Minisplit Heat Pumps – Lessons From the Field

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West Tisbury, MA
What’s A Heat Pump?

A device that consists of a compressor, an expansion valve, a refrigerant, and two heat exchangers, that uses electricity to move heat from a colder location to a warmer one.

The advantage is in the concept of COP…
In an electric heat pump, Coefficient of Performance (COP) is the ratio of how much energy is moved by a heat pump divided by how much electrical energy is put into the system. More efficient heat pumps have higher COPs.

\[
\text{COP} = \frac{\text{energy supplied to the space}}{\text{energy input to the heat pump}}
\]
What’s a Minisplit Heat Pump?

- A minisplit is an electrically-driven heat pump that uses the outdoor air (air source) as the source from which it extracts heat.
- Developed by Japanese manufacturers, minisplits use variable speed, inverter-driven compressors, and variable speed fans, to achieve high efficiency.
- Traditionally, air source heat pumps weren’t used in predominantly heating climates because their capacity dropped off too quickly at cold temperatures, requiring expensive electric resistance as back-up heating.
- Minisplits don’t need back-up heat.
- *Cold climate* minisplit heat pumps are available with rated outputs at temperatures as low as -15°F.
Space Conditioning with Minisplits

- Outdoor air is the source/sink for heating/cooling
- Packaged technology includes controls
- Reliable
- Ducted and non-ducted solutions
- Single and multizone systems
- Inverter-driven, highly variable systems
Space Conditioning with Minisplits

- Residential systems rated outputs 9,000 to 48,000 BTU/hour
- Single and multizone (up to 8) systems
- Several types of indoor terminal units
Space Conditioning with Minisplits

Products

**SINGLE ZONE**
- Wall Mounted
- Universal Floor / Ceiling
- Large Ceiling
- Slim Duct
- Compact Cassette
- Cassette

**MULTI ZONE**
- Multi Zone Systems (2 to 4 Zones)
- Flex Zone Systems (2 to 8 Zones)
COP vs. Temperature

COP is dependent on source (outdoor air) temperature. The colder the outdoor air, the lower the COP is.

<table>
<thead>
<tr>
<th>Outdoor(F)</th>
<th>Indoor(F)</th>
<th>Capacity KBtu/h</th>
<th>Input kW</th>
<th>COP (W/W)</th>
<th>Capacity KBtu/h</th>
<th>Input kW</th>
<th>COP (W/W)</th>
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</thead>
<tbody>
<tr>
<td>-13</td>
<td>70</td>
<td>33.8</td>
<td>4.68</td>
<td>2.12</td>
<td>33.8</td>
<td>5.95</td>
<td>1.66</td>
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<tr>
<td>-4</td>
<td>70</td>
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<td>5.07</td>
<td>2.28</td>
<td>39.4</td>
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<td>1.79</td>
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<td>70</td>
<td>45.0</td>
<td>5.46</td>
<td>2.42</td>
<td>45.0</td>
<td>6.95</td>
<td>1.90</td>
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<td>14</td>
<td>70</td>
<td>45.0</td>
<td>4.81</td>
<td>2.74</td>
<td>45.0</td>
<td>6.12</td>
<td>2.16</td>
</tr>
<tr>
<td>23</td>
<td>70</td>
<td>45.0</td>
<td>4.15</td>
<td>3.17</td>
<td>45.0</td>
<td>5.29</td>
<td>2.49</td>
</tr>
<tr>
<td>32</td>
<td>70</td>
<td>45.0</td>
<td>3.71</td>
<td>3.56</td>
<td>45.0</td>
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<td>45.0</td>
<td>3.57</td>
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<td>59</td>
<td>70</td>
<td>45.0</td>
<td>2.34</td>
<td>5.64</td>
<td>45.0</td>
<td>2.98</td>
<td>4.43</td>
</tr>
</tbody>
</table>
As with COP, heating capacity drops with decreasing outdoor temperature.

### 6-2. HEATING CAPACITY

**MODEL: ASU9RLS2**

<table>
<thead>
<tr>
<th>Outdoor temperature</th>
<th>500</th>
<th>60</th>
<th>65</th>
<th>70</th>
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<tbody>
<tr>
<td>°FDB</td>
<td>°FWB</td>
<td>TC</td>
<td>IP</td>
<td>TC</td>
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<tr>
<td>-5</td>
<td>-7</td>
<td>14.7</td>
<td>1.97</td>
<td>14.3</td>
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<td>3</td>
<td>16.1</td>
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<td>15.7</td>
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<td>14</td>
<td>12</td>
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<td>16.4</td>
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<td>19</td>
<td>18.3</td>
<td>1.84</td>
<td>17.9</td>
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<td>32</td>
<td>28</td>
<td>18.8</td>
<td>1.78</td>
<td>18.4</td>
</tr>
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<td>41</td>
<td>37</td>
<td>21.3</td>
<td>1.85</td>
<td>20.8</td>
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<td>47</td>
<td>43</td>
<td>23.1</td>
<td>1.91</td>
<td>22.6</td>
</tr>
<tr>
<td>50</td>
<td>47</td>
<td>25.5</td>
<td>1.94</td>
<td>24.9</td>
</tr>
<tr>
<td>60</td>
<td>50</td>
<td>26.5</td>
<td>1.96</td>
<td>25.8</td>
</tr>
</tbody>
</table>

**AFR:** Air Flow Rate (CFM)
**TC:** Total Capacity (kBtu/h)
**IP:** Input Power (kW)
Cold Climate Minisplits

The fundamental question is:

*How do I select a minisplit that will heat my project at the design temperature of the location?*
Cold Climate ASHP Spec

Scope

- Air-to-air, split system heat pumps
- Both single-zone and multi-zone systems
- <65k Btu/hour at 47°F (dry bulb)
- Ducted and ductless systems
- Does NOT include ground-source or air-to-water heat pump systems

Performance Requirements

- **Compressor must be variable capacity**
- Indoor and outdoor units must be part of an AHRI matched system
- ENERGY STAR Certified
- **COP @5° F >1.75 (at maximum capacity operation)**
- **HSPF >10 for Single-zone systems or HSPF >9 for Multi-zone systems**
- Engineering data for each system must be reported through the attached “Cold Climate Air-Source Heat Pump Performance Information Tables”. Incomplete tables will not be considered.
Provide engineering data for the conditions shown below. “Minimum” and “Maximum” refer to the steady-state heating capacities at each condition that equipment can deliver during normal operation. Capacities in the “Rated” column should correspond to those listed on the AHRI certificate at 47°F and 17°F ODB. In some cases these may be equal to the “Maximum” capacity values. Btu/hour is total heat output, and kW is power input. Do not include the power required for defrost cycling or drain pan heater operation in the table.

<table>
<thead>
<tr>
<th>Outdoor Dry Bulb (°F)</th>
<th>Indoor Dry Bulb (°F)</th>
<th>Capacity Level</th>
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</thead>
<tbody>
<tr>
<td>47°F</td>
<td>70°F</td>
<td>Minimum kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rated kW</td>
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<tr>
<td>17°F</td>
<td>70°F</td>
<td>Minimum kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rated kW</td>
</tr>
<tr>
<td>5°F</td>
<td>70°F</td>
<td>Minimum kW</td>
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</tbody>
</table>

OPTIONAL- If engineering data are available for operation at lower temperatures (below 5°F), provide this information below.
What Is The Selection Process?

- Determine the design heating temperature for the location
- Determine the building heating load at design temperature
- Determine how many heating zones
- Decide what format(s) of indoor unit is desired (ducted or non-ducted)?
Example: Non-ducted Single Zone System

- Design temperature 8°F
- Design heating load 13,000 BTU/hr
- Wall cassette, single zone

Find a unit that has at least 13,000 BTU/hr at 5°F
Example: Non-ducted Single Zone System

Fujitsu

6-2. HEATING CAPACITY

**MODEL: ASU9RLS2**

<table>
<thead>
<tr>
<th>AFR</th>
<th>500</th>
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</thead>
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<table>
<thead>
<tr>
<th>Outdoor temperature</th>
<th>*FDB</th>
<th>*FWB</th>
<th>60 TC</th>
<th>IP</th>
<th>65 TC</th>
<th>IP</th>
<th>70 TC</th>
<th>IP</th>
<th>75 TC</th>
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</tbody>
</table>

AFR: Air Flow Rate (CFM)
TC: Total Capacity (kBTU/h)
IP: Input Power (KW)

Fujitsu also makes a single zone ducted unit with similar specs.
Example: Non-ducted Single Zone System

Mitsubishi

SPECIFICATIONS: MSZ-FH12NA & MUZ-FH12NA

**MUZ-FH12NA**

<table>
<thead>
<tr>
<th>Outdoor Temperature Degrees (°F)</th>
<th>-13.0</th>
<th>-4.0</th>
<th>5.0</th>
<th>14.0</th>
<th>23.0</th>
<th>32.0</th>
<th>41.0</th>
<th>50.0</th>
<th>69.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Heating Capacity</td>
<td>73%</td>
<td>86%</td>
<td><strong>100%</strong></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Heating at 47°F**
- Rated Capacity: 13,600 Btu/h
- Capacity Range: 3,700 - 21,000 Btu/h
- Rated Total Input: 950 W
- Maximum Total Input: 2,300 W
- HSPF: 12.5 Btu/h/W

**Heating at 17°F**
- Rated Capacity: 8,100 Btu/h
- Maximum Capacity: 13,600 Btu/h
- Rated Total Input: 720 W
- Maximum Total Input: 1,950 W

**Heating at 5°F**
- Maximum Capacity: 13,600 Btu/h
- Maximum Total Input: 1,950 W
Although this is nominally a 24,000 BTU/hr unit, its capacity at 5°F is lower than the previous nominal 9,000 and 12,000 BTU/hr units, and it can’t meet our design heating load.
Observations about Ducted Systems

- In small single zone houses we estimate a cost premium of $2,500 – 5,000 vs. a single wall cassette system, depending on if additional electric heaters are provided and what they cost.
- Advantages over point source include:
  - Quieter
  - Very even temperature distribution
  - Cooling throughout the house
  - Possible integration with ventilation
  - Filtration upgrades possible
Observations about Ducted Systems

- Low external static pressure increases duct sizing
- Beware short return lengths and fan noise (duh Marc)
- Traditional concepts such as throw become challenging
- Cold climate products such as Fujitsu RLFC series offer HSPF as high as 12.2, high outputs at low temperatures, and lower system CFM – smaller ducts, higher supply air temperature

This Fujitsu RLFC is 9,000 BTU/hr in cooling and 15,400 BTU/hr at 5°F using 353 CFM. The air handler can be mounted vertically or horizontally. Note access space required.
Observations about Ducted Systems
An Interesting Phenomenon
Ducted Fujitsu ARU9RLF/AOU9RLFC

Minisplit heat pump, Minute by Minute View for Today

Yesterday's Usage, Usage, Yesterday's Outdoor Temperature, Outdoor Temperature

Feb 16 3:00am 6:00am 9:00am 12:00pm 3:00pm 6:00pm 9:00pm
Ducted Fujitsu ARU9RLF/AOU9RLFC