Heat Pumps: Select and Operate for Efficiency

Li Ling Young
Sr. Energy Consultant
Efficiency Vermont
Agenda

• How do heat pumps do that?
• Mini-splits: Darling of Decarbonization
• Different houses, different heat pumps
• Weatherization, Heat Pump’s best friend
Secrets of Heat Pumps: Making Water Flow Uphill
Familiar heat pumps
What IS a heat pump, anyway?

An air conditioner in reverse

Efficiency Vermont
What IS a heat pump, anyway?

An air conditioner in reverse
Air to Air Heat Pumps

Air source heat pump
Air to Air Heat Pumps
Mini-split Heat Pumps

aka

“ductless heat pump”
“ductless mini-split”
“heat pump”
Mini-split Heat Pumps

• Cheap and easy to install
• Pretty efficient
• Plays nicely with an existing heating system
  – Especially wood heat
• Air conditioning!
• Electrification, zero energy and decarbonization
Low Load Home, Huntington, VT

- 2100 conditioned square feet
- 14.7 KBtu/hr total heat loss
- 6.2 Kbtu/hr total heat gain
- 3 br, 2 ba, finished basement
- Built 2018, modular construction
- Ducted HRV, HPWH
## Single Zone Mini-split vs Multi-split

<table>
<thead>
<tr>
<th>Manufacturer's Data</th>
<th>AHRI Data</th>
<th>NEEP Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooling Kbtu/hr</td>
<td>Heating Kbtu/hr</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>max</td>
</tr>
<tr>
<td>down</td>
<td>AOU9RLS3H</td>
<td>3.1</td>
</tr>
<tr>
<td>up</td>
<td>AOU12RLS3H</td>
<td>3.1</td>
</tr>
<tr>
<td>house</td>
<td>AOU24RLXFZH</td>
<td>6.1</td>
</tr>
<tr>
<td>house</td>
<td>AOU36RLXFZH</td>
<td>12</td>
</tr>
</tbody>
</table>

*NEEP Data:
- COP at 47°F
- COP at 17°F
- COP at -15°F
- Capacity at -15°F (min and max values)
# Single Zone Mini-split vs Multi-split

<table>
<thead>
<tr>
<th></th>
<th>Manufacturer's Data</th>
<th>AHRI Data</th>
<th>NEEP Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooling Kbtu/hr</td>
<td>Heating Kbtu/hr</td>
<td>SEER</td>
</tr>
<tr>
<td>down</td>
<td>3.1</td>
<td>12</td>
<td>3.1</td>
</tr>
<tr>
<td>up</td>
<td>3.1</td>
<td>13.6</td>
<td>3.1</td>
</tr>
<tr>
<td>house</td>
<td>AOU24RLXFZH</td>
<td>6.1</td>
<td>27</td>
</tr>
<tr>
<td>house</td>
<td>AOU36RLXFZH</td>
<td>12</td>
<td>39</td>
</tr>
</tbody>
</table>

Efficiency Vermont
Wise Mini-split Design

Main Floor
- Breakfast Room: 10'2" x 15'2"
- Family Room: 22' x 17'2"
- Master Bedroom: 16'2" x 14'6"
- Dining Room: 16'2" x 13'8"
- Sitting Room: 16'2" x 13'8"
- Front Porch
- Rear Deck
- Screened Porch

Second Floor
- Bedroom: 13'6" x 14"
- Bedroom: 13'6" x 14"
- Bedroom: 17'6" x 14"
- Media Room: 12' x 13'8"
- Attic
- Attic
- Attic
Good Candidates for Mini-split

- Modestly-sized home
- Well-insulated and -air-sealed
- Open-ish floor plan
  - At least one large, multi-purpose, well-used room
- Zoned heating
- Engaged, willing occupants
- Functioning central heat
- If you’re building new...
  - Integrated design
Mini-split Design Best Practices

• Know what you’re trying to accomplish
• Accept indirect heating/cooling
• Single-zones only
• Get a load calculation
• Don’t confuse your thermostat
• Never in a small room
• Consider noise and air currents
• Outdoor unit placement
### Indoor Temperature

<table>
<thead>
<tr>
<th>Outdoor Temperature</th>
<th>60</th>
<th>65</th>
<th>70</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FDB</strong></td>
<td><strong>FWB</strong></td>
<td>TC</td>
<td>IP</td>
<td>TC</td>
</tr>
<tr>
<td>-15</td>
<td>-17</td>
<td>15.8</td>
<td>2.23</td>
<td>15.4</td>
</tr>
<tr>
<td>-5</td>
<td>-7</td>
<td>17.6</td>
<td>2.26</td>
<td>17.1</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>19.3</td>
<td>2.29</td>
<td>18.9</td>
</tr>
<tr>
<td>14</td>
<td>12</td>
<td>20.7</td>
<td>2.33</td>
<td>20.2</td>
</tr>
<tr>
<td>23</td>
<td>19</td>
<td>21.6</td>
<td>2.43</td>
<td>21.1</td>
</tr>
<tr>
<td>32</td>
<td>28</td>
<td>21.8</td>
<td>2.63</td>
<td>21.3</td>
</tr>
<tr>
<td>41</td>
<td>37</td>
<td>23.8</td>
<td>2.32</td>
<td>23.2</td>
</tr>
<tr>
<td>47</td>
<td>43</td>
<td>25.1</td>
<td>2.17</td>
<td>24.5</td>
</tr>
<tr>
<td>50</td>
<td>47</td>
<td>27.7</td>
<td>1.94</td>
<td>27.1</td>
</tr>
<tr>
<td>59</td>
<td>50</td>
<td>28.7</td>
<td>1.95</td>
<td>28.0</td>
</tr>
</tbody>
</table>

### OUTDOOR TEMPERATURE (°F WB)

<table>
<thead>
<tr>
<th>EDB</th>
<th>5</th>
<th>14</th>
<th>23</th>
<th>32</th>
<th>43</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>°F</strong></td>
<td>TC</td>
<td>PI</td>
<td>TC</td>
<td>PI</td>
<td>TC</td>
<td>PI</td>
</tr>
<tr>
<td>59.0</td>
<td>4.76</td>
<td>0.55</td>
<td>5.72</td>
<td>0.58</td>
<td>6.68</td>
<td>0.60</td>
</tr>
<tr>
<td>70.0</td>
<td>4.47</td>
<td>0.56</td>
<td>5.43</td>
<td>0.59</td>
<td>6.39</td>
<td>0.62</td>
</tr>
<tr>
<td>71.6</td>
<td>4.35</td>
<td>0.57</td>
<td>5.31</td>
<td>0.60</td>
<td>6.27</td>
<td>0.62</td>
</tr>
<tr>
<td>75.2</td>
<td>4.23</td>
<td>0.57</td>
<td>5.19</td>
<td>0.60</td>
<td>6.15</td>
<td>0.63</td>
</tr>
<tr>
<td>77.0</td>
<td>4.17</td>
<td>0.58</td>
<td>5.13</td>
<td>0.61</td>
<td>6.09</td>
<td>0.63</td>
</tr>
<tr>
<td>80.6</td>
<td>4.06</td>
<td>0.58</td>
<td>5.02</td>
<td>0.61</td>
<td>5.98</td>
<td>0.64</td>
</tr>
</tbody>
</table>

### EDB vs. Outdoor Temperature

<table>
<thead>
<tr>
<th>EDB</th>
<th>5</th>
<th>14</th>
<th>23</th>
<th>32</th>
<th>43</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>°F</strong></td>
<td>TC</td>
<td>PI</td>
<td>TC</td>
<td>PI</td>
<td>TC</td>
<td>PI</td>
</tr>
<tr>
<td>27.0</td>
<td>5.60</td>
<td>0.69</td>
<td>6.27</td>
<td>0.72</td>
<td>7.04</td>
<td>0.75</td>
</tr>
<tr>
<td>32.0</td>
<td>5.66</td>
<td>0.69</td>
<td>6.33</td>
<td>0.72</td>
<td>7.09</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**70°F / 21.1°C**
- Rated 75% 50% 25%

70°F / 21.1°C
Life With a Mini-split

- Leave bedroom doors open
- Overheat the primary zone
- Do not set temperature back
  - Even risky to do this during vacation
- Use high fan speed during very cold weather
  - Increases efficiency and heat output
  - OK for night or absence; your house will hold the heat
- No “Auto” mode; consider disabling some features
- Clean filters regularly
- Check outdoor unit during snowstorms
Different Houses, Different Heat Pumps

Mini-split Alternatives
Compact Ducted Heat Pump

• Distribute heat without a central heat plant

Images courtesy of Mike Duclos, DEAP Energy Group
Compact Ducted Heat Pump

Indoor Unit
MCA .............................................. 1 A
Fan Type x Quantity .......................... Sirocco Fan x 4
Fan Motor Type .............................. Direct-driven DC Brushless Motor
Fan Motor Output .............................. 96 W
Fan Motor ........................................ 0.74 F.L.A.
Airflow (Lo - Med - Hi) ....................... 423 - 529 - 635 Dry CFM
............................................... 381 - 476 - 572 Wet CFM
Air Filter ........................................ Polypropylene Honeycomb
External Static Pressure .................... 0.02 - 0.06 - 0.14 - 0.20"WG
Sound Pressure Level (Lo - Med - Hi) ...... 30 - 34 - 38 dB(A)
Compact ducted Bottom Line

- Better option than multi-split
- Use a ducted zone to match load to capacity
- Careful, creative duct layout keeps ducts short: essential with mini-ducted
- Provide access to air handler and filter
- DO NOT OVERSIZE
Centrally Ducted Heat Pump

- Whole House system
- Mitsubishi multi-position air handler with outdoor unit PUZ/PVA 36KBtu
- Vertical or horizontal installation
- Higher static pressure capability
- ECM motor
- NEEP cold climate air source heat pump
Dual Fuel and Balance Point Heating

- ccHP replacement for central AC
- NEEP cold climate listed
- Uses furnace ducts, whole building solution
- EVT rebates available
Air: Distribution & Equipment
Air to Water Heat pump

- Can act like a boiler
  - Electric
  - Operates at low water temperature
  - Temperature-dependent output and efficiency, like all air source heat pumps
  - Fully zonable
Cooling with Air-to-Water

Radiant cooling
• Requires whole-house dehumidification
• Floors, walls, ceilings heat and cool

“Ductless” cooling
• Separate zone just for cooling
• Non-distributed
• Can be used for heating
Air to Water Bottom Line

• More design required than mini-splits or ducted systems
• Can be a water heating solution
• Distribution system must be designed for lower temperatures
  • Hard to do in existing homes
• Distribution flexibility
  • Warm floors, panels, baseboard
Ground Source Heat Pump

- Established industry
- Watch out for pumping loads: not included in listed COP
- Oversized pumps are common
- Closed loop versus open loop
- Needs to be paired with careful distribution
Low Temp Hydronic Distribution
Hydronic Distribution and equipment
Weatherization

Heat Pump’s Best Friend
Weatherization

- Better comfort
- Smaller load for your heating system
- Better control over air quality
- Lasting improvement
- Win the heat loss battle!

Weatherization makes your heat pump go further.
Zero Energy Home

Energy Efficiency

Renewable Energy

Heat Pumps
Thank You

Li Ling Young
lyoung@veic.org
802-540-7735
NEEP Guide to Sizing and Selecting Air-Source Heat Pumps
neep.org/sites/default/files/Sizing%20&%20Selecting%20ASHPs%20In%20Cold%20Climates.pdf

NEEP Guide to Installing Air-Source Heat Pumps in Cold Climates
neep.org/sites/default/files/Installing%20Air-Source%20Heat%20Pumps%20in%20Cold%20Climates.pdf

Efficiency Vermont's operator guide for mini-splits
contractors.efficiencyvermont.com/Media/Default/docs/resources/printable-resources/ProductProgramInfo/8%20ways%20NOT%20to%20use%20a%20heat%20pump.pdf

Efficiency Vermont's residential technical resources
contractors.efficiencyvermont.com/programs/new-construction

Efficiency Vermont's mini-split qualified list

Efficiency Vermont's air-to-water heat pump qualified list

GBA article on shared ductwork
www.greenbuildingadvisor.com/article/ductwork-ervs-dehumidifiers-forced-air-heating-systems