Air Source Heat Pumps

Don’t Oversize

Oversizing a heat pump may result in comfort and cost issues

Applying specific strategies can help identify or prevent oversizing and the adverse effect it can have.

How Oversized is Oversized?

The impacts on energy use and comfort begin when air source heat pump systems are sized at 120% of the building load*. Severe impacts of oversizing can begin when systems are sized above 150%. At a certain point, the system may be entirely unable to achieve heating or cooling. For the homeowner, oversized heat pumps are costly, they reduce comfort, and they’re more problematic than an oversized fossil fuel furnace or boiler.

Operational Issues

Low-Load Cycling*

Low-load cycling occurs when the minimum capacity* of the heat pump is higher than the heating or cooling load of the home. Because the system is removing/adding more heat than the home needs, the system will repeatedly cycle on and off. This results in inefficient operation, high energy bills, and increased wear to the heat pump’s mechanical components.

Purge Cycling

Frequent low-load cycling over an extended period can drive the compressor into a purge cycle. During low-load cooling calls, some liquid refrigerant may not boil into a vapor while passing through the indoor coil. To prevent the excess liquid refrigerant from entering the compressor and damaging it, the system purges it. While purging, the system cannot respond to a cooling call, which leaves occupants uncomfortable. Extreme oversizing situations may force the system to start purging almost immediately after the start of a new cooling call, leading to a never-ending purge cycle. When stuck in a purge cycle, the system will have a high electric draw without providing meaningful cooling.

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 heat pump may falsely sense that the room’s thermostat setting is satisfied and turn off the heat pump prematurely. This leads to uneven air temperatures throughout the house.

Dehumidification

Heat pumps 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 heat pump to run for an extended period. Oversized systems have shorter run times and may fail to dehumidify the space.

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Cost Issues

Upfront Cost: A higher capacity heat pump will have more upfront equipment costs than its right-sized counterpart. Installation costs may also be higher, especially if additional outdoor compressors or indoor units are needed to provide that capacity.

Energy Usage, Inefficiency, and High Bills: An oversized heat pump will be more expensive to operate. Inverter-driven heat pumps are most efficient when they are operating within their modulating zone* typically between 40% and 80% of full capacity. An oversized system will have more hours during which the load is below its minimum capacity, resulting in low-load compressor short cycling. Like most machines, heat pumps are least efficient when first starting up. Also, each time a heating/cooling call ends, the compressed refrigerant in the line stops moving and never reaches a distribution unit to heat/cool the house, wasting energy many times with each short cycle. The combination of short cycling and wasted effort leads to an overall efficiency penalty of as much as 25% during periods of low-load cycling.

Shorter Equipment Lifespan: Constant cycling stresses the equipment and increases wear and tear. This can lead to premature breakdown of mechanical components such as fans, the compressor, or valves, resulting in extra repair costs and early replacement.

How to Avoid Oversizing

Conduct an ACCA Manual J Load Calculation: Conduct your own sizing calculation and product selection using an industry approved method like ACCA Manual J, S, and D. Avoid using rules of thumb or replacing a system for a like-sized system without completing your own sizing calculation. Even if the previous system size was appropriate when it was installed, the home may have undergone weatherization or other improvements. Many fossil-fuel furnace and boiler systems are oversized themselves.

Use the Correct Design Temperature*: Always use a design temperature that is appropriate for the location. ASHRAE and ACCA each publish recommended design temperatures by county and weather station that are based on historical weather data. Reference the ENERGY STAR Design Temperature Limit Reference Guide (2019 Edition) online.

Complete Building Take-Offs: Assess the entire building by measuring ceiling height, wall area, window area, roof and floor area. Conduct accurate take-offs* to estimate the insulation R-values, assembly details, and window U-values. For accurate cooling loads, capture the direction that each window and wall faces. South- and west-facing surfaces gain more heat from the sun. Remember that surfaces (walls, ceilings, floors) shared between conditioned spaces are adiabatic, which means they do not lose or gain heat and should not be included in the Manual J model. Conduct a blower door test to accurately assess the air tightness of the building.

Prepare for the Building's Future: Ask the homeowner what their plans are for the next 5–10 years of the home. Will they be adding insulation, re-siding, replacing windows, air sealing, remodeling, constructing additions, or completing other weatherization upgrades? Does the home have a high amount of air leakage or poor insulation? Consider planned weatherization efforts while conducting a Manual J to size for both now and the future so the system can operate efficiently for its entire life.

Look for Systems with Higher Turndown Ratios: A heat pump with a high turndown ratio* can provide all necessary heating and cooling while also having the ability of supplying low loads to the space. This helps maximize the time that a heat pump operates efficiently and minimizes or eliminates the time spent low-load cycling. Use tools such as the NEEP ccASHP Product List to identify equipment that will operate efficiently.

Terms to Know*

Accumulator: The component of a heat pump that stores liquid refrigerant until needed. The device catches and holds liquid refrigerant to prevent it from entering the compressor, which can cause damage.

Building Load: The heat loss or heat gain of the building from the surrounding environment at any given outdoor air-temperature and condition. To maintain a temperature in the building, the heat pump's capacity needs to match the building load.

Design Load/Design Temperature: The building load at the 99th percentile hottest and coolest hour of the year for the home's climate. The design loads must be matched by the heating and cooling system design capacities to ensure occupant comfort year-round.

Low-Load Cycling (e.g., short-cycling or compressor cycling): Occurs when the building load is lower than the minimum capacity of the system. The system cycles on and off frequently and inefficiently.

Maximum Capacity: The maximum amount of heating or cooling that a system is capable of at a given temperature.

Minimum Capacity: The minimum amount of heating or cooling that a system is capable of at a given temperature.

Modulating Zone: The range of heating/cooling output that an inverter-driven heat pump can produce at a given temperature. The zone is bound by the maximum and minimum capacities.

Take-Off: An assessment of a space, area, or project. Measure and collect quantities such as floor area, wall length, ceiling height, number of doors, and other related measurements. An important step in producing an accurate estimation of the building load.

Turndown Ratio: The ratio of the maximum output divided by the minimum output of the system. A system with a high turndown ratio can provide high amounts of heating and cooling while also operating efficiently during low-load situations.

Scan to see how two respected installers overcome unit sizing challenges.

Ready to learn more?

Visit cleanheat.ny.gov to explore additional resources and trainings for overcoming common installation challenges.

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