

Emerging Technologies

Ductless Split Systems

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Most U.S. residences use central ducted systems to deliver cooling and heating. Ducted systems consist of a network of ducts with a blower that delivers conditioned air to different indoor spaces. An outdoor condensing unit cools refrigerant, which then flows to a refrigerant coil mounted in the duct. If the outdoor unit is a heat pump, the indoor coil also transfers heat to the duct during the heating season. More commonly, however, the ducted airflow passes through a furnace that heats the air.

In contrast, a ductless split system provides space conditioning by distributing cooled (and, in the case of a heat pump unit, heated) refrigerant through a network of insulated refrigerant lines to one or more (typically up to four) fan-coil units located in conditioned spaces. A ductless split system with a single outdoor unit and a single indoor unit also is known as a mini-split. Ultimately, low-profile ceiling- or wall-mounted fan-coil units transfer heat between the refrigerant and the room air. Available in capacity ranges from approximately 1 to 4 tons (3.5 kW to 14 kW), ductless split systems are smaller and simpler variations of variable refrigerant volume systems used in commercial buildings.¹

Ductless split systems often include features such as variable-speed fans, variable-capacity compressors, and wireless controls. In addition, units with multiple evaporators have individual thermostats to control the operation (e.g., temperature setpoint) of each indoor coil.

Effective ductless system performance depends upon proper placement of indoor coils. Ductless systems take in ambient room air, condition the air, and then blow the air into the conditioned space. Consequently, the indoor coil must be installed in a location where it can distribute the conditioned air evenly throughout the space. Improper placement can cause an indoor unit to recycle already conditioned airflow (short circuiting), resulting in ineffective space conditioning.²

Ductless split systems are the primary residential cooling systems in many parts of Asia, and most major manufacturers are based in Asia. However, they have yet to achieve significant market share in the U.S., primarily because their system architecture differs from the predominant approach (ducted systems) and operational limitations in colder climates.

Energy Savings Potential

Ductless split systems can reduce HVAC energy consumption relative to ducted systems in at least three ways. First, ductless

systems avoid losses of conditioned energy via duct air leakage. Second, a significant portion of duct runs are placed in unconditioned spaces, such as attics and basements. If they lack sufficient insulation, the ducts can exchange sizeable quantities of energy with these spaces. Third, multi-evaporator systems provide space-by-space heating and cooling control, which enables them to save energy by only conditioning occupied spaces. Although ducted systems also can employ zoning, using dampers and variable air volume blowers, they typically do not.

It is difficult to quantify the energy savings potential from zoning. Studies of residential duct leakage suggest that ducted systems deliver less than 70% of the heating or cooling effect produced to the intended spaces. For example, an evaluation of the delivery efficiency of 24 houses with ducted systems in California found an average thermal delivery efficiency of 64%.³ Assuming that approximately half of the heating or cooling energy lost from the ducts is transferred to unconditioned spaces, the average system would have to run approximately 20% longer—consuming 20% more energy—to meet cooling and heating loads. As a result, ductless AC systems with the same efficiency as ducted split systems could reduce residential HVAC energy consumption by approximately 20%. While ductless systems do lose energy through the insulated refrigerant lines, these have much less surface areas than ducts, limiting their energy impact.

Assuming 20% savings, replacement of typical ducted systems with ductless systems could reduce the 2.1 quads of cooling energy consumed by central residential systems⁴ by approximately 0.4 quads. Additional savings would accrue for central systems with heat pumps, as well as from reduced conditioning of unoccupied spaces from zoned control.

Well-sealed and well-insulated ducted systems have much smaller losses than typical residential ducts, i.e., the most efficient systems evaluated by Jump, et al.³ had delivery efficiencies of about 90%. Relative to efficient ducted systems, ductless systems would realize more moderate savings on the order of 5%, or about 0.1 quad.

Market Factors

Although ductless split systems have become more common in the U.S.,² they still have a small market share. Relative to the typical ducted systems, ductless systems have two primary disadvantages. Foremost, for a new air-conditioning system for an entire home, ductless systems typically have a higher

installed cost than ducted systems, in part because they are not considered typical practice in the U.S. This general unfamiliarity with ductless units decreases the number of contractors that install the systems, as well as the volume of products sold. For potential replacement of ducted systems, the cost premium grows substantially because a ducted system retrofit would only need to replace the indoor and/or outdoor units.

Furthermore, ductless systems in colder climates either require extensive use of backup electric resistance heating, which increases operating costs, or installation of a separate heating system (such as hydronic radiant heating), which further increases their first cost premium.

In addition, ductless systems use refrigerant to distribute heating and cooling and, as a result, have larger refrigerant charges and long refrigerant runs than ducted systems with the same capacity. This increases the potential for refrigerant leakage and the volume of refrigerant lost when a leak occurs.

On the other hand, ductless split systems offer at least three advantages relative to conventional ducted systems. First, ductless systems are easier to retrofit in many existing homes because they use small refrigerant lines instead of much larger ducts to distribute heating and cooling. Second, as currently designed, ductless systems have quieter indoor and outdoor fans, which minimizes their acoustic impact on occupants.²

Third, ductless systems provide zone control, i.e., each indoor unit has its own temperature controls. This enables occupants of different spaces to customize air temperature settings to reflect their personal comfort preferences. In contrast, space-level zoning is not typical practice for most ducted systems because of its cost.

References

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