

Building Science Education Solution Center – Introduction to Heat Pumps

Proficiency Level 1: Remember

Learning Objective 1.1:

- Describe what an air source heat pump is and what it can be used for.

Lecture Notes 1.1:

Reference: <https://www.nysersda.ny.gov/All-Programs/Clean-Energy-Workforce-Development/Clean-Energy-Training-Resources>

Air-source heat pumps (ASHP) are an HVAC technology used for both heating and cooling an indoor environment. However, unlike other heating systems, heat pumps do not create heat, they simply help to move it from one source to another. By using the same concept as refrigeration or air-conditioning, air source heat pumps can cool an indoor environment by removing heat from the inside and pumping it outdoors. Alternatively, heat pumps can also warm an indoor environment by extracting heat from the outside air and pumping it inside. It is therefore possible for an air source heat pump to be a household's primary source of both heating and cooling.

Heat pump technology has improved significantly over the last 15 years, with the latest air source heat pumps being capable of providing the sole source of heat in northern US states. Being able to easily switch between heating and cooling with the same unit makes them distinct from traditional HVAC systems, which typically can only provide heating or cooling separately. Understanding how air source heat pumps operate is important when making decisions on using them for a household's primary heating and cooling source.

The majority of heat pumps used in homes are conventional air-source heat pumps with a central indoor unit which supplies air throughout the house via a duct system. However, other types of heat pumps exist which are becoming increasingly common. These include ductless heat pumps (sometimes called mini-splits), which have one or more indoor units that condition only the space where they are installed, variable refrigerant flow (VRF) heat pumps, which are often ductless and can achieve significant efficiency gains, and ground-source heat pumps (GSHP), which do not have an outdoor unit but instead transfer heat to or from the ground to improve efficiency.

Problem Set 1.1:

- 1) Which of the following can air source heat pumps be used for?
 - a. Cooling a household in the summer.
 - b. Heating a household in a southern US state in the winter.
 - c. Heating a household in northern US states in the winter
 - d. All of the above.

Learning Objective 1.2:

- Define key terms related to sizing and design of heat pumps.

Lecture Notes 1.2:

Coefficient of Performance (COP): Instantaneous efficiency (heating or cooling); Units of energy IN divided by energy OUT. COPs for heat pumps typically range from 2 to 5 meaning that for every one unit of energy the system uses, it provides 2-5 units of heating energy to the space. COPs for gas furnaces are typically less than 1, meaning that for every unit of energy the system uses, less than 1 unit enters the space. This low COP is because fossil fuel combustion only turns energy into heat, with some losses.

Design Heating Capacity: Heat pump's heating output at the outdoor air winter design temperature (Btu/hr).

Design Heating Load: Heating need to meet the target minimum winter indoor temperature setpoint (Btu/hr).

Displacement Heating: A design strategy where the heat pump is only intended to cover part of the home's annual load, displacing heat that would otherwise come from another heating system. Typically, the heat displaced is a fossil-based system such as wood fireplaces or gas furnaces.

Heating Capacity @ 5°F: Maximum heating capacity for a given heat pump make and model when the outdoor air temperature is 5°F.

Heating Seasonal Performance Factor (HSPF): Overall heating efficiency; Heating output (Btu) during a typical heating season divided by total electric energy (watt-hours) used during the same period. Typical HSPF values are 7-18+.

Minimum Capacity: Lowest possible output for a given heat pump make and model at a given outdoor air temperature.

Multi, Mini, Package, Split: ASHP System type descriptions.

Rated Heating Capacity: Nominal heating output of heat pump at 47°F (Btu/hr) as tested.

Refrigerant: A chemical compound that readily absorbs and releases heat by undergoing a phase change. Common heat pump refrigerants include R410a, R32, R134a, R744 (CO₂), and R22 (phased out).

Seasonal Energy Efficiency Ratio (SEER): Overall cooling efficiency; Cooling output (Btu) during a typical cooling-season divided by the total electric energy (Watt-hours) used during the same period. Typical SEER values are 14-25.

Problem Set 1.2:

- 1) Match the terms with the correct definition.

Definition	Key Term
1) Nominal heating output of heat pump at 47°F (Btu/hr) as tested.	a. Design Heating Capacity
2) Heat pump's heating output at the winter design temperature (Btu/hr).	b. Design Heating Load
3) Overall cooling efficiency, typically ranges from 14-25.	c. Displacement Heating
4) Lowest possible output at a given temperature.	d. Heating Capacity @ 5°F
5) Maximum heating capacity when the outdoor temperature is 5°F.	e. Minimum Heating Capacity
6) Instantaneous efficiency (heating or cooling), typically ranges from 2-5 for heat pumps and less than 1 for fossil fuel heating systems.	f. Multi, Mini, Package, Split
7) Heating needed to meet the target minimum winter indoor air temperature setpoint (Btu/hr).	g. Rated Heating Capacity
8) A design strategy where the heat pump is only intended to cover <i>part</i> of the home's annual load, displacing heat that would otherwise come from another heating system.	h. Refrigerant
9) A chemical compound that readily absorbs and releases heat by undergoing a phase change. Common heat pump refrigerants include R410a, R32, R134a, R744 (CO ₂), R22 (phased out).	i. SEER
10) System type descriptions.	j. HSPF
11) Overall heating efficiency. Typical values are 7-18+.	k. COP

Learning Objective 1.4:

- Know the customer benefits of ASHPs

Lecture Notes 1.4:

Heat pumps can be a helpful addition 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.