Mini-Split (Ductless) Heat Pumps

Last Updated: 03/13/2015

Scope

Choose the highest performing heating and cooling equipment that project funding will allow, to meet the design load of the project.

Properly match the indoor and outdoor components of the heat pump system as demonstrated by a certificate from the Air Conditioning, Heating and Refrigeration Institute (AHRI). AHRI assigns a certification number and efficiency ratings to specific combinations of equipment (outdoor unit, indoor unit, indoor coil, fan type, etc.) that have been tested by the manufacturer according to AHRI test procedures using AHRI-specified test conditions (AHRI 2012). If an AHRI certificate is not available, a copy of the catalog data provided by the original equipment manufacturer (OEM) should be attached to the system indicating an acceptable combination and performance data.


Properly size the equipment for the design heating or cooling load of the home (whichever is larger), following the sizing guidelines in ACCA Manual S: Residential Equipment Selection. Calculate the heating and cooling load using the ACCA Manual J Residential Load Calculation. When determining equipment sizing per ACCA Manual S, use the original equipment manufacturer (OEM)’s expanded performance table to obtain performance data at design conditions, rather than using the performance data on the AHRI certificate, which lists heating and cooling capacity and SEER and EER cooling efficiencies at factory conditions of 90°F outdoor, 80°F indoor, and 67°F wet bulb.

The OEM-listed total cooling capacity at design conditions should be between 95% and 115% of the design total heat gain (or 95% to 125% for heat pumps in IECC climate zones 4-8) or the next nominal size. The next largest nominal piece of equipment available may be used to satisfy the latent and sensible cooling requirements. Single-speed systems generally have OEM nominal size increments of one-half ton. Multi-speed or multi-stage equipment may have OEM nominal size increments of one ton. Therefore, the use of these advanced system types can provide extra flexibility to meet the equipment sizing requirements.

If you are participating in an energy-efficiency program, select cooling equipment that complies with the requirements for your climate zone. To determine your climate zone, see the International Energy Conservation Code (IECC) 2012 climate zone map on the Climate tab.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Description

High-performance ductless heat pumps are an efficient alternative to central ducted heat pump systems. These heat pumps may also provide heating savings when compared to some fossil fuel systems (esp. oil and propane), and heat pumps are certainly more efficient than electric resistance heating. Ductless heat pumps provide zoned heating and cooling to the space they are located in without the heat losses and energy consumption associated with ducts. The simplest ductless heat pumps consist of a single outdoor unit (containing the compressor, expansion valve, and coil) and an indoor fan coil (sometimes called a “head”). The outdoor units are mounted on the wall or on a concrete or stone pad outside the house; refrigerant tubing and control wiring connect the inside and outside units through a small hole in the wall. For more information on refrigerant-based heating and cooling systems, see Traditional Split Heat Pumps and Compression Cooling.

Ductless heat pumps have been used in Asia and Europe since the 1970s and they comprise 80% to 90% of the residential HVAC market there. They have been used in U.S. commercial buildings since the 1980s, but they still comprise less than 3% of the U.S. residential market (Karr 2011). They are 25% to 50% more efficient than electric baseboard or wall heaters (NEEA 2009). Ductless heat pumps provide increased energy savings over standard heat pumps in several ways. Because they are ductless and mounted inside conditioned space, they avoid the distribution losses of a central furnace that has leaky ducts installed in an unheated attic or crawlspace. Ductless heat pumps provide zoned heating because units can be turned off or not installed in rooms that aren’t being used. They use a much smaller blower than central units; however, more than one inside unit is typically needed to serve the whole house. Up to eight inside units can be connected to one outside unit.

Advances in technology in recent years have increased performance to the point that units are now available with heating efficiencies as high as 12 HSPF and cooling efficiencies as high as SEER 30.

Mini-split heat pumps also have inverter-controlled, variable-speed compressors. The inverter technology adjusts the compressor speed, allowing the system to adapt more smoothly to shifts in demand with less temperature variation and much lower energy use. When maximum capacity is not needed, the compressor revolution and power decreases, increasing energy efficiency, unlike conventional single-stage air-conditioning and heating systems which must stop and start repetitively. The inverter compressor allows the system to ramp down below 30% of rated capacity. Mini-split heat pumps also have linear expansion valves rather than open/close valves, and multi-speed rather than single-speed fans to continuously match the heating or cooling load. The capacity on a mini-split heat pump is variable; for example, one model reports a capacity range of 3,100-24,000 Btu/hr in heating mode and 3,800-14,500 Btu/hr in cooling mode.

These ductless heat pump models also perform at a much wider temperature range than standard heat pumps. Some models can operate at outdoor temperature of -15°F for heating and up to 115°F for cooling, eliminating the need for backup heat sources in many locations.

Mini-split, ductless heat pumps work well for use in small, very efficient homes with open floor plans or in larger well-insulated homes where zoned heating and cooling are desired. They also work well in additions. They can also be a beneficial part of an energy-efficient renovation where a less-efficient central heating system is kept in place for supplemental heating or cooling and one or more ductless heat pumps are installed in the primary living areas.

Some larger, commercial-scale heat pumps are called variable refrigerant flow (VRF) systems. Variable refrigerant flow refers to the system’s ability to control the amount of refrigerant flowing to each air handler. With VRF technology, one outdoor unit can be connected to different air handlers (heads) that are heating or cooling in different zones. Some very high-end systems can even provide heating to one zone while simultaneously providing cooling to another because they have an additional refrigerant line to each internal unit and a controller which directs them to pull heat from rooms calling for cooling and sending it to rooms calling for heating rather than rejecting it to the outdoors. By moving the refrigerant from one zone to another, the system allows for some heat recovery. The multiple heads can be of differing capacities and configurations, providing for additional individualized comfort control.

The heads for a ductless system can be mounted on a wall (Figure 1) or concealed in a ceiling. (Figure 2).

Figure 1. A wall-mounted ductless air handler for a ductless heat pump system. (Image courtesy of CalcsPlus)
Not having ducts provides additional energy savings for mini split systems. They avoid the energy losses associated with the ductwork of central forced air systems. These losses come in the form of fan energy from the large fan needed to push air through a home’s duct system, heat gain or loss when ducts are run through unconditioned spaces, and loss of pressure loss of conditioned air through duct leaks. Losses related to duct systems can account for more than 30% of energy consumption.

Correctly sizing each indoor unit (head) to the outdoor unit and the room load is imperative for efficient operation. Correctly locating the heads is also important for air delivery to the desired location. Oversized or incorrectly located air handlers can result in short cycling, which wastes energy and does not provide proper temperature or humidity control. A system that is too large will be more expensive to buy and operate. A heat gain/loss calculation should be conducted as described in ACCA Manual J to identify the correct system size.

Zoning can easily be accomplished by using multiple heads. Each head (air handler) is individually controlled by its own wireless thermostat, which also communicates with the outdoor unit.
The three-zone ductless mini-split system in Figure 4 conditions the two bedrooms upstairs and the living room downstairs. While the system shown in this scenario could include additional ductless heads to condition the kitchen, the office, and the bathroom, these additional units would provide more capacity than is needed to condition the small spaces and the extra units would add considerably to the overall cost of the system. Another option, available from several manufacturers, is a mini-split air handler with short ducts to provide conditioned air to several nearby rooms at once, such as bedrooms, bathrooms, offices, or storage rooms. The air handler is typically a horizontal unit, although some manufacturers make vertical units. The air handler has a larger blower motor to move air through the supply ducts and it also has a ducted return.

The ducted air handler is connected by refrigerant tubing to the variable refrigerant flow outdoor unit along with any other ducted or ductless air handlers that are part of the system and, as with all of the indoor air handler units, it must be verified that it matches the outdoor unit using the AHRI equipment matching system.

One variable refrigerant flow outdoor unit can accommodate a single ductless air handler, a single ducted air handler, multiple ductless air handlers, multiple ducted air handlers, or any combination of these (Figure 5).
1. Choose the highest performing model project costs will allow, to meet the design heating and cooling load of the project. If you are participating in an energy-efficiency program, select equipment that complies with the requirements for your climate zone, as described in the Compliance tab.

2. Confirm that the indoor and outdoor components of the heat pump system match, as demonstrated by a certificate from the Air Conditioning, Heating and Refrigeration Institute (AHRI) or a copy of the catalog data provided by the original equipment manufacturer (OEM) indicating an acceptable combination.

3. Properly size the equipment for the design heating or cooling load of the home (whichever is larger). Use ACCA Manual J to calculate your heating or cooling load and use ACCA Manual S to correctly size your system. This is especially important if you have done significant air sealing and insulating, which will reduce your heating and cooling load. When determining equipment sizing per ACCA Manual S, use the original equipment manufacturer (OEM)’s expanded performance table to obtain performance data at design conditions, rather than using the performance data on the AHRI certificate.

4. During construction keep the copper refrigerant tubing charged with dry nitrogen and sealed with solder to keep moisture out of the lines.

5. After connecting the indoor unit and the outdoor unit, vacuum the lines to 500 microns to remove air pockets.

6. Follow the manufacturer’s recommendations for refrigerant charging. Too much or too little refrigerant can reduce the efficiency of the equipment and lead to premature component failures. Use the charging method recommended by the manufacturer. There are three methods for charging: the subcooling method (typically for units with a thermal expansion valve), the superheat method (typically for units with a fixed orifice), or the weigh-in method (using the refrigerant weight amount listed on the data plate on the outdoor unit). Verify that you are using the correct method for the specific heat pump model to be installed. Refrigerant charging must be done by an EPA certified technician.

7. Make sure the condensate line and drain pans are correctly installed.
Ensuring Success

Choose the highest efficiency SEER or HSPF rated product possible.

Verify that the air handlers (heads) are correctly matched to the outdoor units. Matched systems are listed under "Variable-Speed Mini-Split and Multi-Split Air Conditioners" and "Variable-Speed Mini-Split and Multi-Split Heat Pumps"

Correctly size each indoor unit (head) to the outdoor unit and the room load for efficient operation. Locating the heads properly for air delivery to the desired location. Oversized or incorrectly located air handlers can result in short cycling, which wastes energy and does not provide proper temperature or humidity control. Too large a system is more expensive to buy and operate; conduct a good heat gain/loss (ACCA Manual J) calculation to identify the correct size.

Install in accordance with the manufacturers’ instructions and relevant standards including ACCA Standard 5: HVAC Quality Installation Specification and the ACCA’s Technician’s Guide for Quality Installations and ACCA Standard 9: HVAC Quality Installation Verification Protocols. These standards address quality installation and commissioning requirements for vapor compression cooling systems, heat pumps, combustion furnaces, and boilers.

For ducted mini-split heat pumps, install ducts within the home’s conditioned space.

Follow the manufacturer’s recommendations for refrigerant charging.
Climate

For ENERGY STAR and DOE Zero Energy Ready Home climate-specific guidance, see the Compliance tab.

Consider non-compression cooling options such as trees, awnings, pergolas, and porches to shade windows and walls; ceiling fans; and timer-controlled night-time ventilation cooling, to reduce cooling demand in cooling-dominated climates (Gilbride et al. 2011).

In humid and mild or cold climates, consider adding a dehumidifier for indoor humidity control in the shoulder seasons and in locations with short summers as an alternative to compression cooling.

In humid climates, set the time-delay relay on the unit to 30 seconds or less to prevent moisture on the evaporator coil from evaporating back into the air stream and contributing to indoor humidity.

Considerations for Cold-Climate Applications

- When selecting equipment, review manufacturer data and examine capacities and efficiencies at low temperatures. See NEEP recommendations for cold-climate heat pumps.
- Install outdoor units well above snow height.
- Do not install outdoor units where water or melting snow or ice will fall on the unit. If located in such places, protect heat pumps with a cover of some sort.

Figure 6. This heat pump was installed beneath a deck. While protected from direct snow, when snow melted on the deck, water dripped and froze on the heat pump. This dramatically reduced the heat pump’s capacity and efficiency. (Image courtesy of Steven Winter Associates)
Indoor fan coils mounted near the ceiling will draw warmer return air from the space. While this is desirable during cooling season, it is an efficiency liability during heating season. Ductless fan coils may need to be mounted high so as not to obstruct movement within a home, but be mindful of placement.

In general, heat pumps are most efficient when indoor fan speed is set to “auto.” If fan speed is manually set to “low,” capacity and efficiency may be reduced.

To determine your climate zone, see the map below.

Figure 7. A cover to protect a heat pump from water, snow and ice melt. (Image courtesy of Steven Winter Associates)
Training

Right and Wrong Images

Display Image: 2018-HabitatCat-9-InteriorDoor&MiniSplit-wrong not over door.jpg

Display Image: 2019-Habitat Catawba-x-Outdoor HVAC Unit.jpg
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

**ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09)**

The ENERGY STAR Reference Design Home is the set of efficiency features modeled to determine the ENERGY STAR ERI [energy rating index] Target for each home pursuing certification. Therefore, while the features below are not mandatory, if they are not used then other measures will be needed to achieve the ENERGY STAR ERI Target. In addition, note that the Mandatory Requirements for All Certified Homes, Exhibit 2 [see list below], contain additional requirements such as total duct leakage limits, minimum allowed insulation levels, and minimum allowed fenestration performance. Therefore, EPA recommends that partners review the documents in Exhibit 2 prior to selecting measures.

Please note that the Reference Design Home HVAC efficiencies for Version 3.1 differ from those for Version 3.0. Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

<table>
<thead>
<tr>
<th>Hot Climates (2009 IECC Zones 1,2,3)</th>
<th>Mixed and Cold Climates (2009 IECC Zones 4,5,6,7,8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooling Equipment (Where Provided)</strong></td>
<td><strong>Heating Equipment</strong></td>
</tr>
<tr>
<td>• Cooling equipment modeled at the applicable efficiency levels below:</td>
<td>• Heating equipment modeled at the applicable efficiency levels below, dependent on fuel and system type:</td>
</tr>
<tr>
<td>14.5 SEER / 12 EER AC,</td>
<td>13 SEER AC,</td>
</tr>
<tr>
<td>Heat pump (See Heating Equipment)</td>
<td>Heat pump (See Heating Equipment)</td>
</tr>
<tr>
<td>80 AFUE gas furnace,</td>
<td>90 AFUE gas furnace,</td>
</tr>
<tr>
<td>80 AFUE oil furnace,</td>
<td>85 AFUE ENERGY STAR oil furnace,</td>
</tr>
<tr>
<td>80 AFUE boiler,</td>
<td>85 AFUE ENERGY STAR boiler,</td>
</tr>
<tr>
<td>8.2 HSPF / 14.5 SEER / 12 EER air-source heat pump with electric or dual-fuel backup</td>
<td>Heat pump with efficiency as follows:</td>
</tr>
<tr>
<td>CZ 4: 8.5 HSPF / 14.5 SEER / 12 EER air-source w/ electric or dual-fuel backup,</td>
<td>CZ 4: 8.5 HSPF / 15 SEER / 12 EER air-source w/ electric or dual-fuel backup,</td>
</tr>
<tr>
<td>CZ 5: 9.25 HSPF / 14.5 SEER / 12 EER air-source w/ electric or dual-fuel backup,</td>
<td>CZ 5: 9.25 HSPF / 15 SEER / 12 EER air-source w/ electric or dual-fuel backup,</td>
</tr>
<tr>
<td>CZ 6: 9.5 HSPF / 14.5 SEER / 12 EER air-source w/ electric or dual-fuel backup,</td>
<td>CZ 6: 9.5 HSPF / 15 SEER / 12 EER air-source w/ electric or dual-fuel backup,</td>
</tr>
<tr>
<td>CZ 7-8: 3.5 COP / 17.1 EER ground-source w/ electric or dual-fuel backup</td>
<td>CZ 7-8: 3.5 COP / 17.1 EER ground-source w/ electric or dual-fuel backup</td>
</tr>
</tbody>
</table>

**Version 3.0 - Exhibit 1: ENERGY STAR Reference Design Home** (Source: ENERGY STAR Certified Homes, Version (Rev. 09))

**Version 3.1 - Exhibit 1: ENERGY STAR Reference Design Home** (Source: ENERGY STAR Certified Homes, Version (Rev. 09))

Exhibit 2 of the National Program Requirements for ENERGY STAR Certified Homes Version 3/3.1 (Rev. 09) requires that homes complete the following checklists:

<table>
<thead>
<tr>
<th>Party Responsible</th>
<th>Mandatory Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rater</td>
<td>Completion of National Rater Design Review Checklist</td>
</tr>
<tr>
<td></td>
<td>Completion of National Rater Field Checklist</td>
</tr>
<tr>
<td>HVAC System Designer</td>
<td>Completion of National HVAC Design Report</td>
</tr>
<tr>
<td>HVAC Installing Contractor</td>
<td>Completion of National HVAC Commissioning Checklist</td>
</tr>
<tr>
<td>Builder</td>
<td>Completion of National Water Management System Builder Requirements</td>
</tr>
</tbody>
</table>

Exhibit 2: Mandatory Requirements for All Certified Homes Version 3/3.1 (Source: ENERGY STAR Certified Homes, Version (Rev. 09))
National Rater Design Review Checklist

1. Partnership Status.
1.2 Rater has verified that HVAC contractor holds credential required to complete National HVAC Commissioning Checklist, unless all equipment to be installed in home to be certified is an exempted type, in which case check “N/A.”

Footnote 2) HVAC contractors must be credentialed by an EPA-recognized HVAC Quality Installation Training and Oversight Organization (H-QUITO) if a split air conditioner, unitary air conditioner, air-source heat pump, or water-source (i.e., geothermal) heat pump up to 65 kBtuh with a forced-air distribution system (i.e., ducts) or a furnace up to 225 kBtuh with a forced-air distribution system (i.e., ducts) will be installed in the home to be certified. For all other permutations of equipment (e.g., boilers, mini-split / multi-split systems) and distribution systems, a credential is not required. An explanation of this credentialing process and links to H-QUITOs, which maintain lists of credentialed contractors, can be found at energystar.gov/newhomeshvac.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.

Exhibit 2 DOE Zero Energy Ready Home Target Home.
The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Footnote 21) DOE recommends, but does not require, that cooling systems in hot/humid climates utilize controls for immediate blower shutoff after condenser shutoff, to prevent re-evaporation of moisture off the wet coil.

Footnote 22) Air source heat pumps with electric resistance backup cannot be used in homes qualified in Climate Zones 7 & 8 using the Prescriptive Path.

DOE ZERH Target Home HVAC Equipment Requirements (Source: DOE Zero Energy Ready Home (Revision 07))

Washington and California residents – please see the DOE Zero Energy Ready Home website for state-specific requirements.


Comply with all relevant sections of the applicable International Residential Code, including Chapter 14: Heating and Cooling Equipment.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.

2009 IECC

403.1 Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace at least one thermostat must be programmable and capable of controlling the heating and cooling system on a schedule to maintain different temperatures at different times of the day.

403.6 Heating and cooling equipment sizing shall be in accordance with Section M1401.3 of the 2009 International Residential
Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace, at least one thermostat must be programmable and capable of controlling the heating and cooling system on a schedule to maintain different temperatures at different times of the day.

Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methods.

Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

ACCA Standards

ACCA Manual S. Residential Equipment Selection, ANSI/ACCA 3-Manual S-2004, provides information on how to select and size heating and cooling equipment to meet Manual J loads based on local climate and ambient conditions at the building site. Manual S covers sizing strategies for all types of cooling and heating equipment, as well as comprehensive manufacturers’ performance data on sensible, latent, or heating capacity for various operating conditions.

ACCA Manual D: Residential Duct Systems, ANSI/ACCA 1-Manual D-2011, provides ANSI-recognized duct sizing principles and calculations that apply to all duct materials; the system operating point (supply cfm and external static pressure) and airway sizing for single-speed and multi-speed (ECM) blowers; a method for determining the impact of duct friction and fitting pressure drop on blower performance and air delivery; and equivalent length data.


ACCA Standard 5: HVAC Quality Installation Specification, ANSI/ACCA 5 QI-2010, details nationally recognized criteria for the proper installation of residential and commercial HVAC systems, including forced air furnaces, boilers, air conditioners, and heat pumps. The Standard covers aspects of design, installation, and distribution systems, as well as necessary documentation. The Technician’s Guide for Quality Installation, produced by ACCA, explains the HVAC Quality Installation (QI) Specification and provides detailed procedures for the steps technicians must complete and document to show compliance with the HVAC QI Specification.

ACCA Standard 9: HVAC Quality Installation Verification Protocols, ANSI/ACCA 9 QIVP-2009, specifies the protocols to verify the installation of HVAC systems in accordance with ACCA Standard 5. The protocols provide guidance to contractors, verifiers, and administrators who participate in verification efforts using independent objective and qualified third parties to ensure that an HVAC installation meets the requirements in Standard 5.
More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

1. **Existing Whole-House Solutions Case Study: Retrofit of 1915 Home, Dayton, Washington**
   - **Author(s):** PNNL
   - **Organization(s):** PNNL
   - **Publication Date:** December, 2011
   - Case study about an energy efficient renovation in the cold climate.

2. **New Whole-House Solutions Case Study: Technology Solutions for New Manufactured Homes, Idaho, Oregon, and Washington**
   - **Author(s):** BA-PIRC
   - **Organization(s):** BA-PIRC
   - **Publication Date:** December, 2013
   - Case study outlining technologies that can be implemented in new manufactured homes to increase comfort and realize energy savings.

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. **2009 International Mechanical Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code containing 2009 ICC language for mechanical draft systems.

3. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

5. **2012 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.
2015 IECC - International Energy Conservation Code  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** May, 2014  
*Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.*

7. 2015 IRC - International Residential Code for One and Two Family Dwellings  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** May, 2014  
*Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.*

**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** November, 2017  
*Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.*

9. 2018 IRC - International Residential Code for One and Two Family Dwellings  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** August, 2017  
*Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.*

10. ACCA Manual D - Residential Duct Systems  
**Author(s):** Air Conditioning Contractors of America  
**Organization(s):** Air Conditioning Contractors of America  
**Publication Date:** December, 2013  
*Standard outlining industry procedure for sizing residential duct systems.*

11. ACCA Manual J - Residential Load Calculation  
**Author(s):** Air Conditioning Contractors of America  
**Organization(s):** Air Conditioning Contractors of America  
**Publication Date:** January, 2011  
*Standard covering equipment sizing loads for single-family-detached homes, small multi-unit structures, condo-miniums, town houses and manufactured homes.*

12. ACCA Manual S - Residential Equipment Selection  
**Author(s):** Air Conditioning Contractors of America  
**Organization(s):** Air Conditioning Contractors of America  
**Publication Date:** April, 2013  
*Standard covering sizing strategies for all types of cooling and heating equipment, as well as how to use comprehensive manufacturer's performance data on sensible, latent, or heating capacity for various operating conditions.*

13. ACCA Standard 5: HVAC Quality Installation Specification  
**Author(s):** Air Conditioning Contractors of America  
**Organization(s):** Air Conditioning Contractors of America  
**Publication Date:** January, 2015  
*Standard providing a universally accepted definition for quality installation for residential and commercial heating, ventilating, and air conditioning applications.*

**Publication Date:** January, 2016  
*Document detailing the requirements, roles, and obligations for participants in an organized effort, ensuring that HVAC installations comply with the ANSI/ACCA 5 QI – 2010 (HVAC Quality Installation Specification) QI Standard.*

15.
   **Author(s):** Gilbride, Baechler, Hefty, Hand, Love
   **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory
   **Publication Date:** August, 2011
   Report providing information about energy-efficient heating, ventilation, and cooling (HVAC) equipment options to help homeowners cut their energy use, reduce their carbon footprint, and increase their homes comfort, health, and safety.

17. **Directory of Certified Product Performance**
   **Author(s):** AHRI
   **Organization(s):** AHRI
   **Publication Date:** January, 2012
   Online database with efficiency information about residential HVAC systems and commercial refrigeration equipment.

18. **Ductless Heat Pump Project**
   **Author(s):** NEEA
   **Organization(s):** NEEA
   **Publication Date:** June, 2014
   Online resource about ductless heating & cooling systems for installers, utilities, manufacturers and distributors.

19. **EIA Residential Energy Consumption Survey 2009**
   **Author(s):** EIA
   **Organization(s):** EIA
   **Publication Date:** January, 2009
   Federal statistics about national energy consumption in residential homes.

20. **Ground-Source Variable Refrigerant Flow Heat Pumps**
    **Author(s):** Karr
    **Organization(s):** Washington State University Extension Energy Program
    **Publication Date:** March, 2011
    Factsheet describing the uses and benefits of ground-source heat pumps for affordable housing, assisted living, dorms and hotels.

    **Author(s):** Department of Energy
    **Organization(s):** DOE
    **Publication Date:** May, 2013
    Website with consumer information about residential heat pump systems.

22. **Mortgage Industry National Home Energy Rating Systems Standards**
    **Author(s):** RESNET
    **Organization(s):** RESNET
    **Publication Date:** January, 2013
    RESNET standards aimed to ensure that accurate and consistent home energy ratings are performed by accredited home energy rating providers through their raters nationwide.

23. **Residential Central Air Conditioners and Heat Pumps**
    **Author(s):** Department of Energy
    **Organization(s):** DOE
    **Publication Date:** June, 2014
    Website with information from DOE about rules and standards for residential air conditioners and heat pumps.

24. **Strategy Guideline: HVAC Equipment Sizing**
    **Author(s):** Burdick
    **Organization(s):** IBACOS, National Renewable Energy Laboratory
    **Publication Date:** February, 2012
    Report describing the equipment selection of a split system air conditioner and furnace for an example house in Chicago, Illinois, as well as a heat pump system for an example house in Orlando, Florida.
The Technician's Guide equips practitioners with the knowledge to properly implement all of the measurement procedures required in the HVAC QI Specification.

Contributors to this Guide

The following authors and organizations contributed to the content in this Guide.

- Calcs-Plus
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