td>16,400,000</td>
<td>80%</td>
<td>$294.00</td>
<td>$22.41</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>Gallon</td>
<td>138,200</td>
<td>85%</td>
<td>$3.22</td>
<td>$27.41</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Gallon</td>
<td>136,600</td>
<td>85%</td>
<td>$3.80</td>
<td>$32.73</td>
</tr>
<tr>
<td>Propane</td>
<td>Gallon</td>
<td>91,600</td>
<td>90%</td>
<td>$2.86</td>
<td>$34.69</td>
</tr>
<tr>
<td>Electricity</td>
<td>kWh</td>
<td>3,412</td>
<td>100%</td>
<td>$0.15</td>
<td>$43.96</td>
</tr>
<tr>
<td>Electricity (Heat Pump)</td>
<td>kWh</td>
<td>3,412</td>
<td>250%</td>
<td>$0.15</td>
<td>$17.58</td>
</tr>
</tbody>
</table>
## Typical Residential Heating Fuel Costs (75 MMBtu/Yr)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Volume</th>
<th>Unit</th>
<th>$/Unit</th>
<th>$/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>833</td>
<td>Therms</td>
<td>$1.48</td>
<td>$1,233</td>
</tr>
<tr>
<td>Wood</td>
<td>5.7</td>
<td>Cords</td>
<td>$227.00</td>
<td>$1,289</td>
</tr>
<tr>
<td>Pellets</td>
<td>5.7</td>
<td>Tons</td>
<td>$294.00</td>
<td>$1,680</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>603</td>
<td>Gallons</td>
<td>$3.22</td>
<td>$2,055</td>
</tr>
<tr>
<td>Kerosene</td>
<td>610</td>
<td>Gallons</td>
<td>$3.80</td>
<td>$2,454</td>
</tr>
<tr>
<td>Propane</td>
<td>910</td>
<td>Gallons</td>
<td>$2.86</td>
<td>$2,601</td>
</tr>
<tr>
<td>Electricity</td>
<td>21,981</td>
<td>kWh</td>
<td>$0.15</td>
<td>$3,297</td>
</tr>
</tbody>
</table>

- Without Natural Gas (or biomass), heating costs run $2000-$3000+ per year
Heating Fuel Cost Savings with an ASHP (COP 2.5)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>75 MMBtu/Yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>-$68.43</td>
</tr>
<tr>
<td>Wood</td>
<td>-$23.28</td>
</tr>
<tr>
<td>Pellets</td>
<td>$289.41</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>$589.58</td>
</tr>
<tr>
<td>Kerosene</td>
<td>$908.56</td>
</tr>
<tr>
<td>Propane</td>
<td>$1,026.41</td>
</tr>
<tr>
<td>Electricity</td>
<td>$1,582.65</td>
</tr>
</tbody>
</table>

- Savings ~$600-$1600/yr
- Assuming 80% heating fuel offset and no cooling effects
Play with Numbers
(80% Displacement, 75 mmbtu/yr home, 85% efficient oil system)

House before:
- 640 gallons fuel oil ($3.22/gal)
- $2060/yr for heat (88 MMBtu)

House after:
- 128 gallons oil + 7050 kWh electricity ($0.15/kWh)
- $410 (oil) + $1060 (electric) = $1470/yr for heat (42 MMBtu)
- Net Savings - $590/yr (46 MMBtu – 52% Reduction)
- 3600 lbs CO$_2$/yr NET reduction
Cost of Heat Pumps

- Single Zone Ductless - $4,000
- Multi Zone Ductless – $6,000 - $20,000
- Ground Source – $20,000+
Successful Applications

Air-source heat pumps
Good Building Characteristics for Heat Pumps

- Well air sealed and insulated
- Open floor plan/Open doors
- Multi-story homes
- Existing multi-zonal heat
- Functional backup system
- Expensive heating fuel
- Site based electrical generation
A Good Installation

- Install at least 18-24” off the ground
- Do not install under eave without a cover
- Indoor unit placed with best access to volume of space
- Refrigerant line penetration air sealed
- Line-set is insulated and protected
- Properly wired and evacuated
- Integration with existing heating system considerations
Additional Considerations

- They make noise
  - Indoor vs. outdoor noise
  - Wall brackets vs. ground stands
- They are not invisible
- Decreased output as it gets colder
- Decreased efficiency as it gets colder
- Electrical infrastructure (double 15/20 breaker required)
- Low end temperature setting
Heat Pump Myths – Busted!

Myth - Heat Pumps don’t work when it gets really cold
Truth – Cold Climate Heat Pumps operate effectively below -5F

Myth – Heat Pumps are a great replacement when your current heating system dies
Truth – Air source heat pumps provide heating displacement, but not full replacement. You’ll need a backup

Myth – The fuel for heat pumps is coolant
Truth – Heat pumps run on electricity. The coolant (refrigerant) is contained inside a closed loop and is not “used up”

Myth – Heat pumps will lower all my bills
Truth – For most people, they lower fuel bills, but raise electric bills
Efficiency Vermont Program

Cold Climate Heat Pumps
How does it work?

1. Installation contractor (or homeowner) purchases eligible equipment from a participating wholesaler
2. Provide some basic information about installation
3. $300 Discount applied to purchase
4. No forms or waiting for a check
Eligible Equipment

- HSPF ≥ 10.3, EER ≥ 12.0, SEER ≥ 20.0
- COP @5°F ≥ 1.75 (at maximum capacity operation)
- Operation at -5°F or below

For a list of eligible models, visit:
Participating Distributors

For a full list of Participating Distributors and branch locations, visit:
Pay for it with a **low** or **no** interest loan

- Energy efficiency loans pay for improvements such as
  - Cold climate heat pumps
  - Upgrading heating systems (including pellet boilers and furnaces)
  - Air sealing or insulating leaky attics
  - New efficient windows and doors... and more!

- Financing often results in **saving more** money on monthly utility bills **than you are paying** in loan payments

*Next step - Do something*
What are the financing options available?

Improvement loans exist from select financial institutions, but they may not be geared toward energy efficiency upgrades... here are a few that are:

- **For Homeowners**
  - Heat Saver Loan Program
  - PACE (Property Assessed Clean Energy)

- **For Businesses**
  - Business Energy Loan Program
  - Energy Loan Guarantee Program

- **For Farms**
  - Efficiency Vermont Ag Loan Program
How to save, with Efficiency Vermont

• Look for SMART CHOICE electronics & appliances at local retailers
  We’ve researched the products that are proven to save you money and energy, and marked them with a SMART CHOICE label.
  Plus! Most have cash back rebates available.

• Discounted LEDs starting at $4.99 & CFLs starting at 99¢

• Home weatherization offers like a $100 discount on an energy audit and up to $2,000 off eligible improvements

• Efficiency assistance from our customer service and technical support teams
  We can help you determine the best options for your home... Call us!
Thank You!