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ZEBRAIalliance Research Project Shows Promising Results

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Geo Outlook/IGSHPA
1201 S. Innovation Way,
Suite 400
Stillwater, OK 74074

12

COVER STORY



ZEBRAAlliance Research Project Shows Promising Results

By Kaylie Lathe



Two of the ZEBRAAlliance homes in the Crossroads at Wolf Creek subdivision in Oak Ridge, Tenn., were equipped with the foundation heat exchanger technology. (Photo courtesy Piljae Im-ORNL)



Energy efficient ground-source heat pumps and energy efficiency are on the way to becoming affordable and increasingly more desirable options for residential use, thanks to new facts gained from a collaborative research project called ZEBRAAlliance. Research has recently been completed on four Tennessee homes built with the goal of decreasing the cost of residential ground-source heat pump installation.

The project's goal is to show consumers how affordable and appealing energy-efficient homes can be. Schaad Companies, co-founder of the alliance, built four homes, each equipped with different energy-saving

strategies, in an Oak Ridge, Tenn., subdivision.

ZEBRAAlliance, a public/private partnership, was formed by the Department of Energy's Oak Ridge National Laboratory and Schaad Companies in 2008. ORNL provided product management, technical expertise, industry partners and the research on the homes.

The project looked at the efficiency of two technologies: a foundation heat exchanger and a ground-source integrated heat pump. Other experiments were conducted in the homes, including the evaluation of four building envelope strategies:

John Shonder of ORNL, Jeff Spittler of OSU, Simon Rees of De Montfort University and Dan Fisher of OSU, worked together on the ZEBRAAlliance project's research and model development for the FHX.

(Photo courtesy Piljae Im-ORNL)

structurally insulated panels, optimal value framing, double wall system and exterior insulation and finish system.

The primary sponsor of ZEBRAAlliance was the Department of Energy Building Technologies office, but Tennessee Valley Authority also provided funding for the ZEBRAAlliance project, as well as participating in the design process. David Dinse, who works in Technology Innovation at TVA and is on IGSHA's advisory council, participated as a design team member. Being on the design team included work on both mechanical system design and the building envelope, Dinse said.

"The project demonstrated the thermal performance of four different building envelope designs for enhanced thermal performance," Dinse said.

"TVA has worked with ORNL for many years," Dinse said. "This is a part of a continuing effort by TVA over many years promoting the wise



The FHX, buried along the foundation of house 1 (SIP house), used a 3/4-inch pipe with six pipes per trench.

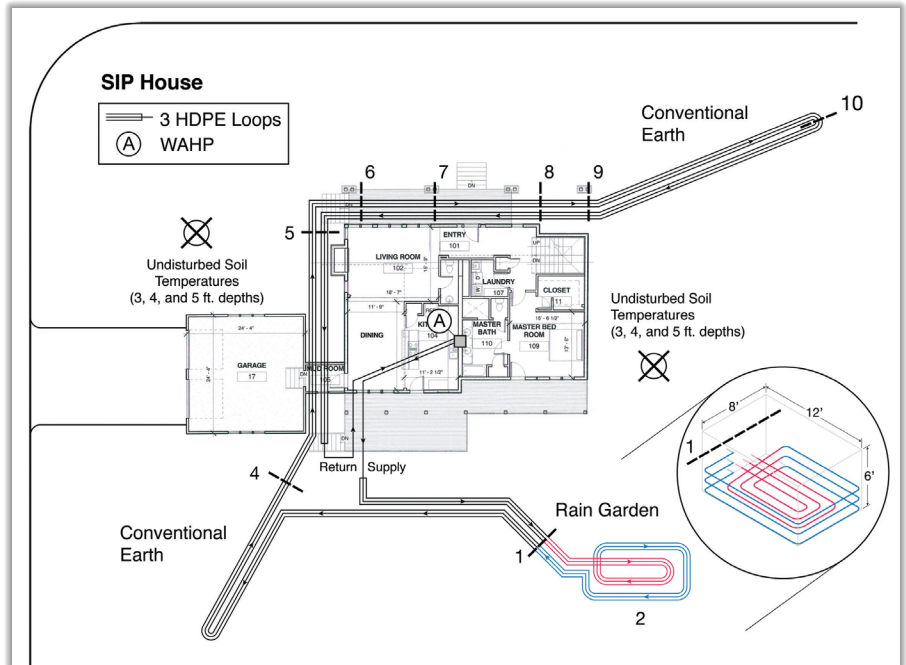
(Photo courtesy Piljae Im-ORNL)

The layout of house 1 (SIP house) shows where the FHX was placed. (Photo courtesy Piljae Im-ORNL)

and efficient use of electricity. The foundation heat exchanger concept used in ZEBRAAlliance houses one and two was first tried on one of the Habitat for Humanity homes in Lenoir, Tennessee.”

ZEBRAAlliance homes one, two and three started out with standard ground-source heat pumps, while home four had a standard air-source heat pump. Systems in homes one and two were later replaced with the GS-IHP prototype.

The homes were vacant during the research phase, but occupancy was simulated for research purposes. After a 30-month research period, the homes were equipped with standard market heat pumps (excluding the fourth home, which kept its standard air-source heat pump) and put on the market for



interested buyers.

For the FHX development, ORNL put together a team led by Jeffrey Spitler, a Mechanical Engineering professor at Oklahoma State University. His team was made up of three students and Simon Rees of De Montfort

(below) The mechanical room in the basement of house 1 (SIP house), shows the GSHP system for space conditioning, water-to-water heat pump system for water heating which is also connected to the FHX, and the hot water tank connected to water-to-water heat pump.

(Photo courtesy Piljae Im-ORNL)





Jerald Atchley and William Miller of the ORNL Building Envelope Group discuss the sensors along the basement wall where one of the FHX systems will be installed.
(Photo courtesy Piljae Im-ORNL)

“Schaad Companies was interested in using that slow time to learn a new product for their home building business,” Hughes said. “We had some technologies and industry partners that were ready to put some new things in and essentially field test them in homes.”

Jennifer Banner, CEO of Schaad Companies, was eager to learn more energy-efficient technologies.

“Having learned about ORNL’s research in residential building technologies and Tennessee Valley Authority’s interest in energy efficiency, Schaad initiated a collaboration that resulted in a win-win-win for all involved,” Banner said.

Schaad brought in Barber McCurry Architects to design four test homes to be built in the Crossroads at Wolf Creek Subdivision in Oak Ridge, Tenn. Schaad leased the homes to ORNL for \$1 a day for 30 months. Banner says ZEBRAAlliance was Schaad’s first endeavor to improve energy efficiency in its residential product offerings.

Each of the four homes had different combinations of energy efficient strategies to be tested. House one used an FHX system, as opposed to the traditional method of drilling boreholes for piping, and was built using the SIP envelope. House two also used an FHX system, but was built with the optimal value wood framing as the building envelope. Houses one and two both had walkout basements. House three used the conventional vertical loop ground-

University in the UK. Spitler and his team developed the models for the loops and the construction excavations.

“We developed the models as Oak Ridge collected data and we compared as we went,” Spitler said. “In the end, we developed models that were validated against Oak Ridge’s experimental data.”

Spitler worked to get the models into Energy Plus, a building energy simulation program used to model energy and water use in buildings.

“The results are promising for the

parts of the country with a moderate climate,” Spitler said. “It could be implemented in quite a few places, but if you were going to test the boundaries farther north, more research homes would be needed. One of the last things we did was a map of the U.S. showing where our technology would work well and maybe where it would be a little more difficult.”

The ZEBRAAlliance project came about at an opportune time when the residential housing market had slowed, Patrick Hughes of ORNL said.

source installation and a double wall system building envelope. House four was equipped with a top-of-the-line standard air-source heat pump and was built with an EIFS envelope. Houses three and four were two-level buildings over crawlspaces.

The FHX was developed to go along the foundation of the house and in utility trenches, reducing the need for traditional trenching or drilling and cutting the cost of installation. Research shows that this installation may reduce the installation cost in this region to \$1,000 per ton. The average cost in this region for traditional vertical-loop and six-pipe-per-trench horizontal-loop systems is \$3,000 per ton and \$2,250 per ton, according to the ORNL Final Report.

ORNL worked with ClimateMaster to develop a ground-source integrated heat pump to eliminate the need for multiple heat pumps. The GS-IHP is used for space conditioning (heating and cooling) and water heating. Houses one and two were initially equipped with ClimateMaster standard geothermal heat pumps and after a year of baseline research on the original units, they were replaced with the GS-IHP.

ClimateMaster donated all the heat pumps used in the project, ClimateMaster product engineer, Shawn Hern said.

“ORNL took our current, high-end standard heat pump to get a baseline while we were still working on the

integrated heat pump,” Hern said. “After we had the GS-IHP installed and running, ORNL provided us with numerous feedback on performance and other issues that could be improved upon.”

Smith and Associates Geothermal was responsible for the installation of the ground-source systems. Houses one and two were both 3,700 square-foot and they started out with a 2-ton

water-to-air heat pump for heating and cooling and a 1.5-ton water-to-water heat pump for water heating. The heat pumps were later replaced with the newly designed GS-IHPs.

House one and two both used the horizontal loop installation method with three-fourths-inch pipe, house one using 1,800-foot of pipe and house two using 2,610-foot of pipe. The loop fluid was 20 percent propylene glycol



About 100 feet of the six-pipe heat exchange loop was placed along the basement and the remaining loop was placed in utility or additional trenches. (Photo courtesy Piljae Im-ORNL)



House 2 in the project was built using the OVF building envelope and the FHX system.

(Photo courtesy Piljae Im-ORNL)

was developed for the project. The Trilogy 40 Q-Model won the heating category of the 2013 AHR Expo Innovation Awards and gold for the second year in a row at the 2012 Dealer Design Awards. Trilogy 40 Q-Mode was also recently recognized with a 2013 R&D 100 Award.

“The product itself was first announced about the middle of 2012, but it wasn’t available until the end of 2012 in limited supply,” Hern said. “So far they have been well received.”

Editor’s Note: Oak Ridge National Laboratory is a multiprogram science and technology laboratory managed for the U.S. Department of Energy by UT-Battelle, LLC. The research from the ZEBRAAlliance project is available on their website under the heading “Whole-Building Integration Research” near the bottom of the publication list found at <http://web.ornl.gov/sci/ees/etsd/btrc/publications.shtml>.

9

solution. About 100 feet of the loop was placed along the basement walls and the remaining loop was placed in additional trenches. Around 60 percent of the excavations used were already required for construction, according to ORNL’s final report.

House three used the vertical loop installation method with 320-foot deep vertical boreholes. It was equipped with a 2-ton water-to-air heat pump and a 1.5-ton water-to-water heat pump. House four had a 2-ton high-efficiency air-source heat pump.

The research done on building energy-efficient homes has shown

immediate results. Schaad has already begun using the energy-efficient building techniques tested during the ZEBRAAlliance project in their residential homes.

“The project transformed our entire residential business line,” Banner said. “All of our residential product offerings now meet or exceed Level III Energy Star standards and achieve HERS ratings in the low 50’s.” Energy Star and HERS are industry standard rating systems that measure a home’s energy efficiency.

ClimateMaster has introduced the Trilogy Series from the GS-IHP that