**Building Science Education Solution Center -** **The Business Case for Heat Pumps**

**Proficiency Level 2:** Understand

## Learning Objective 2.1:

* Understand advancements in heat pump technology

## Lecture Notes 2.1:

***Air Source Heat Pump (ASHP) Myths***

Many consumers and some HVAC contractors have negative impressions concerning residential Air Source Heat Pumps (ASHPs). Many negative impressions have become misconceptions passed down from generation to generation. These myths include:

* They don't work in cold weather
* They blow cold air
* It always costs more to heat with heat pumps than with natural gas

Earlier models of heat pumps did have their drawbacks. These models were essentially residential air conditioner units with reversing valves. In fact, they were called reverse-cycle air conditioners. Many of today’s myths about heat pumps result from people’s experiences with these primitive versions of the technology. Modern heat pumps, however, provide a very different experience.

***Improved Heat Pump Technology***Heat pump technology has been evolving at a rapid pace in recent years. Gone are the days of capillary tubes, single-stage compressors, and permanent split capacitor (PSC) motors. PSC motors have been replaced by electrically commutated motors (ECM), helping to improve the efficiency of the fan and ensure correct airflow under a wide range of installation conditions. Single-stage compressors have been replaced by inverter driven compressors, allowing heat pumps to vary their output to efficiently match the needs of the house. Modern electronic metering devices allow for a more precise flow of refrigerant through the system, once again, creating a more efficient system.

The efficiency of a heat pump is rated by the HSPF, or Heating System Performance Factor. The higher the number the more efficient the heat pump. To be exact, it’s the number of BTUs generated per watt-hour consumed. Older systems were often below 5, newer systems can be above 9. That means that newer heat pumps can be twice as efficient as older models.

Many of today’s heat pumps maintain their ability to heat homes comfortably at below 0 degrees. These systems are referred to as cold climate heat pumps. In some cases, these units can provide effective heating at below -15F. The graphic on this slide indicates how some models maintain their full capacity at very low temperatures. This allows the heat pumps to meet the heating loads of many homes down to design conditions without the use of backup heat.

## *The Design Process*

Today's newer heat pumps have overcome the issues of older units. However, the proper sizing, selection, and commissioning of heat pumps is still critical in achieving high comfort levels and energy efficiency. The design process that is most often used has been developed by ACCA (Air Conditioner Contractors of America) and is outlined in their Manuals J, S & D. Manual J calculates the heat loss and heat gain of the home, Manual S dictates the selection of the heat pump, and Manual D gives guidance on duct design. There are many popular packages that automate the process and not only simplify the design process, but also give your customers confidence in your company’s expertise. With the advent of cold climate heat pumps, ACCA has revised the selection guidance for heat pumps that recognizes their ability to cover the heating at lower outdoor temperatures.

**Problem Set 2.1:**

1. How much more efficient are modern heat pumps than the systems built in the 1980s?

* A: 10 to 20%
* B: 20% to 30%
* C: 30% to 40%
* D: Over 50%

1. Can some modern heat pumps keep a home heated at sub-zero outdoor conditions?

**Learning Objective 2.2**

* Describe how modern heat pumps provide comfort

## Lecture Notes 2.2:

***Creating Comfort with Modern Heat Pumps***  
Modern heat pumps make it easier to provide what most customers want: year-round comfort. Though the air from heat pump registers may not feel as hot as that from traditional furnaces, it remains comfortably warm—above room temperature. It is important to remember that customers are used to high-temperature delivered air that gas and oil heating systems provide and are often concerned about their comfort when switching to heat pumps with their lower temperature delivered air. However, the overall room temperature maintained by heat pumps is comparable to that of traditional furnaces, ensuring consistent comfort across all spaces. Customers may notice a decrease in the temperature of the air exiting the registers, but delivered air temperature is not the primary driver of how we sense thermal comfort.

***Understanding Comfort Beyond Air Temperature***  
The air delivered by modern heat pumps is considerably warmer than the air discharged by older style heat pumps. Additionally, other factors, such as the surface temperature of walls and windows, known as mean radiant temperature, are critical to how people sense comfort. The lower these surface temperatures are, the less likely it is that customers will feel comfortable. Homes with low levels of insulation and single-pane windows will have lower surface temperatures. These homes should consider envelope upgrades in conjunction with a heat pump.

Heat pumps will have longer run cycles than fossil fuel systems. This allows for greater air mixing within zones and the whole house, eliminating hot and cold spots. In homes with ceiling registers, this effect is especially true since the hotter air from the fossil fuel systems tends to cling to the ceiling, while the cooler air from the heat pump system will more easily mix with air in the room.

***Optimizing Heat Pump Efficiency and Comfort***  
This cooler delivered air temperature of heat pumps is most noticeable during periods of cooler outdoor temperature. However, inverter-driven cold-climate heat pumps can maintain higher delivered air temperatures than older single-stage units, even in colder climates.

Of course, it is important to size the system correctly and make sure any ducts located outside of the conditioned space are well-sealed and insulated. This will keep delivered air temperatures hotter in winter and cooler in summer.

**Problem Set 2.2**

1. Other than delivered air temperatures, what other factors determine indoor comfort?
2. Compared to fossil fuel systems, how do heat pumps do a better job of mixing the air?

## Learning Objective 2.3:

* Identify customer motivations for choosing heat pumps

## Lecture Notes 2.3:

***Customer Motivations for Purchasing Heat Pumps***  
To increase sales of ASHPs, a business should be able to relay the benefits of ASHPs as best as possible to customers. These benefits, while numerous, need to be clearly communicated to the customers in order to finalize a larger number of sales.

Heat pumps can be an excellent choice for homeowners or other building occupants. Due to their high efficiency, they can be more cost-effective than conventional fossil fuel systems. Customers can add new or additional cooling capacity using a heat pump since they provide both heating and cooling. Smaller supplemental heat pumps, such as mini splits, can be installed in specific areas where the existing heating or cooling systems are inadequate. Lastly, switching from fossil fuel equipment to all-electric air source heat pumps allows customers to avoid the risks of carbon monoxide or other potential pollutants from fossil fuel systems.

**Problem Set 2.3:**

1. List three reasons customers may be interested in purchasing a heat pump.

## Learning Objective 2.4:

* Analyze different use cases for heat pumps

## Lecture Notes 2.4:

***Heat Pump Upgrades in Homes with Electric Resistance Heat***  
Homes with electric resistance heaters, such as wall heaters or baseboards, are an excellent target audience for heat pumps. This type of heat is expensive, uncomfortable, and does not offer air filtration opportunities. In addition, these systems do not provide cooling. There are three main options for installing heat pumps in homes with this type of heating system:

* a central heat pump, including cutting in a new duct system
* a ductless heat pump
* a system that incorporates multiple ductless heat pumps (DHP) that may include mini air handlers

***Cut-In Systems***

Cut-in systems involve installing a duct system connected to a central air handler. While this type of system can be expensive, it does allow the installer control over the sizing and installation of the ductwork. Some homeowners will view having central heating and air conditioning as a major upgrade that will increase the value of their home.

Central systems have other advantages. They avoid having multiple pieces of equipment on the wall or floor. They can typically provide better filtration. It can be more straightforward to get heating into small spaces like bathrooms. They can be used to provide whole-house ventilation and/or whole-house dehumidification. They can be easier to maintain (just one filter to change, just one AHU to fix if condensate gets clogged, etc.).

***Ductless Systems in Homes with Existing Zonal Electric Resistance Heat***Ductless Heat Pumps (DHPs) can offer homes with electric resistance heat an excellent solution. Obviously, there is no duct system to install, lowering the cost of installation. They can be a whole-house solution with DHP diffusers (also commonly referred to as “heads”) in all major rooms of the house, or they can provide any space in the house with an economical way to heat and cool. Mini-split heat pumps can also be paired with ducted heat pumps for a whole-house solution.

***Upgrades for Central Electric Furnaces***  
Central heat pumps are great upgrades for homes with electric furnaces. The high efficiency of heat pumps offers savings in the heating months and comfort in the cooling season. While it may be possible to use the existing air handler, it is best practice to replace the existing air handler with an air handler that creates an AHRI-rated system. AHRI rated systems are required by most incentives and tax credits. To increase savings and comfort, it is critical to seal the ductwork. Depending on the air carrying capacity of the duct system, duct modifications may be necessary to ensure that the heat pump can move sufficient amounts of air, so the system operates at its peak efficiency and that adequate amounts of air are delivered to each conditioned room.

***Electrification - Switching from Fossil Fuel Heating Systems to a Central Heat Pump***  
Many consumers are making personal decisions to lower their carbon footprint. As with electric vehicles, central heat pumps offer an appealing option for some homeowners. The Energy Information Administration captures the rapid growth in this market with this statistic: as of 2020, [nearly 18 million](https://www.eia.gov/consumption/residential/data/2005/) heat pumps were sold. This represents a 50 percent increase in heat pumps for heating compared to 2015. With the growing momentum and the passage of the Inflation Reduction Act (IRA), this number is expected to climb significantly.

Electrical panel upgrades may be required for some homes. This obviously adds expense to the project. In many cases, the National Electric Code (NEC 220.87) allows an alternative, labeled load study approach that may eliminate the need for a panel upgrade. It is best practice to inquire with the electrical subcontractor if this approach will work on a given job site.

As an installer, you can offer three main solutions for sizing and backup heat sources during cold weather:

1. The first is to select a cold-climate heat pump to meet the heat loss at design conditions.
2. If backup heat is required to meet the calculated heating load, electric resistance heat strips are a second option. Contractors should size the heat strips to fill the gap between the heat pump's capacity at design conditions and the house's heat loss. Sizing the auxiliary heat to fill the difference between the heat pump’s capacity and the design heat loss and not the entire heat loss of the home can significantly lower any electrical upgrade costs.
3. The third option is to use a gas furnace as backup. This allows the homeowner to enjoy the efficiency of the heat pump during average winter temperatures and utilize the gas furnace during periods of extreme cold weather. This option is a good way to future proof the system as it allows the homeowner to adapt to changes in fuel prices. Offering a heat pump to customers requesting a new air conditioner is a good upgrade option and may qualify for local incentives available to heat pumps.

***Switching from Central Fossil Fuel Systems to Heat Pumps***  
When switching from central fossil fuel to heat pumps, there is a good chance that the duct system will be undersized. If this is the case, simply switching out the fossil fuel system with a heat pump without addressing the ducting will lower the efficiency and capacity of the system. It can shorten the life of the fan motor, be louder, decrease air filtration, and cause comfort issues. The easiest and best solution is to focus on the return drop. The best practice recommendations are to increase its size, avoid right angle turns, and install a 4-inch filter with low pressure drop. A good rule of thumb for filter size is a minimum 1 square inch of cross-sectional area per 2.5 CFM of design airflow.

**Problem Set 2.4:**

1. When selecting a heat pump for a cold climate installation, list the three methods for maintaining thermal comfort during periods of cold weather.