

ORNL's new GE Appliances project aims to revolutionize home refrigeration

Not much has changed in refrigeration technology in the past 100 years, until now. Researchers with Oak Ridge National Laboratory's (ORNL's) Building Technologies Program have teamed with General Electric (GE) Appliances through a cooperative research and development agreement (CRADA) to revolutionize home refrigeration using magnetocaloric cooling.

GE's research team is working to apply the concept of the magnetocaloric effect (MCE) to household refrigeration, replacing conventional vapor compression technology while still reaching the desired cooling temperatures. Instead of traditional refrigerants, the system uses a water-based, non-global-warming secondary working fluid, which is more environmentally friendly and lower cost.

"It's the equivalent to a gas-powered car moving to electric—that's the kind of leap we're making in refrigeration," said Ed Vineyard, Building Equipment Research Group leader with the Building Technologies Research and Integration Center (BTRIC) at ORNL.

A drastic upgrade in design using MCE means changes to the mechanisms through which the refrigerant flows. ORNL researchers Ayyoub Momen, Omar Abdelaziz, and Vineyard are working to determine the new requirements for refrigeration circuit seals and hydraulics, creating a feasible design with emerging magnetocaloric materials.



ORNL's Ed Vineyard (right) participates in a Google Hangout event with GE engineers Michael Benedict (left) and Venkat Venkatakrishnan (center).

ORNL's Ayyoub Momen leads the MCE project tasked with building a "breadboard" prototype magnetocaloric refrigerator-freezer to evaluate magnetocaloric material, hydraulic system, heat transfer rate, and machine components.



The ORNL team is also tasked with building a "breadboard" prototype refrigerator-freezer to evaluate material compatibility and to analyze components including the magnet, generators, motor, pump, heat exchangers, plumbing, and leak-less rotating valve.

ORNL's early results in employing MCE for both residential and commercial refrigeration show the technology as a promising alternative to the vapor compression systems used in today's appliances, one that could theoretically reduce energy consumption by 25%. The researchers will continue to develop this new design that will cost a little more but will have a favorable payback for the consumer because of the reduced energy costs.

In March, Vineyard participated in a Google Hangout event hosted by GE at Appliance Park in Louisville, Kentucky, to educate the public about GE's intent to commercialize magnetocaloric refrigerators for use in homes by 2020. A video of the Hangout event can be viewed at www.youtube.com/watch?v=uDF_COU1OJI.

According to GE, the MCE technology can be applied to other heat pump applications, such as heating, ventilation, and air conditioning (HVAC), and has the potential to impact nearly 60% of the average US household's energy consumption.*

ORNL's BTRIC staff has partnered with GE on many projects for the past seven years, such as the Geospring Heat Pump Water Heater, High EER (Energy Efficiency Ratio) Window Air Conditioner, and three other high-efficiency appliances. The magnetocaloric refrigerator-freezer project is sponsored by the US Department of Energy's (DOE's) Building Technologies Office.

*Source: US Energy Information Administration's annual energy outlook for the residential sector.

FEATURES**Urban design leader selected as UT-ORNL Governor's Chair**

Philip Enquist, UT-ORNL Governor's Chair in High Performance Energy Practices in Urban Environments.

Philip Enquist, leader for Urban Design & Planning with Chicago-based architecture powerhouse Skidmore, Owings & Merrill (SOM), was named 16th University of Tennessee (UT)-Oak Ridge National Laboratory Governor's Chair. Enquist will collaborate with ORNL's Building Technologies Research and Integration Center. The center aims to push new energy-efficient building products to the market.

Enquist and a select research team will serve as Governor's Chair for High Performance Energy Practices in Urban Environments and will be affiliated with and administer projects through the UT College of Architecture and Design.

"The creation of this position is further evidence of the commitment ORNL and UT have to lending their nationally recognized expertise to advance sustainability on a local and global scale," said Martin Keller, ORNL's associate lab director for energy and environmental sciences.

As the world's most highly awarded urban planning group, SOM will focus on research in energy performance and environmentally responsible design for buildings and communities. The Governor's Chair team will be a research partnership among many designers at the firm who specialize in sustainable urbanism and high-performance buildings.

SOM and its team of designers will promote innovative energy practices for new and existing buildings in urban areas, encourage interdisciplinary collaboration, create the foundation for new UT graduate programs and develop new models for the contemporary construction industry.

Enquist is an authority on holistic city building. His global experience includes the Beijing Central Business District Master Plan and Beijing Bohai Innovation City—a 1.5-million-acre site representing a new model of compact, environmentally enhanced urban design for the rapid development of satellite cities along Chinese high-speed rail corridors. Read more about Enquist's new role at www.utk.edu/govchairs.

New research house provides flexible field analysis

ORNL's new unoccupied research house, a two-story residential home located in the Yarnell Station subdivision in Knoxville, Tennessee, is the latest addition to the Building Technologies Program's ability to characterize the performance of prototype appliances and equipment in a real-world environment.

The Yarnell Station research house gives researchers flexibility in validating the capabilities of new and emerging energy-efficiency technologies.

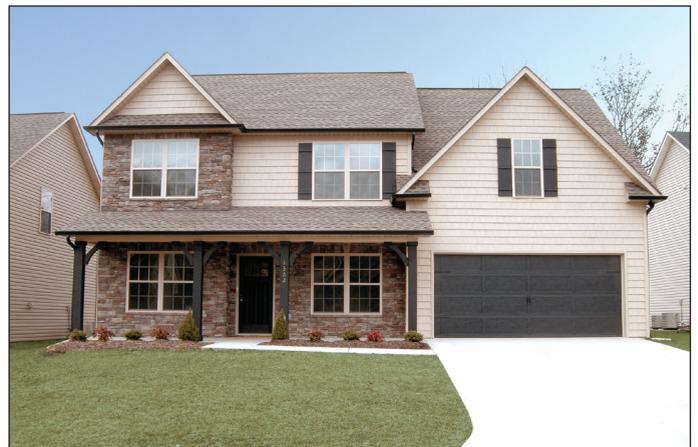
Earlier this year, the house was put into service for the first time when a team from BTRIC transitioned a NORDYNE prototype variable-speed air-source integrated heat pump from laboratory experimental facilities to Yarnell Station. (ORNL works with NORDYNE through a CRADA.) At the unoccupied house, researchers have implemented a data acquisition system that collects data at regular intervals while the heat pump operates in a residential setting.

"At Yarnell Station, ORNL's building technologies research teams can work with industry partners to meet their customized product analysis needs," said Melissa Lapsa, BTRIC's deputy director.

ORNL also partners with the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI) on

TVA's Campbell Creek research project, which established a unique facility that evaluates the effectiveness of residential construction and efficiency technologies in a controlled environment. The three Campbell Creek homes include a "builder house" typical of how the entire subdivision was built, which serves as a monitored comparative baseline for

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ORNL's new unoccupied research house welcomes diverse R&D opportunities.

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the multiple-instrumented evaluations of energy efficiency and solar technology upgrades at the other two houses.

In 2008, ORNL and Schaad Companies founded the ZEBRAAlliance, a public-private partnership that comprised four research houses serving as both a research project and a multi-faceted energy-efficiency education campaign. These extremely energy-efficient houses (with Home Energy Rating System Indexes in the mid-40s) served as the validation platform for a variety of innovative technologies developed by ORNL and industry partners, including the ClimateMaster Trilogy 45 Q-Mode ground-source integrated heat pump, which won an R&D 100 Award in 2013 and a Federal Lab Consortium (FLC) Technology Transfer Award in 2014. The ZEBRAAlliance project was completed in 2013, and Schaad has since released the homes for sale.

The common denominator among all of these research houses—Yarnell Station, Campbell Creek, and ZEBRAI-

liance—is that they were held unoccupied during the research period so that controlled experiments could be conducted. In addition to natural exposure to weather, an average occupant effect on energy use is imposed during experiments so that the technologies being characterized experience realistic loads, operating conditions, and interactive effects. Human occupancy is simulated by using process control to cause actions such as hot water draws and lights turning on and off.

Upcoming research projects at Yarnell Station will characterize the performance of energy-efficient appliances, HVAC systems, and energy-saving strategies based on advanced sensors and controls—projects that will emerge from ongoing CRADA collaborations between ORNL and multiple industry partners in the near future.

BTRIC science seminars feature cutting-edge research

In FY 2014, BTRIC kicked off its Science Research Seminar Series, featuring state-of-the-art building technologies research, to promote BTRIC's extensive range of capabilities and encourage lab-wide collaboration opportunities.

Ayyoub Momen launched the monthly series in November 2013 with a presentation titled, "Advancements in Building Equipment Technologies: Flexible Energy Storage and Advanced Cooling Systems," which focused on magnetocaloric refrigeration technology that offers an efficient and environmentally friendly substitute for conventional vapor compression technologies.

Kyle Gluesenkamp followed in December 2013 with an overview of "Sorption Heat Pumps for a Sustainable Economy," focusing on cutting-edge research that is enabling thermally activated absorption and adsorption technologies to become more accessible and cost-effective. These technologies have the potential to double the energy use efficiency of natural gas in multiple end-use applications, including domestic water heating.

In January, Teja Kuruganti's seminar on "Buildings to Grid Integration: Retrofit Control Techniques for Peak Reduction and Energy Efficiency Improvements" highlighted opportunities to reduce building energy use and cost for consumers, while improving utility company asset use by reducing the need for expensive peaking plants and supporting infrastructure. Low-cost wireless sensors that enable affordable gathering of information to drive transactive controls is the key.

In February's seminar, Omar Abdelaziz spoke on how ORNL researchers are "Accelerating the Transformation of Building Energy Efficiency," specifically in advanced water heating technologies, cold climate heat pump technologies, and

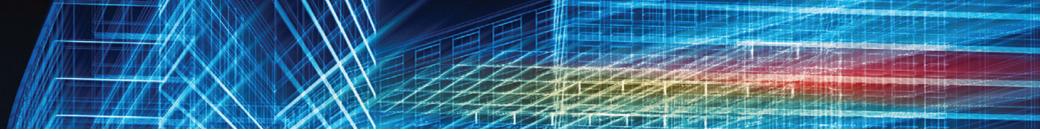


ORNL's Joshua New presented the benefits of software capabilities to building energy efficiency, specifically use of the popular Roof Savings Calculator (RoofCalc.com) online tool.

high-performance phase change material development—all of which achieve energy savings and emissions reductions.

Patrick Geoghegan spoke in March on "Altering the Course of Heat Transfer Through Additive Manufacturing (AM)," providing an overview of techniques for embedding heat transfer enhancements such as heat pipes directly into AM parts, as well as examples of how AM is helping researchers to better understand fundamental heat transfer.

In May, Joshua New shared insights during his seminar titled, "Software vs. Reality: Bridging the Gap." This seminar focused on (1) a new methodology that has been developed to automatically calibrate building energy models to energy consumption data, on (2) using calibrated energy software models to optimize building retrofits, and (3) scale retrofits in the market through the ability of automation to reduce retrofit project development costs.



Patrick Hughes, ORNL's Building Technologies Program manager and BTRIC director.

Note from Patrick Hughes

On behalf of the management team, researchers, and staff with ORNL's Building Technologies Program, I'm proud to introduce our first program newsletter, a publication that aims to cover our successes, impacts, and technical achievements as we break new ground in energy efficiency.

It's a pleasure to report that all of the building energy efficiency laboratory facilities that were built or revitalized as part of the \$20.2 million MAXLAB project (competitively awarded under the American Recovery and Reinvestment Act) are either online or being commissioned or acceptance tested. The success of these upgrades is manifested, for example, through the pipeline of energy-saving product launches by our industry CRADA partners. These state-of-the-art experimental facilities position us and our partners as leaders as we continue to advance the future of building technologies R&D.

I believe we're also experiencing a revitalization of leadership and research staff within BTRIC and among our world-class research teams that extend beyond BTRIC, as we leverage the best and brightest talents from across ORNL to advance building energy efficiency—applied R&D.

Translating ORNL science into new and better building energy efficiency applications will be extremely important as we move forward. Depending on specific industry partner needs, leveraging ORNL's advanced man-

ufacturing expertise could also add value, reduce manufacturing costs, and accelerate real energy-saving impacts in buildings.

Our cross-cutting research teams will help us tackle the challenge of making buildings—where 41% of primary energy in the US is consumed—more sustainable. Buildings use more energy than either the transportation or industrial sectors and provide the greatest opportunity for reducing waste. Buildings represent 74% of the nation's electricity consumption and directly consume 34% of natural gas (56% when counting natural gas used to generate electricity consumed in buildings).

ORNL's Buildings Program will continue to emphasize bringing cost-effective technologies and practices to market by applying its multi-disciplinary science and technology expertise and state-of-the-art facilities to CRADA and other collaborations with industry. In these collaborations, the industry partner is self-funded, DOE resources are leveraged 2 for 1 or more, and advances occur more quickly by virtue of industry engagement. This approach has generated nine R&D 100 Awards and a long list of successful products in the market saving energy in real buildings. We look forward to continuing and developing new collaborations with industry at our DOE-designated National User Facility.

ClimateMaster heat pump earns prestigious award

The ClimateMaster Trilogy™ 40 Q-Mode™, developed by ClimateMaster and ORNL through a CRADA sponsored by the DOE Building Technologies Office, won a 2013 R&D 100 Award and is also a winner of numerous other industry awards for its groundbreaking efficiency and technology. In addition to the R&D 100 Award, regarded as the "Oscar" of innovation, the ClimateMaster heat pump garnered every award available including the AHR Expo Innovation Award in 2013, the ACHR NEWS Dealer Design Gold Awards in 2012 and 2013, and a Federal Laboratory Consortium Technology Transfer Award in 2014. ORNL researchers Ed Vineyard, Moonis Ally, Jeffrey Munk, Bo Shen, Keith Rice, Van Baxter, and Anthony Gehl worked on the ClimateMaster project.

The Trilogy 40 Q-Mode is a water-to-air integrated heat pump that provides not only space conditioning but also all the water heating needs of a typical residence. Energy savings is 60–65% compared to a SEER (seasonal energy efficiency ratio) 13 air-source heat pump and electric storage water heater, and 30–35% compared to a state-of-the-art, two-stage geothermal heat pump with desuperheater for partial domestic hot water.



ORNL researchers stand with the award-winning ClimateMaster Trilogy 40 Q-Mode Geothermal Heat Pump.



Accepting the AHR Expo Innovation Award for the Trilogy 40 Q-Mode are, from left, ORNL's Ed Vineyard and Patrick Hughes, ClimateMaster President Dan Ellis, and Shawn Hern, ClimateMaster lead Trilogy product development engineer.

BRIEFS



Johney Green, ORNL's Energy and Transportation Science Division director.

Johney Green speaks at buildings conference

Attendees from across multiple disciplines in building science convened at the Buildings XII International Envelopes Conference in Clearwater, Florida, in December. Johney Green, Energy and Transportation Science Division director, participated as an opening plenary session speaker, in addition to Richard Karney of DOE; Tom Phoenix of the American Society of Heating, Refrigerating, and Air-Conditioning

Engineers; Henry Green of the National Institute of Building Science; and Chris Mathis of Mathis Consulting. In addition to organizing and hosting the event, members from BTRIC's Building Envelope Research Group presented many peer-reviewed technical papers. Primary authors and presenters included Kaushik Biswas, Andre Desjarlais, Diana Hun, Manfred Kehrer, William Miller, Simon Pallin, and Som Shrestha.

ORNL shines in BTO Top Inventions blog post

In April, DOE posted the "Top 4 Energy Department Inventions Saving You Energy & Money at Home" on its highly visited Energy Saver blog (energy.gov/articles/top-4-energy-department-inventions-saving-you-energy-money-home), and ORNL shined by contributing to three of the four inventions listed. Congratulations to all BTRIC research staff who played a role over the past few decades in bringing these technologies to fruition—technologies that are now considered mainstream. Thank you to Van Baxter and Andre Desjarlais for researching the historical information needed to prepare these success stories.



ENABLE program's functionality expands

The functionality of the ENABLE Investment Grade Audit (IGA) tool has grown beyond lighting, water, and HVAC controls to include HVAC equipment retrofits and solar photovoltaic system installations. ORNL's Mark Adams

has simplified operation of the tool by building an Excel interface, linked to OpenStudio and EnergyPlus building energy modeling software in the background. The IGA tool is supported by DOE's Federal Energy Management

Program (FEMP), but it leverages EnergyPlus and OpenStudio, which are supported by the Building Technologies Office. This tool is an excellent example of ORNL helping DOE achieve greater value through inter-office collaboration.

MAXLAB environmental chambers near completion



The HVAC chamber chiller was lifted onto the MAXLAB roof.

The components for the new, multi-zone HVAC environmental chambers were delivered in December. Installation was completed at ORNL's Maximum Building Energy Efficiency Research Laboratory (MAXLAB), and commissioning and acceptance testing are under

way. This facility characterizes the performance of multi-zone electric or gas HVAC systems (up to 10 tons) for residential and small commercial use. Variable refrigerant flow and other styles of multi-zone systems with up to four separate indoor zones can be characterized.

Air sealing progresses under CERC-BEE project

With partners Dow Chemical and 3M, BTRIC staff continue making progress in the evaluation of air-sealing products developed under the US-China Clean Energy Research Center for Building Energy Efficiency (CERC-BEE) project in the MAXLAB's air and moisture penetration chamber. Recently, Simon Pallin (left photo) completed the LabView code to subject prototype

walls to pressure cycles that induce accelerated aging from wind loads. Dow's Katherine Faber (right photo) installed Dow's Liquid Flashing onto a prototype wall designed to represent commercial construction with steel framing and Thermax exterior sheathing to undergo performance characterization in ORNL's chamber.



Experts weigh in on guidelines for building energy audits

The subject matter experts (SMEs) who initially provided input in May 2013 on guidelines for building energy audits recently reconvened to provide a final review of guidelines that provide compiled information on the technical background, resources, and best practices relevant to multifamily building energy audits. ORNL's Joel Eisenberg and Mark Ternes, along with Michael McDonald from SRA, participated in the February SME review meeting. SME input is being incorporated into the guidance by ORNL's Mini Malhotra and Ternes, and McDonald.

BTRIC hosts Science Saturday

About 60 West High School students participated in a Science Saturday event that was hosted by ORNL's BTRIC. Researchers including Mahabir Bhandari, Kaushik Biswas, Heather Buckberry, Edwin Figueroa, Diana Hun, Roderick Jackson, and Som Shrestha provided demonstrations illustrating the effect of various building envelope materials on energy consumption. Students used computer simulation models to see how changes in building envelope material properties can affect energy use.



ORNL researchers in building technologies participated in STEM outreach.

SCI team receives GreenGov award

The Sustainable Campus Initiative (SCI) team was presented the prestigious GreenGov Presidential Award at the White House for their work with Indian River State College to create a sustainable campus and for playing a key role in developing an electric vehicle-charging corridor across Tennessee. From left, Nancy Sutley, chair of White House Council on Environmental Quality; Melissa Lapsa, ORNL's BTRIC deputy director, Teresa Nichols, ORNL technical project specialist; Johnny Moore, DOE Office of Science, ORNL site manager; Jennifer MacDonald, DOE Sustainability Performance Office director; and Dr. Michael Knotek, deputy undersecretary for Science and Energy.



EMPLOYEE EXCELLENCE



Hughes



Fricke

- **Patrick Hughes**, Building Technologies Program manager and BTRIC director, was recognized by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) with the Distinguished Service Award (DSA), as well as the Exceptional Service Award (ESA).

- **Brian Fricke**, Building Equipment Research group, was also recognized by ASHRAE with the DSA. The DSA recognizes those who have served the Society faithfully and with distinction to accomplish its research, standards writing, publishing, and continuing education. The ESA recognizes those who have served the Society with exemplary effort, far in excess of that required for the DSA. Both Patrick and Brian will be recognized at the ASHRAE conference in June.



Shonder



Williams

- **John Shonder**, Residential and Commercial Energy Efficiency group, began a 4-year term on ASHRAE's Research Advisory Committee, which works with ASHRAE's technical committees to coordinate basic research and technical studies in heating, ventilating, air conditioning, refrigeration, and related fields. John is the head of ASHRAE's Section 10 and liaison to seven technical committees concerned with refrigeration.

- **Teresa Williams** recently received recertification as a Certified Administrative Professional through the International Association of Administrative Professionals.

VISITS AND EVENTS

- In April, BTRIC was included in a protocol visit by Dr. Franklin Orr, distinguished Stanford University professor nominated to serve as the Undersecretary for Science at DOE. ORNL's Martin Keller and Patrick Hughes participated in this tour stop.
- BTRIC staff welcomed the following visitors from the DOE Building Technologies Office (BTO) and Federal Energy Management Program (FEMP):
 - Bahman Habibzadeh, technology manager in the Emerging Technology Program
 - John Cymbalsky and Ashley Armstrong of BTO Standards
 - Andre Sayles and Chris Ford of the DOE Office of Economic Impact and Diversity
 - Eric Werling, BTO-Residential R&D, and Karma Sawyer, BTO-Envelope and Windows R&D
 - Timothy Unruh, director of FEMP, and Kurmit Rockwell of FEMP energy savings performance contracts
- Patrick Hughes hosted Shyam Sunder, senior advisor for laboratory programs at Commerce/National Institute of Standards and Technology. As part of his role on

the Energy and Environmental Sciences Directorate Scientific Advisory Committee, Sunder learned about the buildings R&D at ORNL during his visit.

- Mark Ternes hosted 11 beta testers of the Multifamily Tool for Energy Audits (MulTEA), the new multifamily energy audit being developed by ORNL for the DOE Weatherization and Intergovernmental Program. The testers, who traveled from all over the nation, provided overall positive feedback and discussion of this new energy auditing tool.
- Patrick Hughes hosted Ron Domitrovic, EPRI's program manager for energy efficiency, providing tours of BTRIC labs and discussing collaborative opportunities in variable refrigerant flow.
- Diana Hun and Andre Desjarlais hosted visitors from 3M, primarily to discuss the CERC-BEE project on building envelope air sealing. 3M a new industry partner on this project.
- Helene Pierce and Bill Woodring of GAF Materials Corporation visited Andre Desjarlais to discuss the findings of their joint project on the hygrothermal performance of wood deck roofing systems on the West coast.

- John Scott and Rockford Boyer of ROXUL visited ORNL to discuss collaborative projects opportunities on commercial roofing with Andre Desjarlais.
- Representatives from Emerson/Copeland met with David Fugate and Bo Shen to discuss projects related to refrigeration DR and next-generation rooftop units.
- BTRIC was included in a protocol visit by TVA board members Marilyn Brown, Barbara Haskew, and Joe Ritch. ORNL's Melissa Lapsa, Ed Vineyard, and Roderick Jackson participated in this tour stop.
- Heather Buckberry, Mahabir Bhandari, and Piljae Im hosted members from the Metal Building Manufacturers Association.
- Jie Chen and Justin Hampton, project engineers from NORDYNE's variable-speed air source integrated heat pump project team, visited ORNL to commission and start up the 1-year system field test at the Yarnell Station research house.

Do you have news or information you would like to share?

Please submit ideas or suggestions to
ORNL Building Technologies Research and Integration Center at
buildings@ornl.gov or (865) 574-7267.

The Building Technologies Update newsletter aims to cover news and technical highlights associated with building technologies and building technologies-related research activities and projects. This publication is produced and distributed by the Oak Ridge National Laboratory's Energy and Transportation Science Division.

www.ornl.gov/buildings