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COMFORT IN THE CLOUDS

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The primary function of this beautiful new home, at 8,500 feet in the Colorado sky, is to serve as an entertainment getaway for family, friends, and business associates of the owners, Dean and Kathy Buysee. The Buysees are successful turkey farmers from Minnesota, who commissioned this home to be built in Woodland Park, CO, overlooking Pike's Peak, one of the most celebrated of U.S. landmarks.

The Buysees had installed a geothermal system in a farm shop business, and were familiar with geothermal's capabilities and benefits. Fortunately, as they scouted for a Colorado-based contractor, they became acquainted with someone with a grasp of geothermal concepts, and an understanding of how to leverage them for absolute efficiency: Al Wallace, president and principal owner of Energy Environmental Corporation (EEC) of nearby Centennial, CO.

Wallace and EEC had been designing and installing high-performance, integrated HVAC and renewable energy systems for 10 years, for projects of many sizes. From stand-alone ground source heat pumps to fully integrated hydronic and air systems with BACnet controls, EEC has been there, done that. Al Wallace knew what the Buysees wanted, and he knew how to make it a reality.

"We toured EEC on an extremely hot day, and it was the type of cool, air conditioned comfort we wanted, without any air movement," Dean Buysee recalls. Kathy Buysee also appreciates the elimination of dust in the air, for a home that's easy to keep clean.

Comfortable, Efficient, Durable
At an altitude of 8,500 feet in a dry climate, there was concern over maintaining a comfortable level of indoor humidity. In addition, without access to natural gas and rising propane costs, the homeowners wanted high energy efficiency to reduce utility costs. Durability was a concern as this home was intended for occupancy on an irregular basis, and subject to severe weather.

While the Buysees didn't desire Leadership in Energy & Environmental Design (LEED) or Energy Star certification for the home, EEC consulted with the owners and their designer — Jerrod Nelson, Nelson Design Service — to implement elements of both LEED and Energy Star. Of first priority was a tight, well insulated, high mass building envelope incorporating energy recovery ventilation. The home is built using an insulated concrete form (ICF) structure, for superior energy efficiency.


The home features windows with a U-factor of .31, and a solar heat gain coefficient of .29, to reduce the solar heating load.

"Dean Buysee was very conscientious about having a tight building envelope, and it's performing better than off-the-shelf homes," explains Wallace. "The home has 10-in. walls on the first floor, and 8-in. walls on the second, for an oversized thermal mass. We've been able to take advantage of the improved building envelope to lower compressor speed, which provides higher efficiency operation."

The integrated systems design provides heating and cooling through a 120/MBTUH ground source heat pump with reversing valves to provide hot or chilled water to dedicated heating and cooling buffer tanks. Water is distributed through half-inch diameter Uponor AquaPEX-A hydronic distribution piping at six inches on-center, a critical measurement.

"With radiant floor cooling you have to put the tubing six inches on center, which is a higher density than any heating recommendation you'd ever find elsewhere," says Wallace. "By installing the tubing six-inches on center, it allows you to deliver as much heat as you need to any zone. So if you have a small bathroom, with tubing six inches on center, you're able to provide any heat response to the room that's required. Once we designed the system for radiant floor cooling, we didn't worry about the spacing of tubing in heating mode because we knew we had far more capacity than we needed. We only had to determine the flow rates for each zone and sizing our supply and return manifolds to support that.

"Larger piping also makes the system more efficient, because the pump pressures are a lot lower when you're circulating the supply and return," Wallace says.

The mechanical room in the Buysee's Colorado home features flawless work by Master Plumber Kasey Cole.

The home's geothermal heat pump (GHP) has the capacity to heat domestic hot water (DHW) through a heat exchanger. A wine cellar is cooled via radiant floor cooling and a chilled water hydronic fan coil.

Precise Radiant Zone Control
The home's BACnet control system used commercial off-the-shelf control modules from an Uponor Climate Control System. Additional BACnet programming was required to support the radiant floor cooling.

The home was divided into 19 individually-operated radiant zones. Five snowmelt zones, including the garage zones, operate separately, and are freeze protected with propylene glycol.

All bathrooms are zoned separately from adjacent living spaces. Bathrooms are enabled for heating only (no cooling), due to the possibility of condensation when cooling, from the rapid rise in humidity from showers.

The Buysee's desire to have remote access was especially challenging.

"In that regard, you have to look at the systems from the point of view of what will happen should one system fail and another system has to pick up the load," Wallace explains. "You have to consider multiple 'layers' of comfort but also layers of reliability. The biggest challenge for us was designing the system so you had automatic roll over. Because, if the system froze up, there could be severe issues. If the heat pump fails, the boiler has to kick on. If the boiler fails the electric heating element has to kick on. We fused those elements together and staged them to activate in the right order, based on energy efficiency. The geothermal ground loop consisted of 3,600 ft. of piping in solid granite, "which provides the best thermal connectivity you can get," Wallace says. Six wells were drilled, 300 ft. below the surface.

Control Benefits of Radiant Systems
EEC's design eliminates many of the inherent balancing and comfort issues prevalent in air systems, such as hot and cold spots, and zoning control. Wallace truly appreciates radiant's simplistic efficiency.

"It's hard to get an air molecule to go where you want it to go, or to get the right volume of air to go off of a branch duct. A radiant system doesn't require any of that math. It's a pipe that carries water. Hot is left, cold is right. Because of the type of hydronic technology that's available today, we can deliver energy to a zone or room much more easily," Wallace says.

Each zone contains an Uponor Climate Control Network (CCN)-compatible thermostat. The thermostat has an air temperature sensor, an infrared floor temperature sensor, connections for an in-slab temperature sensor and a humidity sensor. These intelligent devices communicate with the CCN control system to determine radiant supply temperatures to the home. In heating mode, the supply temperature uses outdoor reset control to maintain the lowest temperature required to meet heating demand. The GHP maintains the heating buffer tank at this temperature. With PEX-A tubing installed at six inches on-center to accommodate RFC, the system operates at a lower operating temperature than when tubing is installed more typically at 8- or 12-in. on-center. The extra capacity provides some insurance to the contractor when two zones have different entering water temperature requirements.

In cooling mode, the CCN calculates dew point and sets the cold tank temperature below dew point, to provide chilled water to fan coils in-line with the ERVs. At the same time, a three-way thermostatic mixing valve provides the supply temperature to the radiant manifolds at an offset temperature above the dew point (usually 4- to 5-degrees) to prevent condensation in the floors. When outside humidity is below 50% (the normal Colorado climate), the ERVs operate without the chilled water fan coils in operation. However, when outside humidity increases substantially (as will happen during summer thunderstorms), the chilled water is circulated in the fan coils to dehumidify the indoor air below 50% so that the radiant floor system maintains its effectiveness.

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