

## ORNL to host first EERE-sponsored Industry Day event

On Sept. 23–24, ORNL will host an inaugural Industry Day event, sponsored by the US Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE), to foster relationships and encourage dialog among researchers, industry representatives, and DOE representatives. This 2-day event is designed to introduce new energy-efficient innovations in buildings, transportation, and advanced manufacturing and to facilitate public–private partnerships and collaborations that will enable these technologies to enter the market.

“We have a proven track record of developing successful R&D relationships with large industry partners. This event is meant to introduce mid-size and smaller businesses to a national lab; give them an opportunity to network with researchers, our current large industry partners, and DOE; and discuss ways they can utilize our expertise and capabilities to help them produce more energy-efficient products and resolve issues of pushing these products into the market,” said Patrick Hughes, director of ORNL’s Building Technologies Program (BTO).

The goal of Industry Day is to introduce small businesses throughout the southeast and nationally to EERE capabilities and to promote ways that small businesses can increase their interactions with ORNL and other DOE laboratories.

Other featured activities include opportunities to

- participate in facilitated networking sessions with industry stakeholders, technical experts, and financial advisors to explore opportunities for advancing innovations;



- discuss the challenges preventing disruptive technologies from mass adoption and hear how leading manufacturers are moving advanced technologies to market;
- see demonstrations including a 3D printed building envelope and vehicle;
- tour some of ORNL’s world-class facilities; and

- learn about a new model for rapid innovation that directly engages customers by gathering feedback through crowdsourcing and prototyping designs using 3D printing.

Last spring, the Building Technologies Research and Integration Center (BTRIC) launched the ORNL Buildings Crowdsourcing Community—the lab’s first external crowdsourcing website. The BTO-sponsored website provided a forum for technology innovators to gather feedback from customers and other stakeholders about next-generation building technologies. Approximately 360 users posted 71 new technology design ideas in three different categories: equipment and appliances, sensors and controls, and envelope technologies. Participants voted on the various ideas and

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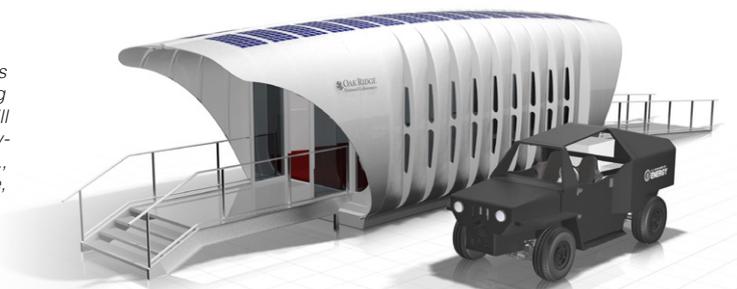
## Delivering innovation: ORNL to unveil AMIE demo project

ORNL is tackling some of the world’s challenges in accessing reliable, resilient, and affordable electricity. Working with industry partners, the Additive Manufacturing Integrated Energy (AMIE) team is leveraging the combined capabilities of four ORNL research areas—additive manufacturing, building technologies, vehicle technologies, and integrated energy systems—to develop a 3D printed building and vehicle with innovative integration of energy systems.

“We’re looking at large community issues from the single-unit level. Our research provides solutions on a small scale, which will translate to a significant reduction in energy use and an increase in cost savings when ramped up to a national, and even global, level,” said Martin Keller, associate laboratory director for ORNL’s Energy and Environmental Sciences Directorate (EESD).

ORNL will demonstrate the AMIE project for the first time at the EERE Industry Day event at ORNL on Sept. 23–24.

*The AMIE demonstration project engages numerous industry partners including Skidmore, Owings & Merrill LLP; Alcoa/Kawneer, Clayton Homes, Cincinnati Inc., GE Appliances, NanoPore, Tru-Design, and the University of Tennessee, among others.*



## FEATURES

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provided comments that promoted discussion and valuable feedback.

**“We are excited about ORNL’s crowdsourcing platform,”** said Anne Clawson, manager, Government Programs & Partnerships at Alcoa.

After the crowdsourcing website closed on May 31, a predetermined, indepen-

dent panel of experts reviewed the most popular idea submissions. The best ideas will be recognized at Industry Day. Site members and users can still view the submissions, comments, and votes at [buildings.ideascale.com](http://buildings.ideascale.com).

“We’re already making plans for the next crowdsourcing effort,” said BTRIC’s deputy director Melissa Lapsa. “It will facilitate public–private partnerships that will co-design campaigns to address the most pressing energy challenges currently facing the build-

ings industry.” The new project is called JUMP: join in the discussion, unveil innovation, motivate transformation, and promote technology to market.

“We are excited about ORNL’s crowdsourcing platform,” said Anne Clawson, manager, Government Programs & Partnerships at Alcoa. “It gives industry access to innovative ideas that could contribute to solving some of the toughest challenges in building technology today.”



*ORNL’s Ayyoub Momen demonstrates ultrasonic clothes dryer technology for David Danielson, DOE assistant secretary for EERE; Joyce Yang, director of EERE’s National Laboratory Impact Initiative; Roland Risser, BTO director; and Mark Johnson, director of the DOE Advanced Manufacturing Office, who toured MAXLAB, a part of ORNL’s BTRIC.*



*ORNL signed a memorandum of understanding with GE Appliances at MAXLAB. Seated, from left, are Venkat Venkatakrishnan with GE and ORNL director Thom Mason. Standing, from left, are Joyce Yang, director of EERE’s National Laboratory Impact Initiative; Roland Risser, BTO director; David Danielson, assistant secretary for EERE; and Mark Johnson, director of the DOE Advanced Manufacturing Office.*

## ORNL showcases revolutionary energy-efficient building technologies

Last spring, ORNL highlighted its cutting-edge innovations in building technologies during a visit by David Danielson, DOE assistant secretary for EERE.

Danielson toured the Maximum Building Energy Efficiency Research Laboratory (MAXLAB), the flagship lab of BTRIC, and received briefings on many of BTRIC’s latest groundbreaking, energy-saving developments, including two collaborations with GE: the magnetocaloric refrigerator, which uses 25 percent less energy than today’s models, and the revolutionary “heatless” ultrasonic clothes dryer.

Also showcased were Dow Chemical’s new LIQUIDARMOR and 3M’s new 3M 3015 building envelope air sealing technologies, which recently cleared aggressive durability evaluations at ORNL. A new foam board composite insulation under development by NanoPore, Firestone, and ORNL that has the potential to double the thermal resistance (R per inch) of today’s foam board products and to be cost competitive when installation costs are considered also was highlighted.

Two environmentally-friendly supermarket refrigeration technologies also were featured: Hillphoenix’s hydrofluorocarbon-free CO<sub>2</sub> system—the first in North America—with 25 percent energy savings and 75 percent fewer greenhouse gas emissions, and Honeywell’s new refrigerant that is 67 percent less harmful to the environment. The refrigerant works with existing hardware and improves refrigeration systems’ efficiency by 10 percent.

GE Appliances will work with ORNL through a memorandum of understanding (MOU) to evaluate the potential for innovative products before making multimillion-dollar investments in mass production facilities. GE’s FirstBuild business model takes advantage of open innovation, advanced technologies, and manufacturing techniques to define new products, perform rapid prototyping, produce in low volumes, and validate new product concepts through low-volume sales. During his visit at ORNL, Danielson attended the MOU signing ceremony to recognize this new and innovative approach.

“Our research in building technologies provides solutions on a small scale, which will translate to a significant reduction in energy use and an increase in cost savings when ramped up to a national, and even global, level,” said Martin Keller, associate laboratory director of the EESD, who hosted Danielson.



## Two BTRIC co-developed technologies are R&D 100 Award finalists

R&D Magazine has selected the newly launched Hillphoenix Advansor Transcritical CO<sub>2</sub> Booster System and Honeywell's Solstice N40 Refrigerant projects as finalists for its annual R&D 100 Awards.

Congratulations to:

- Hillphoenix and the ORNL research team, including Ed Vineyard, Brian Fricke, and Vishaldeep Sharma, for being selected in the Green Tech and Mechanical Devices/Material categories, and;
- Honeywell and the ORNL team, including Omar Abdelaziz, Brian Fricke, and Ed Vineyard, for placement in the Mechanical Devices/Material category. The winners will be announced in November at an event in Las Vegas.

## New pilot helps small businesses tap ORNL expertise

ORNL was among five national laboratories selected to participate in a new DOE small-business voucher program that aims to connect small clean-energy businesses with technical experts and world-class facilities at the national labs.

EERE is funding the \$20 million pilot as part of its National Laboratory Impact Initiative. ORNL will receive \$5.6 million to conduct outreach, merit review, matchmaking, and voucher implementation for small-business projects.

"Through this program, we will help small businesses achieve their goals of developing innovative, energy-efficient products and being more competitive in the marketplace, particularly in manufacturing, building, and vehicle technologies," said Energy and Transportation Science Division (ETSD) Director Johney Green, Jr.

As part of the pilot, companies will have access to unique equipment and expertise at ORNL facilities such as the Manufacturing Demonstration Facility, National Transportation Research Center, and BTRIC.

## ORNL hosts Envelope Stakeholders Workshop

ORNL hosted the DOE BTO Envelope Stakeholders Workshop on May 18 with tours of the BTRIC user facility and the Manufacturing Demonstration Facility on May 19. The workshop at ORNL's conference center brought together about 100 industry representatives, researchers, building owners, and other stakeholders who conduct research, develop products, or use materials to construct a building's envelope, which includes walls, windows, roofs, and foundations.

Five BTO representatives participated in the workshop: Amy Jiron, commercial buildings technology lead, and Eric Werling, Building America program coordinator, who kicked off and concluded the workshop; Bahman Habibzadeh, technology manager for Envelope and Windows in Emerging Technology; Sam Rashkin, project manager in Residential Building Integration; and Jeremy Williams, project manager in Building Energy Codes. Participants met together and

in smaller residential- and commercial-specific groups for presentations, panel discussions, and working sessions. Joseph Lstiburek with Building Science Corporation presented the keynote address, "Adventures in Building Science," about how ideas in commercial and residential building technologies can be shared more freely to provide solutions to similar issues and to work toward common goals in achieving building energy efficiency. Nicholas Holt from Skidmore, Owings & Merrill LLP (SOM) gave the lunch presentation, "A Return to Performance," that included examples of increasing energy efficiency at the convergence of envelope R&D and architectural design choices.

During the workshop, participants

- identified current and anticipated barriers to the adoption of energy-efficient commercial building envelope technologies (e.g., wall, fenestration, and attachments),



Amy Jiron kicked off the Envelope Stakeholders Workshop.

- reviewed emerging and market-ready applications for new and existing commercial buildings,
- defined a path forward for commercial building envelope products, and
- discussed and solicited feedback on DOE's strategic research road map for high-performance, moisture-managed envelope solutions for residential buildings.

## ORNL wins three projects on non-vapor compression technology research

ORNL will lead one and participate in two of seven total projects recently funded through a funding opportunity announcement awarded by DOE BTO. Of the \$7.6 million that DOE awarded, ORNL is involved in projects receiving



*The magnetocaloric device moves copper, brass, or aluminum rods in and out of a magnetic field. The rods transfer heat to and from the magnetic regenerative bed, which changes temperature as the magnetic field changes. The heat is transferred through forced air at both ends of the magnetic regenerator.*

\$4.3 million, \$2.2 million of which will be used for in-house research. Each research and development project focuses on the advancement of next-generation heating, ventilating, and air conditioning (HVAC) technologies to support DOE's goal of developing cost-effective, energy-efficient technologies that also reduce the use of chemicals that have a negative effect on the global climate.

ORNL will receive about \$1.4 million to develop a novel magnetocaloric air conditioner with the potential for efficiency improvements of up to 25 percent over conventional vapor compression systems, equivalent to saving 1 quad of energy annually for space heating and cooling in the US residential sector. If successful, the window air conditioner concept, which is the focus of this project, possibly could be scaled up to larger systems.

In partnership with Dais Analytic (Odessa, Florida), ORNL will work on a \$1.2 million project to advance membrane HVAC technology using nanostructured polymer materials (membrane) to manipulate water molecules, allowing the system to condition air while improving energy efficiency and eliminating the need for fluorocarbon refrigerants. The project will result in a rooftop-capable system for field evaluation. With Xergy, Inc. (Seaford, Delaware), ORNL will participate in a \$1.4 million project to develop electrochemical compression (ECC) technology in combination with an energy recovery module to replace traditional electromechanical compressors for use in heat pumps. ECC uses fuel cell technology to enable heat pumps to use water as the refrigerant. Thermodynamic modeling shows efficiency improvements of 30–56 percent are theoretically attainable. The project seeks to produce a prototype unit with the potential of achieving a payback period of 5 years or less when produced on a commercial scale.

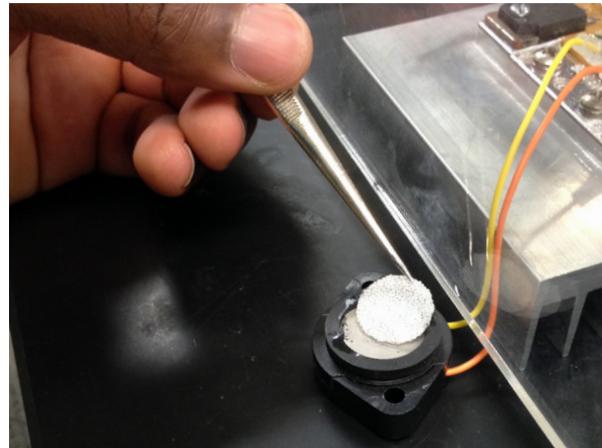
## ORNL develops world's first heatless dryer with GE Appliances

ORNL researchers are collaborating with General Electric (GE) Appliances to develop the world's first ultrasonic clothes dryer that could forever change the concept of residential heat-drying technology. This novel approach will use high-frequency mechanical vibrations instead of heat to extract moisture as a cold mist, dramatically reducing drying time and energy use.

Electric clothes dryers consume about 71 terawatt hours (0.2423 quads) of energy annually and are one of the largest energy-consuming appliances in US households. ORNL's approach is to extract water mechanically from fabric using high-frequency vibrations generated by piezoelectric transducers. This process raises moisture from clothing into a fine mist that can be removed easily by a modest flow of room-temperature air.

The revolutionary technology has the potential to make a full-sized clothes dryer three to five times more energy-efficient than conventional heat dryers. Currently, the prototype is able to dry small pieces of fabric in seconds. Drying times for a typical load of clothing could be reduced to 15 to 20 minutes with virtually no shrinkage, fading, or lint produced.

"When I put a very small piece of fabric on top of these transducers, the fabric went from saturated to bone-dry in just 14 seconds. It was quite amazing

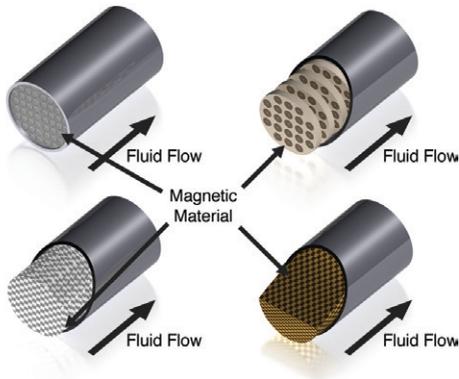


*The small-scale ultrasonic dryer experimental setup dries saturated fabric in just a few seconds.*

to see," said Ayyoub Momen, principal investigator. Momen and his team are using the BTRIC and Sensors and Embedded Systems labs for this research.

ORNL is currently in the patent application process for this invention. The research team hopes to have a full-sized working prototype by August 2016. Funding for this project was competitively awarded by DOE BTO in 2014.

## Additive manufacturing process boosts new refrigeration technology development



ORNL is the first lab working to develop high-resolution, 3D printed microchannels.

A building technologies project with General Electric (GE) Appliances has tapped into ORNL's advanced manufacturing and materials science expertise to revolutionize today's 100-year-old home refrigeration technology. Researchers are exploring ways to preserve our food with greater energy efficiency by exploiting the magnetocaloric effect and avoiding altogether the need for a vapor compression cycle and

associated refrigerants, which have negative environmental impacts.

A drastic upgrade in refrigerator design using magnetocaloric materials (MCMs) eliminates the need for refrigerants but creates a new challenge—how to transfer heat from the solid MCM using a heat transfer fluid. ORNL researchers Ayyoub Momen, Omar Abdelaziz, and Ed Vineyard are innovating new circuit seal and hydraulic solutions to create a feasible design.

Using facilities at BTRIC and the Manufacturing Demonstration Facility, the research team evaluated various processes—including sintering, pressing, hot pressing, extrusion, 3D printing, and additive manufacturing—to determine the best way to develop high-resolution microchannels directly from the MCM material, providing the means to transfer heat in and out of the MCM.

“Binder jet 3D printing, which is an additive manufacturing process, has shown outstanding promise for

generating microchannels from MCM materials with a hydraulic diameter of less than 300 microns,” said Momen, explaining that the microchannels provide an enhanced heat transfer rate with minimum pressure drop.

ORNL's early results in employing MCM 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 percent and eliminate the need for refrigerants and their associated global warming potential should they leak into the atmosphere.

ORNL and GE have been working on this project through a cooperative research and development agreement since March 2014, and GE hopes to commercialize magnetocaloric refrigerators for use in homes by 2020. GE is self-funded, and ORNL's effort is sponsored by BTO through the Annual Operating Plan process.

## ORNL develops affordable energy-saving retrofit technology for commercial HVAC

Heating and cooling a commercial building and paying the monthly utility bill are not for the faint of heart.

Given that buildings consume 41 percent of primary energy sources and 74 percent of all electricity produced in the United States, maintaining a comfortable temperature throughout the winter and summer months is a major expense for homeowners and business owners alike.

But business owners take the brunt of heating and cooling costs because, unlike homes, most commercial buildings are on utility tariffs that charge extra for electricity consumed during peak load periods. Commercial buildings account for 46 percent of energy consumption in all buildings; a full third or more of the energy consumed by small- and medium-sized commercial buildings is traceable to HVAC systems.

ORNL pulled together a team of researchers with expertise in computational sciences, electrical and electronic systems, sensors and controls, and building technologies to find a low-cost way to decrease energy

A desktop demonstration emulates RTUs and thermostats that are controlled by Volttron apps running on a BeagleBone Black.



usage and expenses accruing from multiple HVAC roof top units (RTUs) in small- and medium-sized commercial buildings. The method involves retrofitting existing units so they can coordinate with each other automatically.

“Currently, RTUs operate independently, each maintaining the temperature of its assigned area within the building with no communication among the units,” says ORNL's Jibonananda Sanyal. “One consequence of this uncoordinated control is that during peak load periods, most of the units for a building likely will run at the same time, resulting in unnecessary peak power charges.”

With most utility companies, commercial buildings pay a demand charge per kilowatt (kW) in addition to the

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cost per kilowatt-hour (kWh). For example, the Knoxville Utilities Board (KUB)—the utility service provider for the Knoxville, Tennessee, area—sets a demand charge on each kilowatt in excess of 50 kW (i.e., the total kilowatts used in a month minus 50). The rate is \$12.73 per kilowatt in the summer and \$11.94 per kilowatt in other seasons. Depending on the building and month, the demand charge can be of a magnitude similar to the charge for the kWh of electricity consumed.

The researchers used the open-source Volttron platform, developed by Pacific Northwest National Laboratory, to run an ORNL-developed open-source software app that senses both outdoor temperature and indoor temperature in each RTU area or zone. The app runs intelligent

control algorithms and relays control information to the RTUs, reducing the number of units running at once.

To reduce the power footprint and make the approach easy to retrofit in buildings, Sanyal and ORNL's Teja Kuruganti have embedded the Volttron app in miniature devices, such as an Intel Next Unit of Computing (measuring 3 ½ by 3 ½ in.), the credit-card sized Raspberry Pi, and the tiny BeagleBone Black (1 ½ by 2 in.).

Kuruganti, Sanyal, and ORNL researcher James Nutaro recently upgraded a system of four 10-ton RTUs at a large Knoxville church to evaluate performance and efficiency. They expect a return of \$1,200 in energy savings within 6 months to a year. The DOE Building Technologies Office (BTO) sponsored this work.



*ORNL's Pradeep Bansal examines an Embraco linear compressor, which will be used in a Whirlpool-ORNL project aimed at building a more energy-efficient refrigerator.*

## ORNL, Whirlpool to develop new energy-efficient refrigerator

ORNL's BTRIC and Whirlpool Corporation are collaborating to design a next-generation household refrigerator that could cut energy use by up to 40 percent.

The goal of the cooperative research and development agreement, or CRADA, is to design a more energy-efficient refrigerator by using WISEMOTION, an innovative linear compressor manufactured by Embraco, and other novel technologies and materials. Whirlpool is self-funded, and ORNL's effort is sponsored by BTO through the Annual Operating Plan process

## Researchers evaluate high performance cold-climate heat pump

ORNL researchers Bo Shen and Omar Abdelaziz have been working with CRADA partners Emerson Climate Technologies and Unico on the development of high performance cold-climate multistage air-source heat pumps. Last winter, the technical performance targets were achieved in a field prototype demonstrated in Sydney, Ohio. While operating at an outdoor temperature of -13°F, the unit was able to retain 75 percent of the heating capacity the unit has when the outdoor temperature is a balmy 47°F. In addition, the heating coefficient

of performance (the ratio of energy output over energy input) exceeded 4.0 at 47°F. For the prototype, Shen modified the unit's control board to operate two Emerson single-stage tandem compressors, which were optimized for heating mode. In January, the field prototype was shipped to Sydney, where it was installed for evaluation in an occupied residential home. The unit operated flawlessly during the ensuing extreme cold snap when the outdoor temperature dipped to -13°F. During that period, there was no need for backup electric resistance

heat in the home, and the occupants stated they were very comfortable.

The next prototype under development is a heat pump with two equal-size vapor injection compressors. It is expected to offer even better performance in extremely cold climates and will be field-tested in Fairbanks, Alaska. Emerson is self-funded, Unico is a funding opportunity announcement awardee, and ORNL's effort in these CRADAs was funded by DOE BTO through the Annual Operating Plan process.

## HVAC systems compared using two-story flexible research platform

Although variable refrigerant flow (VRF) heat pumps have several advantages, higher initial costs and difficulty in quantifying those benefits serve as deterrents to their widespread use. ORNL's two-story flexible research platform (FRP-2), however, provides a solution that enables researchers to characterize real-world performance. FRP-2 is an instrumented, unoccupied, two-story small office building with 10 thermal zones and several separate multi-zone HVAC systems

installed. By rotating between HVAC systems weekly—operating each during cold, hot, and mild outdoor conditions—and controlling the occupant impact on energy use to be the same for each HVAC system through emulation, apples-to-apples performance for each HVAC system type can be directly measured.

Using this methodology, ORNL measured the performance of an all-electric VRF system and an all-electric direct

expansion-cooling rooftop unit, with variable air volume terminals in each zone with electric resistance reheat coils (RTU/VAV/reheat). The performance of the VRF system was characterized with standard thermostat control and with enhanced control algorithms known as the comfort control method (CCM). The VRF system outperformed RTU/VAV/reheat, providing heating and cooling savings of 74 percent and 17 percent, respectively, with standard thermostat control, and 80 percent and 26 percent savings, respectively, with CCM control. Details were published in a conference paper for the ASHRAE June 2015 Annual Meeting.



*Samsung's VRF outdoor unit sits outside BTRIC's two-story FRP.*

This work was sponsored under a Work for Others agreement with Samsung.



International  
Institute of  
Refrigeration



## ORNL collaborations forge new paths to sustainability

ORNL has been on the forefront of technological innovations on a global scale for more than 40 years through participation in organizations such as the International Energy Agency (IEA) and the International Institute of Refrigeration (IIR). These two organizations, through international collaborations and shared information, have been instrumental in the research and development of environmentally safer and more energy-efficient technologies since their inceptions.

IEA focuses on reducing the global demand for oil by exploring and harnessing alternate energy sources and developing energy-saving technologies. IIR's research is on advancing the basic arts and sciences underlying refrigeration systems and advanced refrigerants with lower global warming potential (GWP) than the hydrofluorocarbons in use today.

The IEA Heat Pumping Technologies (HPT) Program supports technology improvements for and increased implementation of heat pumps to reduce energy consumption in buildings and industrial processes. Most recently, in part through HPT, ORNL has improved cold-climate heat

pumps and heat pumps for highly efficient (zero-energy ready) buildings. ORNL currently is investigating the role of heat pumps in future smart electric grids.

As a member of these important organizations, ORNL has significant input in the global dialogue on energy. BTRIC's Melissa Lapsa and Van Baxter serve as coordinators of the US National Team (USNT) for the IEA HPT Program (on behalf of BTO's Antonio Bouza, the official IEA HPT US delegate). USNT is a voluntary body consisting of high-level experts and leaders in the US HVAC&R community with representatives from industry, academia, and utilities. Baxter and BTRIC's Brian Fricke are the chair and second vice chair, respectively, of the US National Committee for the IIR, the body that engages US industry and coordinates US activities and collaborations with the IIR and other member countries.

"Since joining the IEA HPT in the late 1970s, DOE BTO, ORNL, and the USNT have been active and influential in about 35 HPT multicountry collaborative projects, called Annexes, nine of which currently are ongoing," Baxter said. In addition, HPT disseminates innovations in technology through a quarterly newsletter published by the IEA Heat Pump Centre and through its flagship international heat pump conferences conducted once every three years. The next conference will be in Rotterdam in May 2017.

"Both the newsletter and the conferences are regarded worldwide as the preeminent sources of information on new heat pumping technologies," Baxter added.

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ORNL's unique position as a major research laboratory, broadly engaged with US-based industry and university leaders in heat pumping and refrigeration, provides a strong platform for moving the world toward sustainability. The modest investment to participate in

IEA HPT and IIR made by DOE BTO provides the US industry and research community with insights from peers and leaders in dozens of other countries also striving to improve energy efficiency, reduce carbon emissions, and eliminate high-GWP refrigerants.

## BTRIC evaluates durability of Dow's energy-saving LIQUIDARMOR for buildings



*A liquid flashing product invented by Dow and evaluated at ORNL can be brushed or sprayed on surfaces to seal gaps, cracks, and seams to improve a building's energy efficiency. Photo courtesy of Dow.*

Drafty buildings are a thermostat's worst enemy. Leaks around windows and a multitude of other breaches in the building envelope can cause heating and cooling systems to run excessively, hogging energy as they continually warm—or cool and dehumidify—the invading outside air.

The energy loss from air leakage in buildings is estimated to be about 4 quads (4 quadrillion BTUs) or about 4 percent of the total energy used in the United States annually, according to DOE's Energy Data Book.

Building technology researchers at ORNL collaborated with Dow to evaluate a new Dow product that significantly reduces air leakage and helps to make residential and commercial buildings more energy efficient. Branded as LIQUIDARMOR™-CM Flashing and Sealant, the product was patented and introduced to the US market in 2014. The one-step liquid flashing can be brushed or sprayed on surfaces to seal gaps, cracks, and seams in the building envelope. It is especially effective on

rough openings where windows and doors are installed. The fluid nature of the product allows it to fill or bridge gaps, providing a greater seal.

“Reducing air leakage in residential and commercial buildings is among the most cost-effective means to lower energy consumption,” said Diana Hun, BTRIC researcher. “We have the ability to evaluate air barrier assemblies to determine whether sealants like LIQUIDARMOR can stand up to the elements and improve energy efficiency.”

The elastomeric—or rubbery—liquid adheres well to most substrates, even as buildings settle or adjust to wind pressures and changes in temperature. Additionally, its water-based acrylic formula significantly decreases workers' exposure to volatile organic compounds (VOCs) and reduces VOC emissions into the atmosphere.

“One of the main advantages a liquid sealant such as LIQUIDARMOR has over tape is that it can be faster to install,” Hun said. “Because it can be sprayed on, installation can be as much as three to four times faster than tape. Also, the spraying process can be more forgiving and foolproof, and a high-quality seal can be more reliably achieved, especially in areas with complex shapes.”

Hun and her research team evaluated the sealant's effectiveness by using ORNL's Heat, Air, and Moisture (HAM) Penetration chamber to measure the impact that various environmental conditions have on wall assemblies treated with LIQUIDARMOR. The HAM chamber—the only apparatus of its kind—simulates indoor temperatures

of 60°F to 90°F and outdoor temperatures of 0°F to 110°F. Additionally, the chambers can subject walls to 10 to 90 percent relative humidity and other outdoor conditions such as rain, solar radiation, and pressures from wind and wind gusts that range from -30 to 30 pounds per square foot.

Hun and her team installed LIQUIDARMOR on a wall assembly to seal the gaps between THERMAX™ Brand rigid insulation boards and exterior drywall as well as gaps around window openings. The evaluation process per wall lasted about 5 days. Based on ORNL's findings, Dow was able to subject LIQUIDARMOR to a more rigorous evaluation that included aging caused by pressure and temperature cycles, thus validating the performance of the LIQUIDARMOR seal under stress.

DOE BTO sponsored the ORNL–Dow collaboration through the US–China Clean Energy Research Center (CERC) for Building Energy Efficiency, which supports the development of advanced technologies to reduce energy consumption and CO<sub>2</sub> emissions in the United States and China. Widespread opportunities for use of LIQUIDARMOR exist in China because construction practices there include minimal air sealing of building envelopes.

In 2015, research continues on LIQUIDARMOR durability characterization in additional building envelope applications to increase energy savings potential, further contributing to DOE's mission to reduce energy use in buildings.

## ORNL participates in 2015 FEMP and FUPWG events

ORNL recently welcomed Timothy Unruh, director of DOE's Federal Energy Management Program (FEMP) as part of a 2-day program review of ORNL's support of FEMP in the area of energy-savings performance contracts. FEMP's Skye Schell and Kurmit Rockwell also attended the program review. ORNL supports FEMP performance contracting efforts through data analysis, project development at agency sites, energy audit and benchmarking toolsets, agency training, and institutional behavioral change research. This year's program review was well received by the FEMP sponsors with an acknowledgment by Unruh that ORNL continues to serve as a lead laboratory in FEMP's performance contracting initiatives.

In April, ETSD Director Johney Green, Jr. and Michael Starke from the Electrical and Electronics Systems Research Division presented at the semiannual meeting of the Federal Utility Partnership Working Group (FUPWG) hosted by the Tennessee Valley Authority in Nashville, Tennessee. More than 250 federal agency energy and facility managers, utility company representatives, and industry stakeholders attended. Green provided an overview of ORNL's research capabilities, and Starke spoke on grid research projects involving battery storage. BTRIC's Julia Kelley organized and facilitated the concurrent Energy Lawyers and Contracting Officers Working Group meeting.

### EMPLOYEE EXCELLENCE:

- During his visit to ORNL in April, David Danielson, DOE assistant secretary for EERE, recognized three buildings researchers for their outstanding work with industry—Ayyoub Momen on development of magnetocaloric refrigeration and ultrasonic dryer technologies, Teja Kuruganti for low-cost wireless sensor and building-to-grid integration technologies, and Ed Vineyard for a career that has included 20 cooperative research and development agreements worth \$75 million.
- BTRIC researcher Diana Hun recently presented her work to Secretary of Energy Ernest Moniz and Chinese Minister of Science and Technology Wan Gang. Each year at the US–China Clean Energy Research Center (CERC) Steering Committee meeting, each of the three CERCs select one technical achievement to highlight. This year, the CERC for Building Energy Efficiency selected Hun's building envelope air sealing project, being implemented in collaboration with Dow Chemical and 3M. Hun also is profiled in *Clean Energy*, the lab's EESD quarterly newsletter, for making great strides in her discipline as an early career researcher.
- BTRIC's Andre Desjarlais recently became the fourth recipient of the Cool Roof Rating Council's (CRRC's) annual Marty Hastings Award, CRRC's most prestigious award. As a CRRC Technical Committee member and 13-year advocate, Desjarlais helped establish standards and policies that allow the organization to expand rating criteria and opportunities for cool roofing materials. He has also served as an ex-officio member of CRRC's board of directors since 2002.



Front row: Ed Vineyard, Ayyoub Momen, Bill Partridge, and Gui-Jia Su; Back row: Zhili Feng, Asst. Sec. David Danielson, Lonnie Love, Teja Kuruganti, Lab Director Thom Mason, DOE's BTO Director Roland Risser, Madhu Chinthavali, and DOE Advanced Manufacturing Office Director Mark Johnson.



Diana Hun



Andre Desjarlais

### VISITS AND EVENTS:

BTO sponsored a live webinar titled "Additive Technology: Rethinking of Building Design, Construction, and Recycling" on July 14. The webinar is part of a series of panel discussions exploring the future of the built environment beyond this century. Philip Enquist (partner, SOM), Lonnie Love (group leader, ORNL Manufacturing Systems Research Group), Roderick Jackson (group leader, ORNL Building Envelope Systems Research), and James Rose (director, Institute for Smart Structures, University of Tennessee College of Architecture and Design)

discussed how additive technology enables researchers to rethink building design and construction methods.

In May, Xiaobing Liu contributed to the series of Building Science Seminars, titled "Using the Ground's Energy to Condition the Built Environment," in which he discussed efforts to expand the use of ground source heat pumps (GSHPs). Visit the Innovations in Buildings website for information on previous seminars: <http://web.ornl.gov/sci/buildings/seminars/>.

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A paper titled “A Comparative Study of the Status of GSHP Applications in the United States and China,” coauthored by Xiaobing Liu, Patrick Hughes, Shilei Lu, and Zhe Cai, was published in the August 2015 issue of *Renewable & Sustainable Energy Reviews*. doi:10.1016/j.rser.2015.04.035.

Building Technologies Program manager Patrick Hughes hosted BTO visitors John Cymbalsky, Ashley Armstrong, and Antonio Bouza for a program review of ORNL’s work for the BTO Standards Program.

Melissa Lapsa hosted visitors from DOE’s Office of Energy Policy and Systems Analysis (EPSA) for meetings in June. EPSA visitors included Sam Bockenbauer, James Bradbury, Lindsay Brumbelow, Rebecca Dell, Eric Hsieh, Stephen Hendrickson, Lara Pierpoint, and Greg Singleton. This was the first visit for most, and Martin Keller gave a welcome to ORNL and an overview of EESD. Georgia Tech’s Marilyn Brown, Dan Matisoff, Jeff Hubbs, Alex



Members of DOE’s Office of Energy Policy and Systems Analysis visited ORNL in June.

Smith, and Ben Staver also participated in the visit. Several ORNL staff gave presentations. The group’s last stop was a tour of the Manufacturing Demonstration Facility.

## MEDIA MENTIONS:

The Weatherization Assistant, developed and maintained by BTRIC for DOE’s Weatherization and Intergovernmental Programs office, was featured in a *Knoxville News Sentinel* article on the success of Knoxville Utilities Board’s “Round It Up” program, which automatically rounds up customers’ utility bills with proceeds going toward a home weatherization program. The Weatherization Assistant is composed of the National Energy Audit Tool and the Manufactured Home Energy Audit. [http://www.knoxnews.com/business/kub-eyeing-success-of-optout-program\\_14961053](http://www.knoxnews.com/business/kub-eyeing-success-of-optout-program_14961053)

BTRIC’s ultrasonic clothes dryer technology project, led by Ayyoub Momen, received widespread media attention, including the following:

- Nashville Public Radio: <http://nashvillepublicradio.org/post/oak-ridge-scientists-make-breakthrough-age-old-problem-drying-clothes-faster>
- WBIR-TV Knoxville: <http://www.wbir.com/story/news/2015/06/05/ornl-is-creating-a-heat-less-clothes-dryer/28559813/>
- Knoxville News Sentinel: [http://www.knoxnews.com/news/local-news/ornls-clothes-dryer-of-future-uses-vibrations-not-heat\\_77968983](http://www.knoxnews.com/news/local-news/ornls-clothes-dryer-of-future-uses-vibrations-not-heat_77968983)

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

Please submit ideas or suggestions to  
ORNL Building Technologies Program at  
[buildings@ornl.gov](mailto:buildings@ornl.gov) or (865) 574-7267.

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