# Sizing Electric Heating Swaps

## Introduction

This fact sheet is intended to assist those looking to make the transition to all-electric heating systems from systems that rely on fossil fuel combustion. Electrifying building heating systems allows building owners to decarbonize their property while improving indoor air quality for tenants. In some jurisdictions, electrifying building heating systems will help futureproof buildings from potential financial penalties imposed by legislation aimed at reducing the carbon footprint of buildings.

Multifamily buildings with fossil fuel heating generally provide heat to occupants in one of two ways: via a centralized heating system (typically with a large gas or oil burning boiler) or unitized (individual furnaces or packaged through-wall units). The process for sizing electric replacements will differ depending on your system type and heating needs. This guide focuses on buildings making the transition to air source heat pump split systems from either existing unitized or central fossil-based systems.

# Multifamily and Single-Family Unitized Systems

## Appropriate Steps to Take When Planning Your Heating Swap

## 1 Establish Clear Goals

Many factors can influence the decision to make a switch to unitized electric heating systems. For example, an owner could be looking to lower the carbon footprint of the building, there may be comfort issues that are best addressed by allowing individual dwelling units to have control over the heat in each space, or the current system may be near the end of its useful life and upgrading the system would require a costly and invasive renovation. Understanding and clearly articulating the goals of the project is a crucial first step in the process as it allows designers and installers to formulate a plan that works best for the project.

## 2 Evaluate Current Conditions

One of the first steps to take when considering electrifying your heating system is to evaluate your building's current energy performance by performing an energy audit and implementing low and no cost energy efficiency measures found in the process. An ASHRAE Level 2 audit will help identify major energy uses in the building and provide recommendations for how to improve efficiency for major systems in the building. It is especially important to address any issues related to air infiltration and weatherproofing (such as seals around windows and other penetrations in the building envelope) that will help your building retain heat during cold months. These are very low-cost fixes that can make a big impact on occupant comfort. Additionally, reducing heat loss by addressing air infiltration will allow for smaller replacement systems.

If you have the capacity to make additional capital improvements to your building, take time to address other potentially wasteful loads such as incandescent or fluorescent lighting and old appliances. Depending on your jurisdiction, some of these improvements may be incentivized by your local utility. While these improvements may not have a substantial impact on the overall heating demand for each unit, they will help lower cooling demand for warmer months. Taking this step allows you to confidently and accurately calculate your building's loads using an industry standard calculation methodology such as **ACCA Manual J** or the **ASHRAE Handbook of Fundamentals**.

# 3 Calculate Loads Accurately

Once you have addressed any existing building envelope issues and reduced other inefficiencies identified through an energy audit, it is time to perform load calculations.

Too often, mechanical engineers and designers will oversize mechanical systems by either assuming existing equipment is properly sized, not performing load calculations, using outdated rules of thumb, directly converting gas input capacity to electric capacity, or overestimating the required demand for the system. This can lead to a number of problems once the mechanical system is installed, including:

- Efficiency losses due to equipment short-cycling (turning on and off)
- Durability issues due to equipment turning on and off repeatedly
- Indoor air quality issues

## Load Sizing for Heat Pumps

Heat pumps produce lower temperature supply air than furnaces, which can make spaces more comfortable if the systems are appropriately sized and the building is sufficiently air-tight and insulated. They are also much more efficient at producing heat than gas furnaces, enabling significant energy and carbon savings when sized correctly.

However, if systems are oversized, occupants may experience comfort issues and the energy savings associated with improved efficiency from heat pumps will be diminished. Heat pumps are only efficient if they are running properly, and oversized systems will cycle on and off even on the coldest days.

In Figure 2, the heat pump never came close to its rated capacity even on the coldest days, showing that this unit is approximately 3x oversized. Because of this, the system cycles on and off, and measured performance was significantly lower than anticipated, increasing the cost of operating the system. Heat pump technology has improved significantly in recent years, and cold climate heat pumps (CCHPs) have demonstrated that heat pump technology can be used efficiently in very low temperatures (some are rated to -15° F). However, some designers will still choose to oversize a system in an effort to guarantee that there will be enough heat on the coldest days. Unfortunately, this wastes energy and can lead to bigger comfort issues due to the system not operating continuously.

To accurately size your system, follow the guidelines of an industry standard calculation methodology such as ACCA Manual J. Sizing should not be a long, arduous process. Experienced engineers and designers should be able to complete calculations in 30-60 minutes per unique unit type and orientation depending on the complexity of the design. Manual J is also already conservative in its approach to sizing mechanical heating and cooling loads, and you do not need to add additional safety factors to accurately size your systems.

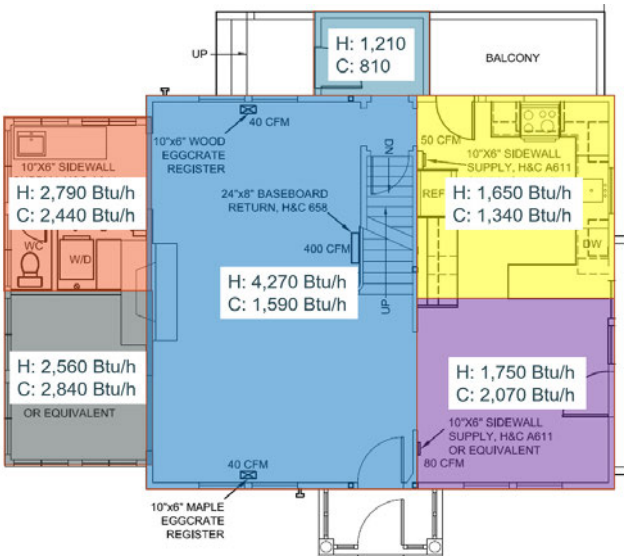



Figure 1. This graphic shows an example of a correctly performed load calculation.

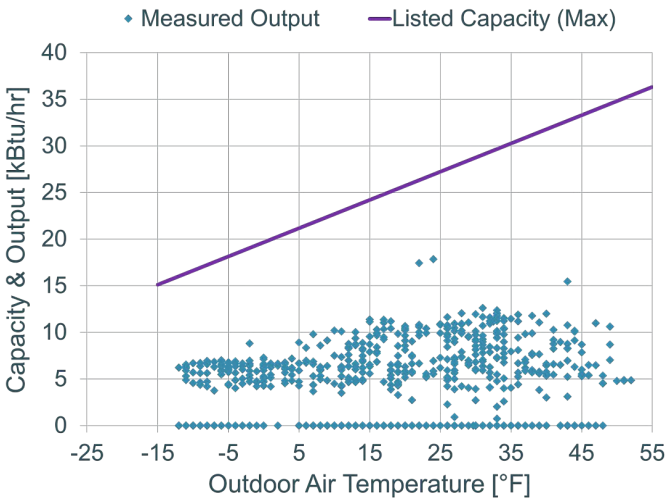



Figure 2. This graphic shows the actual output of an oversized heat pump. The purple line demonstrates the maximum capacity of the heat pump while the blue dots represent one hour of actual measured output.

For example, ACCA Manual J recommendations for outdoor design temperatures should be followed, and accurate building characteristics should be utilized such as actual building orientation, window performance, insulation levels, air-tightness, duct tightness, location of supply registers, and internal loads.

For multifamily buildings, it is important to size loads for each apartment configuration. Units of different size and shape and on different floors will require different inputs. Some of the largest mistakes are made by assuming the worst-case scenario (largest unit, north facing, top floor) and sizing all mechanical systems for that scenario. Building owners will save on upfront equipment costs by performing load calculations accurately according to Manual J.

## 4 Identify Configuration & Distribution Strategy

If the building already has centralized air conditioning in each unit, a heat pump outdoor condenser unit can replace the air conditioning condenser unit and provide heat in the winter and cooling in the summer. The unit's existing heating system can then be configured to supplement the heat pump during extremely cold days, thus reducing back-up electric resistance heat utilized by the heat pump and saving building owners on utility bills. If supplemental heating is a concern, consider utilizing a CCHP as they are rated to perform at lower temperatures and will be more efficient than electric resistance back-up. CCHPs can be used in more temperate climates as well as colder climates. If the building does not already have air conditioning, another benefit of heat pumps is their ability to provide cooling during hotter months.

Because heat pumps use refrigerant and reject heat to the outside, it is important to make sure the outdoor units are properly aligned. Properly aligned condenser units will reject heat away from the intake for other units. The image to the right shows proper alignment of condenser units with heat rejection fans facing away from the intake for other units. These units are also elevated to allow for clearance in the event of snow.

If your building does not already have cooling, you will need to determine how to best run refrigerant lines from your outdoor units to the indoor air handler. Refrigerant lines should be well insulated and ideally the run length should be as short as possible to improve efficiency.

Photo Credit: Steven Winters Associates

# 5 Select and Install Equipment

Now that you have performed your load calculations and identified the ideal layout for the outdoor units, it's time to select proper equipment. Select equipment that is efficient and meets the design standards identified in your load calculations. ACCA Manual S provides guidance on selecting equipment of appropriate capacity to satisfy calculated loads. It is sometimes difficult to closely match equipment capacity to loads, especially in small or very efficient structures. ACCA Quality Installation (QI) Guidelines and ACCA Manual S specify the following:

- **Single Stage:** Total equipment capacity between 90% and 115% of the calculated system load.
- **Dual Stage:** Total equipment capacity between 90% and 120% of the calculated load.
- **Variable Stage:** Total equipment capacity between 90% and 130% of the calculated load.

One should match the structure's total calculated load (sensible + latent) to the total capacity of the equipment. Matching only the building's sensible load to the sensible capacity of the equipment ignores latent capacity that shifts to sensible capacity at higher outdoor temperatures. This can result in systems that are oversized and deliver poor comfort at slightly lower temperatures. It is important to note that some manufacturers' equipment can be more closely matched to the calculated loads than others. Additionally, some equipment can better deliver capacity at design conditions.

## Correctly Sized

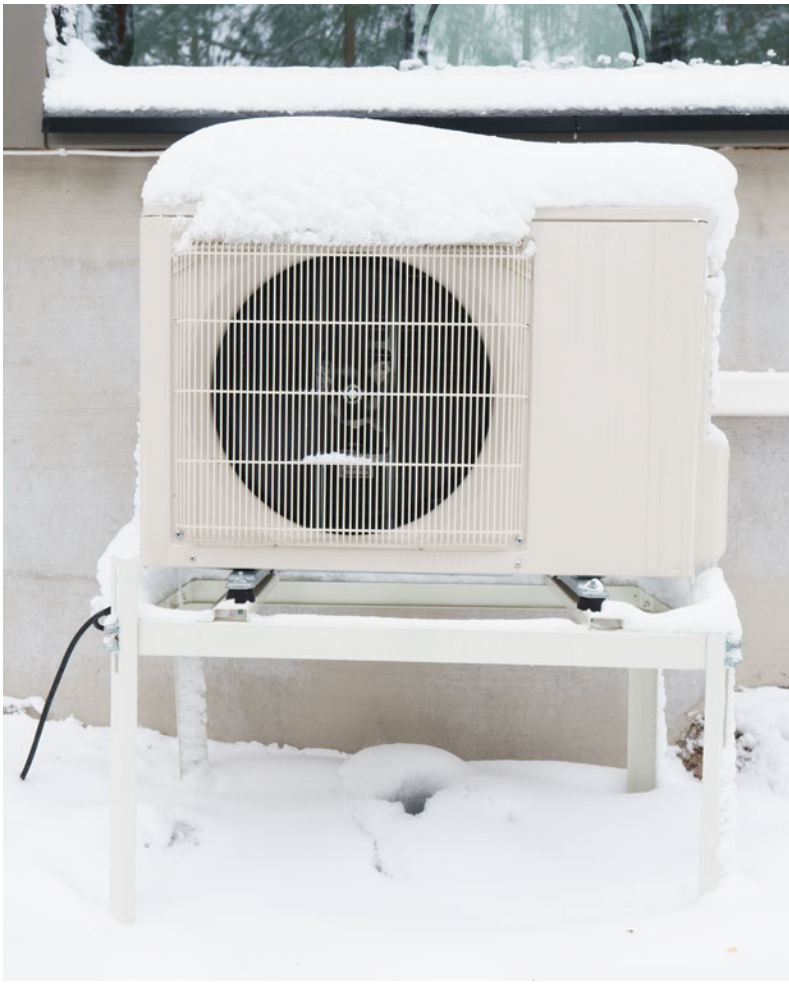
Because multifamily buildings have units of differing sizes and orientations, it is critical to review the load calculations and select equipment that meets the requirements of each unit. It is likely that this will result in purchasing equipment of varying capacities.

## Climate Appropriate

Heat pump systems have differing capacities depending on the outdoor air temperature. It is critically important to review the rated capacities for the systems you are considering installing in your building to ensure that the system will perform optimally in your climate. Also, note that mechanical designers will often design systems based on the design day, or worst-case condition. While this ensures that occupants will be comfortable on the coldest days, this can also lead to oversizing on typical days.

## Install and Commission

Once the design is complete and the equipment is purchased, it is time to install your systems. One advantage of selecting a unitized system is that it allows owners to install systems in individual units as they turn over or in a larger renovation project. Once the system is installed, it is important to have a third party commission the system by performing a series of tests to ensure that everything is operating properly.



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