FROM THE FIELD

Passive house, anyone? Part 2

BY DAN FOLEY CONTRIBUTING WRITER

Last month's column covered my introduction to the Passive House concept. In summary, these houses are built super-tight to rigid standards and have very low infiltration and heat loss. The project profiled had a design heat loss of 24,000 Btu/hr. for a 4,600 square ft. structure. This month's column will detail the mechanical system design and how we met the stringent Passive House Institute standards.

The mechanical system design was formulated over multiple meetings with the architect, David Peabody. David brought in consultant Michael LeBeau, a Duluth, Minn., based contractor who has designed and installed several mechanical systems for passive houses. Together, we worked as a team to design the system.

I studied the mechanical systems of several passive houses completed in various parts of the U.S. Some used simple electric duct heaters or electric baseboard with no provisions for cooling other than the HRV/ERV. These houses were situated in cold climates. Some used ductless mini-splits for cooling but relied on only one or two wall mounted cassettes. These systems relied on the tight envelope and ventilation system for air and temperature distribution. Due to the hot, humid summers and fairly cold winters here in the D.C. metro area, I knew that a more elaborate mechanical system would be required for this house.

All duct runs were sealed with mastic and insulated with R-8 foil-faced duct wrap, and were as short as possible.

In order to guarantee comfort at all times of the year, I felt it was necessary to design a ducted system with supply outlets in each room. The exceptions were the kitchen and baths, where the ventilation system would draw conditioned air into these spaces as air was continuously exhausted. The first several submissions were rejected as being too complicated. I revised and redesigned my system to meet the objections without compromising comfort.

I finally came up with a design that met the acceptance of the Passive House Institute. This was a two-zone design

Due to the hot, humid summers and fairly cold winters in the D.C. metro area, a more elaborate mechanical system would be required for the O'Neill Development Passive House in Bethesda, Md.

with a ducted distribution system. All duct runs were sealed with mastic and insulated with R-8 foil-faced duct wrap. All duct runs were as short as possible. The mechanical equipment was chosen for efficiency, reliability and electrical draw. Every blower and pump motor uses efficient ECM variable speed technology. Every electrical component was scheduled and plugged into a spreadsheet required for passive house certification. Electrical draw had to be absolutely minimized.

The heat source is a Lochinvar Knight WHN055 wall-mounted condensing gas boiler (96% AFUE). This boiler has a low pressure drop fire tube heat exchanger and can modulate from 11–55 K Btu input. This was a perfect fit for this system. The low pressure drop also allowed the system to operate with only one Grundfos Alpha pump that only draws approximately 18 watts at design conditions.

DHW is provided through a stainless steel dual coil indirect water heater. The second coil allows for a future solar thermal connection. Insulated stainless steel solar lines were roughed-in up to the attic to facilitate this future connection. Space heating is provided by two hot deck coils installed above each air handler. Supply water temperature is controlled by the boiler's integral outdoor reset control with a maximum temperature of 120 F at 5 F outdoor temperature. During space heat, the boiler will be in condensing mode at all times. Keep in mind that design heat loss is 24,000 Btu/hr. for the entire house.

Since these houses are sealed extremely tightly (.6 AHH @ 50 Pascals), ventilation is key. We have two ERVs (energy recovery ventilators) that run continuously on low speed to exhaust stale air and bring in fresh air. We are exhausting air from the baths, kitchen and laundry room, while bringing in fresh air to the duct distribution

➔ Turn to FOLEY on p 50

| FOLEY |

CONTINUED FROM PAGE 48

The heat source is a Lochinvar Knight WHN055 wall-mounted condensing gas boiler (96% AFUE). This boiler has a low pressure drop fire tube heat exchanger and can modulate from 11–55 K Btu input. The low pressure drop also allowed the system to operate with only one Grundfos Alpha pump that only draws approximately 18 watts at design conditions.

system. We have used dozens of ERVs/HRVs in our past projects — mostly Renewaire and LifeBreath. Neither of these units was rated by Passive House Institute and would incur a rating penalty if used. Instead, we used a model from Zehnder that came with a high rating. The ComfoAir models we used have efficient cores and ECM motors that minimize electrical usage. This was the first time we used these, and we were happy with the quality of the product and support from Zehnder America.

The two ERVs run continuously on low speed at all times to provide adequate ventilation. Controls installed in each bath, as well as in the kitchen, allow the ventilation system to ramp up to any one of five speeds to ventilate quickly, up to a maximum of 200 cfm per system.

We incorporated an experimental passive ground loop to temper the incoming fresh air to the ventilation system. This is simply a 350' loop of 5/8" PEX-a tubing buried in the over dig around the foundation, approximately 8 – 10 feet below grade. A small Alpha ECM pump circulates a propylene glycol solution through this ground loop with an average temperature of 55 – 60 F. This fluid runs through a small heat exchanger that tempers incoming fresh air. It is important to use a heat exchanger with a drain pan and condensate drain as it will condense under certain conditions.

I do not know what total effect this ground loop will have on energy use, but it was relatively inexpensive and worthy of this experiment. We are in the process of data-logging this component to actually measure Btu transfer. We are measuring flow and delta-t across the loop to measure the actual energy transferred by the ground loop. When I visited the site in early June, the ground loop was running at 58 F when the ambient temperature was 93 F.

I left the most controversial issue for last. In studying other passive house mechanical systems, I found that cooling was simply left to the ERVs or a ductless split or two. This project was a four-level American Foursquare with 4,600 sq. ft. in a climate with oppressively hot, humid summers. If I could not design a system that would control humidity, as well as keep the house cool in mid-July, this would be my first and last passive house design. I have since learned that this house is on the market for $1.7 million. Rest assured that whoever buys the house will have expectations of comfort as well as efficient, low-cost operation. If I could not deliver comfort, the latter point is moot.

In order to guarantee comfort at all times of the year, I felt it was necessary to design a ducted system with supply outlets in each room. The exceptions were the kitchen and baths,

The AC system was designed around a two-zone ducted system with one air handler in the basement serving the finished basement and first floor and a second air handler in the unfinished part of the third floor attic serving the second and third floors. A Mitsubishi City-Multi S VRF (variable refrigerant flow) system was chosen for similar reasons as the boiler: low electrical draw and its ability to vary its output through its inverter drive compressor. This system can modulate from 30% — 100% capacity depending on load, or one — three tons. This was a more expensive solution, but I felt that this variable output was a critical design component. It was important not to oversize the system but to allow for capacity during high load conditions.

I visited the site during an early heat wave we had in late May. On a 102 F afternoon, the house was a cool, comfortable 74 F. I dropped the temperature down to 70 F to see how the system would respond under stress. The compressor ramped up, and the temperature started to drop inside. It passed my test.

This system met all the specifications of passive house design without compromising the comfort of the occupants. The system is flexible enough to respond to changing conditions without being oversized or short-cycling, yet has the horsepower to maintain comfort at extreme conditions. After working through this process over the past year, I better understand the concept of the passive house and expect it to expand in coming years. I am already working with Peabody Architects on their next passive house commission.

Learn more about this project at this blog, http://passivehouse.greenhaus.org/ or visit www.greenhaus.org/passive-house/ ●

***Dan Foley** is owner of Foley Mechanical Inc. His company has 14 full time and two part-time employees. His primary focus is on radiant and hydronics with large custom homes. Foley also does service, replacement, HVAC, sheet metal, controls, piping, renewables (geo and solar thermal) and services the Washington, D.C. metro area.*