SYSTEM DESIGN WITH **EXISTING HEATING**

CEE[SM]

Who: Heat pump installers | **Why:** Learn how to install a heat pump in a home that has existing heating

Heat pumps provide efficient heating and cooling for homes in all climates. When sized to be the sole source of heating and cooling, a heat pump is capable of doing so. However, not every project is a perfect match to be heated and cooled only by a heat pump.

PARTIAL LOAD APPLICATIONS

1. **Sized for Cooling** - Heat pump that provides all cooling and some of the heating to the home.
   - Adding or replacing air conditioning to a home with existing high efficiency heating.
   - A heat pump sized for cooling in a heating driven climate.
2. **New Addition - A heat pump providing heating and cooling to a zone that was not previously conditioned.**
   - Conditioning and adding dehumidification to a basement or sunroom.
   - Heating and cooling a new addition.
3. **Partial Coverage - A heat pump that provides part of the heating or cooling in part of the home.**
   - Supplements heating and cooling in an area of the home that the existing system struggles with.
   - Increases zoning and customizability of the home's heating and cooling.

Even in a partial load application, a heat pump provides clean and efficient heating and cooling.

BENEFITS OF A HEAT PUMP IN A PARTIAL LOAD APPLICATION

- **Maximum cooling efficiency**: Inverter driven and multiple capacity heat pumps typically have higher seasonal efficiencies than standard central air conditioners and most heating systems. These high levels of efficiency result in reduced summer electricity expenses and winter fuel bill savings.
- **Climate friendly**: For an average home heated by natural gas, switching to a heat pump reduces your carbon footprint by an amount comparable to not driving a gas car for 9 months of the year. A heat pump can lower carbon production by reducing the use of fossil fuel heating.
- **Better dehumidification**: Some inverter driven or multi-stage heat pumps' ability to control fan and compressor speed allows the heat pump to run efficiently at low speeds for long periods of time which wicks more moisture from the air than a standard air conditioning system.
- **Year-round comfort**: A heat pump can take the place of an air conditioner in cold climates and provide heating when temperatures are mild, keeping you warm in the winter and cool in the summer.
- **Increased indoor air quality**: Most heat pumps provide constant air flow with options to add an enhanced filtration system to clean the air of pollutants, dust, pollen, and allergens.
- **Affordability**: Installing a heat pump in a partial load situation can be a cost-effective alternative for homeowners who can't afford a full installation immediately, potentially making it more appealing during home sales.
- **Correcting existing heating and cooling issues**: Homes with heating and cooling problems can address these issues with a heat pump to ensure year-round comfort.

PARTIAL LOAD CONFIGURATIONS

1. Sized for Cooling

Most commonly a dual fuel configuration with the heat pump and furnace sharing the duct system but can be various configurations of heat pumps (ducted, ductless, or mixed) and other heating systems that share or have separate distribution systems. The controls should be configured to prioritize the heat pump as the primary stage of heating and only engage the secondary heating source when necessary. The homeowner should be aware of how the two systems interact.

2. New Addition

Typically a ductless or compact ducted system, this heat pump will provide all heating and cooling necessary for the space. It should have minimal interaction with the home's other systems. The homeowner should be informed on how to operate the system independently of the existing system.

3. Partial Coverage

This heat pump can be ductless or ducted with a separate duct system. Ideal for spaces that are far from the existing air handler or have large windows, the heat pump will supplement the existing system in spaces it struggles to heat or cool. The heat pump should be sized to add to the existing system to make the space comfortable. The controls should be configured to operate both systems at the same time and the homeowner should be made aware of how the two systems should interact.

PARTIAL SYSTEM

When should a partial system be selected:

Partial systems are a perfect solution for a homeowner looking to lower their carbon footprint, heat and cool a new addition, electrify in stages, add an efficient cooling system, or supplement a functioning legacy system.

Benefits of partial:

- ✓ Low installation cost
- ✓ Potential capability to cover all heating or cooling for mild temperatures
- ✓ Can cover all cooling in heating driven climates
- ✓ Reduces carbon production of fuel system

WHOLE-HOME SYSTEM

When should an existing system be fully replaced by a whole home solution:

A whole home heat pump should be selected when a homeowner is looking to reduce their carbon footprint, replace an outdated or inefficient system, provide efficient heating and cooling year-round, lower maintenance costs, and maximize their incentives.

Benefits of whole home:

- ✓ One system - only need maintenance and upkeep for one system
- ✓ Path to full electrification
- ✓ Greatly reduced carbon footprint
- ✓ High efficiency heating and cooling

CONTROL STRATEGIES AND WHEN TO USE

Controls should be configured to prioritize the heat pump as primary heating then engage the existing system as secondary heating when necessary. In a partial load application where the heat pump is sized for cooling, the heat pump will provide efficient heating but may not have the capacity to cover *all* of the heating. In this case, the controls can be configured to the homeowner's goals.

CARBON FOCUSED CONTROLS

The controls should prioritize the heat pump by running the heat pump at all times. The secondary heating system should be used only when the heat pump cannot maintain the temperature in the space. The controls should engage the secondary heating system to return the space to the temperature setpoint, then disengage the secondary heating system. The heat pump will remain running throughout this time. The carbon savings from using this method can be substantial.

COST FOCUSED CONTROLS

These controls are configured to switch from the heat pump to the secondary heating system when it is calculated the secondary heating system is deemed cheaper to operate. The point at which the secondary heating system is cheaper than the heat pump is called the switchover temperature. Calculating the switchover temperature manually is difficult and constantly changing with the prices of fuel and electricity. The savings seen from using this method are usually minimal. This method also ignores the fact that carbon production comes with a cost. Because of the ever-changing switchover temperature, modest savings, and lack of carbon costs, it is suggested that the carbon focused controls be used whenever possible.

More information on two-system control methods can be found in CEE's Controls for a Heat Pump with Secondary Heating. The document gives in-depth explanations on each method, when they should be used, and how they can be configured.

CALCULATE THE ECONOMIC SWITCHOVER TEMPERATURE

To calculate when the secondary system is cheaper to run than your heat pump, you will need to gather the efficiency of both systems and the cost per unit delivered of electricity and the fuel. This method can be difficult to calculate but accurate at time of sizing, design, and installation. However, fluctuating costs of fuel and electricity require the economic switchover temperature be re-evaluated every heating season. The savings realized by using this method are often minimal. This method also ignores the cost of carbon production by the fossil fuel system. Because of these reasons, it is suggested other methods be selected when possible.

Natural Gas Switchover

Natural gas is most commonly used in dual fuel systems as it is an inexpensive and available fuel. To find the economic balance point when using a natural gas system, use the heat pump's manufacturer specifications to find the temperature that matches with the switchover COP.

Economic Switchover COP = $/kWh x 29.31 kWh/Therm x AFUE ÷ $/Therm of Gas

$/therm = $/CCF x 1.038

Other Fuel System Switchover

For all other systems, use the below method to find the economic balance point for the fuel and heat pump systems.

Fuel Heating: Cost per Btu = $/unit ÷ Fuel Heating Value ÷ Efficiency

Because the fuel heating system does not rely on the outside air for heat, the efficiency of the system typically stays level. Calculate the cost of running the fuel heating system, then find which COP the heat pump requires to equal that cost. Use the manufacturer specifications to find which temperature aligns with the calculated COP. This temperature is the economic switchover point of the system.

Heat Pump: Heat Pump Switchover COP = $/kWh x 0.293 ÷ 1000 ÷ Cost per Btu

It should be noted that COP of a single-speed heat pump varies by outdoor air temperature and COP of a multi-speed heat pump varies by compressor speed and outdoor air temperature. Because the COP varies at any outdoor temperature, it should be estimated carefully depending on the output of the system at the temperature in question. Use the manufacturer specification or the NEEP ASHP Tool (ashp.neep.org/#!) to determine the COP of your heat pump.

Fuel cost and heating value

Fuel Type	Typical Efficiency	Average Cost	Heating Value
Fuel oil	0.8-0.9	$4.073/gallon	138,500 (BTU/gal)
Natural Gas	0.8-0.95	$1.371/therm	100,000 (BTU/therm)
Propane	0.9-0.98	$2.671/gallon	92,500 (BTU/gal)

Fuel source costs based on U.S. national average. Data from U.S. Energy Information Administration. www.eia.gov

RUNNING A HEAT PUMP AND OTHER HEATING SYSTEM

It is important to install and correctly program controls for heat pumps meant to work in unison with an existing heating system. Traditionally, HVAC systems are oversized in most homes for the required heating and cooling needs. Running a heat pump with another heating system simultaneously may have adverse effects as they could combine to a single oversized system. Oversizing causes both operational and cost issues.

Oversizing Operational Issues

Low-load Cycling

Low-load cycling arises when the HVAC system's minimum capacity exceeds the home's heating or cooling requirement, causing frequent on-off cycling that lead to inefficiency, elevated energy costs, and added strain on mechanical components.

Comfort

An oversized system can push hot/cold air towards the thermostat or ductless head's temperature sensors before mixing evenly into the space. In these cases, the thermostat may falsely sense that the room's temperature setting is satisfied and turn off the equipment prematurely. This leads to uneven air temperatures throughout the house.

Dehumidification

Heat pumps and air conditioners dehumidify the air as they cool. In theory, a larger system would be able to wick more moisture from the air than a smaller system would. However, the process of dehumidification requires the equipment to run for an extended period. Oversized systems have shorter run times and may fail to dehumidify the space.

HOW TO CALCULATE SAVINGS OF A PARTIAL SYSTEM

Installing a heat pump in a partial load situation typically leads to energy savings through heightened efficiency. These savings can be approximated using data on existing systems, heat pump efficiency, and past utility bills. Transitioning from fuel to electric heating might bring higher winter electric bills but fuel saving should exceed the electric increase.

Heating Cost Savings

Use the past year's fuel bills to find what it should cost to heat your home with a heat pump this year.

Annual Heat Load = Amount of Fuel Used x Heating Density of Fuel x Efficiency

Cost of Operating a Whole Home Heat Pump = Annual Heat Load (Btu) x $/kWh ÷ 3.412 ÷ 1000 ÷ COP

Because a heat pump in a partial load situation will not cover the entire annual heating load, how many of those hours will be heated by the secondary system and how many will be heated by the heat pump will need to be estimated. Calculating the switchover point or using a tool like the NEEP ASHP Sizing Tool will help to determine what percentage of the potential whole home savings will be realized.

Cooling Cost Savings

Cooling savings are typically easier to calculate because a heat pump operates very similarly to a traditional air conditioner. The annual cooling costs can be estimated by comparing electricity bills of months that do not require any cooling to the months that do require cooling.

Annual Cooling Cost = Sum of electric bills for cooling months - (Average of all months without cooling or electric heating x Number of cooling months)

Annual Cooling Cost Savings = Annual Cooling Cost x (1 - Existing AC Efficiency ÷ Heat Pump Efficiency)

Cost of fuel source per therm and efficiencies

Source	Average Cost/Therm	Typical COP	Cost/Therm with COP
Electric Resistance	$4.69	1	$4.69
ASHP	$4.69	2.4	$1.95
Natural Gas	$1.37	0.95	$1.44
Fuel Oil	$2.94	0.9	$3.26
Propane	$2.90	0.9	$3.23
Kerosene	$2.74	0.9	$3.04
Cord Wood	$0.69	0.9	$0.76
GSHP	$4.69	4	$1.17

Cost/Therm is based on national cost of source converted to Therm. www.eia.gov
Therm is equal to 100,000 BTUs.
Efficiency based on highest possible efficiency for furnaces and electric resistant heating sources.
GSHP efficiency of 4 based on average Coefficient of Performance.
ASHP COP will vary as outdoor temperature changes.
Cold-climate ASHPs COP are typically greater than 2.0 at temperatures less than 5°F.

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