Getting the Mechanicals Right

A carefully designed mechanical system rounds out the heating and cooling load of a superinsulated house

BY STEVE BACZEK

Although many superinsulated houses are designed and built to be heated primarily by the energy from sunlight, there is almost always a secondary source of heating. The house shown here, which was covered in a recent series of five articles and videos, is no exception. It receives 50% of its total required heating from the sun—with another 25% from electronics, appliances, and occupants—but the remaining 25% must be handled by mechanicals. This heating requirement—about 6000 Btu—leads to some challenges.

The first is that such a small heating load makes it difficult to find right-size equipment. But even at twice the necessary output, the 12,000-Btu minisplit we ended up choosing is still more reasonable than the smallest furnace, which typically isn't designed to produce anything lower than 50,000 Btu.

The second problem is distribution of the conditioned air. Unlike a typical furnace and attendant ductwork, a ductless minisplit delivers the heating and cooling in bulk, and all in one location. Although the open floor plan of the house is designed to help distribution, there are still bedrooms and bathrooms that require some level of privacy and are therefore more difficult to keep comfortable. In other Passive House designs, I have solved this issue by spreading the work across multiple minisplits located in different areas of the house. In this home, we wanted to deliver the needed loads with a single minisplit, so we relied on the ERV (energy-recovery ventilator) to handle our distribution.

An essential element in this tight house, the ERV operates all day every day, taking stale air from the kitchen and the bathrooms and exchanging it with fresh outdoor air, which is then supplied to the bedrooms. The conditioned air from the minisplit is piggybacking on the circulation already provided by the ERV. This approach is working well, and the house stays at a comfortable 65°F to 70°F.

Wanting to have a backup plan—due to concerns that a single minisplit might have trouble keeping up with the summer dehumidification—we plumbed and powered a second minisplit rough-in should it be necessary to add a second unit.

We also outfitted the three bathrooms with small wall-mounted electric-resistance heaters. Although they were not necessary from a whole-house-heating standpoint, a bit of extra comfort is appreciated in bathrooms, especially on cold New England mornings.

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VIDEO CONNECTION Online members can get an in-depth look at how this house was designed and built at FineHomebuilding.com/passive-house.

Photo this page: David Fell, courtesy of Steve Baczek. Photos facing page: Justin Fink. Drawing: John Hartman.

ERV Functioning as the lungs of the house, a Zehnder ComfoAir 350 brings fresh air through an intake in the lower gable on the left side of the house. Stale air discharges from a vent in the upper gable. The ERV operates continuously, pulling conditioned air from the kitchen and bathrooms, and transferring 75% of its energy to the incoming clean, fresh air that is then supplied to the bedrooms and the study.

Distribution breakdown The 10 corrugated ducts bringing stale air to the ERV must be balanced by the 10 ducts supplying clean air from the ERV. Each duct is designed to carry 12 cfm. Here's how the distribution works in this house.

Stale air

Full baths: 1 double-duct exhaust in each (24 cfm × 3 baths = 72 cfm)

Half-bath: 1 single-duct exhaust (12 cfm)

Kitchen: 3 single-duct exhausts (12 cfm × 3 = 36 cfm)

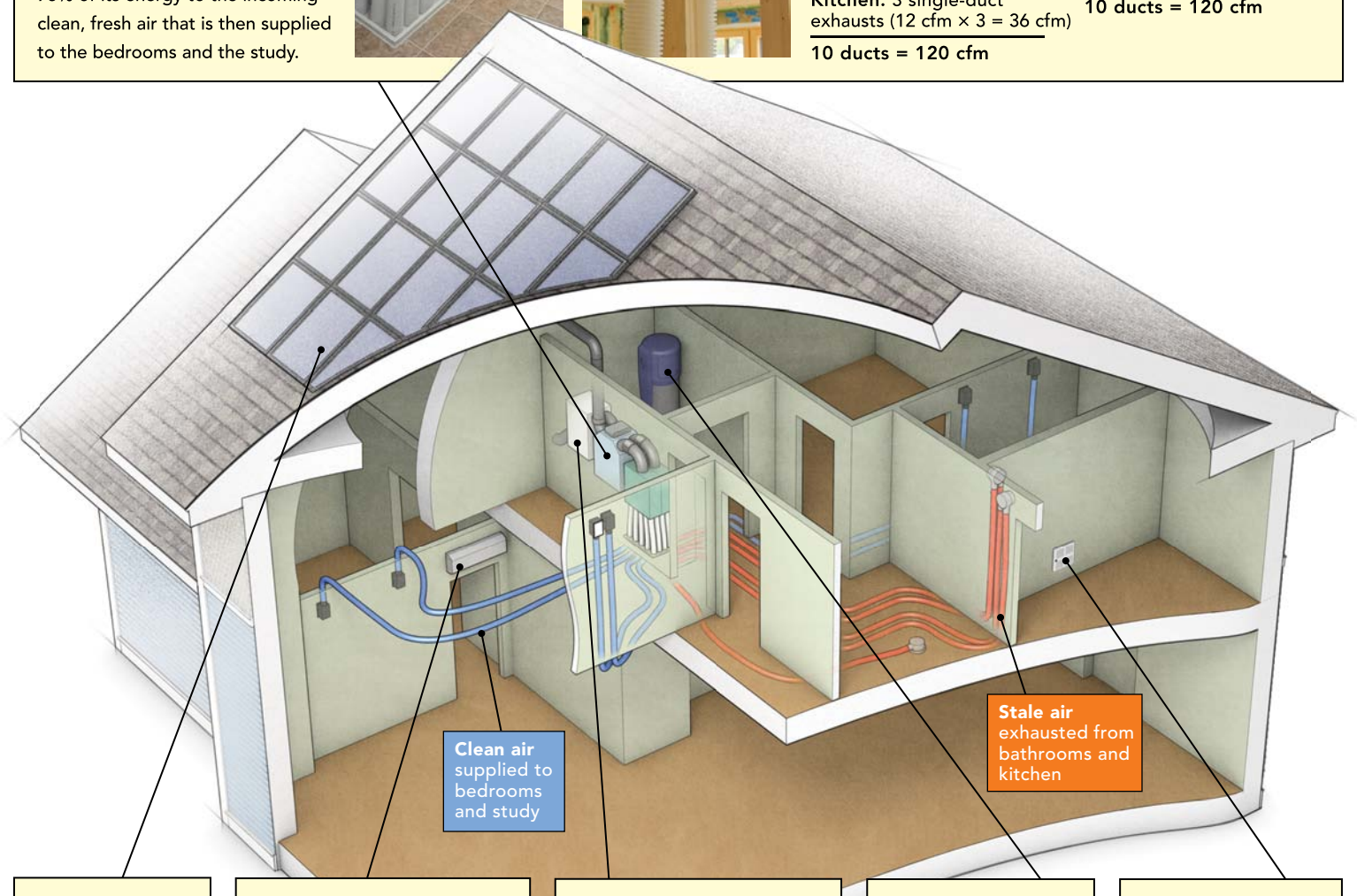
10 ducts = 120 cfm

Clean air

Bedrooms: 2 single-duct supplies in each (24 cfm × 4 bedrooms = 96 cfm)

Study: 2 single-duct supplies (24 cfm)

10 ducts = 120 cfm



Solar panels Although solar panels were not allowed to be part of the Passive House calculations, the homeowner added a 8.75kw photovoltaic array, tipping the scale from Passive House to net-zero standards.

Ductless minisplit A 12,000-Btu Daiken Quaternity minisplit air-source heat pump has slightly more than twice this house's required heating load and also provides summer cooling. Although intentionally oversized to address the humid summers in this coastal location, this system contains technology that allows it to run at a high efficiency even at partial heating loads.

Geothermal heat exchanger A Zehnder ComfoFond L connected to the ERV provides the initial tempering—either precooling or preheating—to the incoming fresh air. The heat exchanger kicks on only when necessary, circulating a mixture of water and glycol through a loop of PEX tubing that runs 7 ft. below grade, where the ground temperature is a constant 50°F to 55°F.

Water heater The 80-gal. A.O. Smith Voltex heat-pump water heater sources its heat from the surrounding air. Although it's equipped with a backup heating element, the homeowners have met their needs using only the heat-pump mode.

Supplemental comfort Each bathroom includes a TPI 3200 series fan-forced heater mounted on the wall opposite the toilet. Each 1500w heater is paired with an Aube TH115 thermostat and takes a few minutes to bring the bathrooms from 66°F to 74°F.