

ORNL is awarded eight new BTO projects, will lead six

The US Department of Energy (DOE) Building Technologies Office (BTO) awarded funding for 15 total projects—8 of which include Oak Ridge National Laboratory (ORNL) building technologies researchers—that will contribute to advancing early-stage, breakthrough, energy-efficient solutions for buildings and homes. ORNL will lead six of these projects, partnering with industry, academia, and other national laboratories. Total ORNL post-negotiation funding is projected at just under \$6 million for the eight projects, with approximately \$4 million for in-house research at ORNL.

Of the eight projects, ORNL will participate in three incubator projects designed to improve heating, ventilation, and air conditioning (HVAC), water heating, sensors and controls, and building energy modeling. The other five projects fall under frontier projects that aim to improve efficiency in advanced clothes dryers, windows, and building thermal insulation.

“Our researchers and staff work hard to provide the best possible R&D [research and development] expertise and support to our sponsors and industry partners, and I recognize and commend our entire team for their outstanding efforts leading to this successful competitive outcome,” said Patrick Hughes, ORNL’s Building Technologies Program (BTP) director.

ORNL’s project partners include Sandia National Laboratories, University of Maryland, Richman Surrey, University of Tennessee (UT), University of Florida, Stony Brook University, GE Appliances, Sheetak, NanoPore, Firestone Building Products, VELUX, and PPG Industries.



Patrick Hughes (left) and Martin Keller, director of ORNL’s Energy and Environmental Sciences Directorate, congratulated BTP staff during an August 11 celebration.

Governor’s Chair event spurs ideas toward sustainable urbanism



Keith Boswell (SOM, left) and James Rose (UT) each presented past projects that could shape future energy and urbanism opportunities.

On July 24-25, ORNL’s BTP hosted a two-day event that brought together 33 participants from ORNL, UT, and Skidmore, Owings, and Merrill (SOM), plus invited consultants and local representatives. The primary partners have expanded upon the traditional UT-ORNL Governor’s Chair model, where an individual serves as Governor’s Chair Professor, to a more collaborative approach. SOM’s Philip Enquist serves as the Governor’s Chair for High-Performance Energy Practices

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in Urban Environments, but he leads a team of SOM designers (who specialize in sustainable urbanism and high-performance buildings) who will be working with ORNL and the UT College of Architecture and Design. The event participants shared presentations and engaged in roundtable discussions to better understand their individual offerings, identify needs and challenges, and determine ways to work together and use each other's strengths.

The BTP director and Building Technologies Research and Integration Center (BTRIC) managers introduced the lab's unique offerings in building technologies expertise and R&D facilities and the availability of ORNL's multidisciplinary science and technology expertise and state-of-the-art facilities to the Governor's Chair collaborators and their clients. The group toured select facilities including the MAXLAB, Spallation Neutron Source, Exploratory Visualization Environment for Research in Science and

Technology (EVEREST), the supercomputing facility, the Manufacturing Demonstration Facility, and the UT Fab Lab located in the Jewel Building in downtown Knoxville.

On July 24, Keith Boswell, technical director of SOM, and James Rose, senior lecturer from UT Architecture and Design, spoke during a lab-wide seminar. Boswell's presentation on "High Performance Design and Execution: Principles to Application" demonstrated that high-performance design and execution not only surpass visual appearance, but also integrate the science of physics with the science of materials. Rose's presentation, titled "Net Zero and the Design-Build Studio," highlighted design-build projects that explore the intersection of passive and active technologies in net zero-energy buildings, including in-depth discussion of the UT Zero Prototype and the Living Light Solar Decathlon houses.

FEATURES

New, Sanyal develop Autotune software for building energy modeling

There are many ways to save energy in residential and commercial buildings. There are products that use less energy to light, cool, and heat buildings; materials that better insulate and seal building envelopes; and architectural and engineering designs that lower utility bills through efficient use of space and renewable energy. In fact, building technology experts specify up to 3,000 parameters when modeling a building's energy use.

Building energy modeling (BEM) uses computer simulations to estimate energy use and guide the design of new buildings as well as energy improvements to existing buildings. BEM allows users, such as engineering firms, to adjust a building's features to meet the needs of owners and occupants while reducing energy bills.

"When modeling a building, you might be simulating for total energy saved after implementing new features. Or you may be optimizing for utility cost savings, or limiting electricity use during peak load periods, or other desired results," said Jibonananda



BTRIC's Jibonananda Sanyal and Joshua New used ORNL's Titan supercomputer to architect the Autotune BEM tool.

Sanyal of BTRIC, a DOE user facility that develops new building technologies and provides unique capabilities for evaluating products and whole-building systems for market.

In 2010, US building owners spent \$431 billion on energy. Buildings in the United States consumed 41% of the nation's total energy and were responsible for 40% of carbon dioxide (CO₂) emissions. Increased building energy efficiency, if widely implemented, could significantly impact energy and environmental sustainability at local to national scales.

ORNL buildings researchers Sanyal and principal investigator Joshua New have developed automated, or "Autotune," calibration software, which reduces the amount of time and expertise needed to optimize building parameters for cost and energy savings.

Over the last 20 years, DOE has invested in EnergyPlus, its flagship whole-building energy simulation tool. The tool estimates energy usage based on weather data and the thousands of input parameters related to HVAC systems, water heating, lighting, weather interaction,

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occupancy schedules, and more.

Use of EnergyPlus or other BEM tools for energy-efficient, large building design is growing. But before using BEM to identify energy improvements to existing buildings, BEM parameters must first be collected, entered into the tool, and adjusted so that outputs reasonably match past energy usage.

This can be a time-consuming chore, but it's often required to receive tax rebates and utility incentives.

"Currently, the biggest barrier is the cost of getting an accurate model of the pre-retrofit building because it requires hiring an expert," Sanyal said.

New and Sanyal's Autotune software will reduce the time and expertise needed to achieve an accurate

model, and they're collaborating with universities and industry to make their approach accessible to more building engineers and owners.

The team is currently making Autotune capabilities available to a limited set of beta testers through a web service and anticipates making it publicly available in September 2015. This project was funded by DOE-BTO.

Hughes serves as co-chair of ACEEE Summer Study

This year, ORNL's BTP Director Patrick Hughes served as conference co-chair for the biennial week-long American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings held at the Asilomar Conference Center in Pacific Grove, California. Philip Enquist (Governor's Chair for Energy + Urbanism) spoke at an evening plenary session and addressed "Designing Our Urban Future." This theme aligned with one of the week-long parallel panels titled, "Resilient, Sustainable Communities: New Urban Strategies."

Roderick Jackson served as a co-leader for the "Residential Buildings: Technologies, Design, Operations, Performance, and Building Industry Trends" panel. Lead and co-authors of accepted papers at the summer study included BTRIC's Philip Boudreaux, Diana Hun, Piljae Im, Roderick Jackson, Mini Malhotra, and Som Shrestha.

The summer study featured 11 parallel panels and 330 peer-reviewed technical papers and attracted a record-breaking attendance of 1,109 from industry, research, and academia. This event is widely regarded as the most comprehensive and impactful conference entirely devoted to building energy efficiency. ORNL has sponsored the summer study many times since its inception in 1996.



Integrated energy systems enable buildings to efficiently use and store energy from available resources (such as solar energy).

New project to transform buildings through integrated energy systems

ORNL has composed a multidisciplinary team across several directorates that pools the necessary expertise for a new challenge to transform buildings through integrated energy systems. The team's expertise includes materials, buildings, vehicles, advanced manufacturing, power systems, and microgrids.

Specifically, the team will establish a proof-of-concept system that demonstrates how diverse new technologies can enable more intermittent renewable power generation while radically reducing non-renewable primary energy consumption and carbon

emissions. BTRIC's flexible research platforms will serve as the home for the team's research project over the next two years, and the lab's 50-kilowatt solar array and Distributed Energy Communications and Controls facility will help the research team create a holistic microgrid test bed. In time, the project aims to establish the foundation for an ORNL institute focused on integrated energy systems.

Outputs from four individual tasks, run in parallel, will be integrated to successfully achieve the proof-of-concept integrated energy system. Those tasks focus

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Philip Enquist

Patrick Hughes

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on advanced heat engine power generators, high round-trip efficiency energy storage, a building management system with on-grid or off-grid flexibility, and use-inspired basic research to bridge performance gaps and reduce costs.

The ORNL lab-directed R&D project team includes BTRIC's Roderick Jackson and Ayyoub Momen; Robert Wagner with the Fuels, Engines, and Emissions Research Center; Lonnie Love from Manufacturing Systems Research; and Ivan Vlassiounk with Nanosystems, Separations, and Materials Research.

New M&V Guidelines will be easier to apply

In July, DOE's Federal Energy Management Program (FEMP) released for public review the latest version of its measurement and verification (M&V) guidelines document, to which ORNL was a major contributor. It describes FEMP's standard procedures and guidelines for M&V for federal energy

managers, procurement officials, and energy service providers. The document, titled M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 4.0, is available on FEMP's website at <http://energy.gov/eere/femp/downloads/draft-measurement-verification-guidelines-version-40>.

ORNL, CERC-BEE building technologies showcased during DOE visits to China

During a June tour of the China Academy of Building Research (CABR) facility in Beijing, China, ORNL's building technologies projects were demonstrated for DOE's Assistant Secretary for Energy Efficiency and Renewable Energy David Danielson and Deputy Chief of Mission at the US Embassy in Beijing Daniel Kritenbrink.



DOE Secretary Moniz tours the China Academy of Building Research facility in Beijing.

US Secretary of Energy Ernest Moniz also visited the CABR facility during a trip to Beijing from July 8 to 11. During his trip, Secretary Moniz met with the Chinese Minister of Science and Technology Wan Gang to review research progress and consider extension of the joint US–China Clean Energy Research Center (CERC) for another five years.

The building technologies projects, which are part of CERC–Building Energy Efficiency (CERC-BEE), included air barrier systems, a water-repelling material for “cool roof” coatings, and advances to ground source heat pump (GSHP) systems. The air barrier systems, developed by Dow Chemical and 3M with use of ORNL lab facilities and expertise, are spray-on (Dow) or self-adhering membrane (3M) materials that improve the airtightness of commercial and residential structures and reduce energy consumption by decreasing heating and cooling loads. The superhydrophobic water-repelling material developed by ORNL, if successfully incorporated into cool roof coatings by Dow Chemical, will sustain high initial solar reflectance by repelling dirt and microbial growth.

Advances to GSHP systems—such as alternative ground heat exchangers that require 20–30% less borehole length than a conventional single U-tube ground heat exchanger while retaining the same performance—reduce the cost of these systems, for which ORNL industry partner ClimateMaster manufactures components. The CERC-BEE collaboration includes evaluating and characterizing the performance of these technologies in the CABR facility and/or at other demonstration sites, which could lead to additional innovation, invention, and technology improvement.

In August, ORNL's Patrick Hughes, Diana Hun, Xiaobing Liu, and Scott Hunter participated in the CERC-BEE Joint Annual Workshop in Berkeley, California, for a mid-term technical review of current demonstration projects and industry engagement and for initial discussions on the five-year extension.



Building technologies researcher Brian Fricke examines a sample container in the refrigeration research environmental chambers.

Curbing greenhouse gas emissions with eco-friendly refrigeration systems

Keeping food fresh is no easy feat. Trials of transporting ice over long distances and the hazards of systems that rely on toxic gases riddle the pages of refrigeration history. And although cooling science has come a long way in the past two centuries, modern refrigeration has an environmental cost that poses new challenges.

However, by experimenting with CO₂ refrigerant systems and new refrigerant molecules, BTRIC's Brian Fricke looks to mediate and minimize conventional refrigeration's environmental footprint.

"Each supermarket has a lot of refrigerant in its system—two to

four thousand pounds—and about 20% of that leaks out every year. That's a lot of greenhouse gas into the atmosphere," Fricke said.

In his lab, Fricke is installing a refrigeration system that uses solely CO₂. As a refrigerant, CO₂ is nearly ideal because it is nonflammable and nontoxic, doesn't affect the ozone, and has low global warming potential (GWP).

While it's not perfect, "CO₂ is only going to get more and more popular as time goes by," Fricke said. "That said, CO₂ operates at a much higher pressure than existing systems so it is important to have a low-GWP drop-in

replacement refrigerant as well. Food preservation is something essential to our well-being. It's a big energy user and big producer of greenhouse gases. I think it's important to try to make these systems more efficient and produce less environmental impact."

Fricke's refrigeration project is sponsored by DOE-BTO. ORNL has cooperative research and development agreements (CRADAs) with refrigerant manufacturer Honeywell and with refrigeration systems manufacturer Hillphoenix.

ORNL assists roll-out of residential weatherization audit tools

For the DOE Weatherization and Intergovernmental Program Office, ORNL's Joel Eisenberg and Mark Ternes developed an FY 15 plan for the maintenance and development of the Weatherization Assistant residential audit tool. This tool was developed in cooperation with several national laboratories under the direction of ORNL and is the primary computerized audit instrument used by the

DOE Weatherization Assistance Program to assess structures for determining cost-effective measures for installation under the program.

Under the plan, two new audit instruments developed under the American Recovery and Reinvestment Act for use by the program's network of local agencies—one dealing with multifamily housing and the other with

health and safety measures—will be rolled out to the weatherization community beginning in October 2014 through a combination of webinars, program notices, and one-on-one discussions with interested states. The plan also calls for multiple trainings and technical support for the entire audit suite, which includes a single family audit (NEAT) and a manufactured home audit (MHEA).

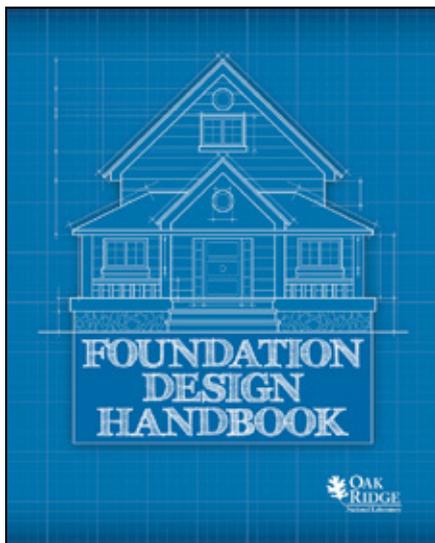
BRIEFS

New equipment lab opens in MAXLAB

Located in the MAXLAB, the new equipment lab will be used to evaluate next-generation appliances and equipment for homes and buildings. In the initial phase, there will be a focus on new and better control strategies to further increase energy savings and performance. For example, better controls for heat pump water heaters will enable them to “transact” and minimize power draw during peak load periods. Home appliances, including dishwashers, will also be evaluated and improved. The goal of this research is to increase the adoption and deployment of efficient products into the market.



BTRIC's Philip Boudreaux shows the new heat pump water heater evaluation setup in the MAXLAB facility as he educates participants during "Take Your Child to Work Day" at ORNL.



Revised Foundation Design Handbook goes online

In coordination with the University of Minnesota Center for Sustainable Building Research, ORNL launched the newly updated Foundation Design Handbook, as an online energy efficiency tool to enable designers, builders, and homeowners to understand foundation design problems and solutions. First published as an extensive technical manual in 1988, this marks the first year that the handbook is available online, with the added benefits of 3-dimensional construction details, construction animations, and

case studies. Contents carried over from previous editions and updated to align with the latest advancements in building science include detailed information on the major foundation categories; basements; crawl spaces; slabs-on-grade; radon; termites; and checklists. Based on the clear need to reflect current understanding and recent research in the field, the revision was made a priority by DOE-BTO. View the new online handbook at <http://foundationhandbook.ornl.gov/handbook/>.

Seminar series promotes buildings R&D

- Simon Pallin spoke about “Probabilistic Energy and Durability Assessment in Buildings Design” in May, sharing experiences from actual case studies and explaining the greater value provided by implementing a probabilistic approach to the assessment of building envelopes over traditional deterministic pass-fail methodologies.
- Brian Fricke presented on “Reducing the Energy and Environmental Footprint of Commercial Refrigeration” in June, where he addressed the key factors in effective commercial refrigeration systems.
- Roderick Jackson led the July seminar titled, “Radically Transforming Buildings through Integrated Energy Systems,” which explored how buildings with the flexibility to be on- or off-grid would benefit building owners and improve overall reliability of access to electricity.
- In August, Diana Hun presented, “Effects of Improved Building Envelope Air Sealing on Energy, Moisture Durability, and Indoor Air Quality.” She focused on the evaluation of typically used and recently developed air barrier technologies and provided insight on how increases in airtightness can enable greater energy efficiency without negative moisture durability and indoor air quality consequences.
- Bo Shen gave a talk in September about “Science of Vapor Compression System Modeling—DOE/ORNL Heat Pump Design Model,” discussing the lab’s leading position in the vapor compression system cycle modeling field and why this capability is essential in numerous ORNL collaborations with industry to advance HVAC and refrigeration, water heater, and appliance energy efficiency.

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On October 29, Kaushik Biswas will present “Next Generation Insulation Materials—Challenges and Opportunities,” and William Miller will lead a seminar scheduled for December 3.

Visit the Innovations in Buildings website for information on all BTP speakers and seminars throughout the 2014 fiscal year: <http://web.ornl.gov/sci/buildings/research/seminars/>.

BTRIC staff contribute at annual ASHRAE conference

BTRIC was well represented at this year’s Annual Conference of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in Seattle, Washington. Several papers were presented at this conference, including those written by Charles Castello, Anthony Gehl, Xiaobing Liu, Mini Malhotra, Jeffrey Munk, Joshua New, Roderick Jackson, and Jibonananda Sanyal. Kyle

Gluesenkamp helped conduct a seminar on “Successfully Applying Sorption Technologies for Fun and Profit.” Other BTRIC attendees participating in technical and project committee meetings in support of BTO and FEMP-related activities included Mark Adams, Van Baxter, Andre Desjarlais, Brian Fricke, Manfred Kehrer, John Shonder, Som Shrestha, and Ed Vineyard.

Sanyal leads 2nd Annual ORNL Postdoc Research Symposium

As president of the Oak Ridge Postdoctoral Association, BTRIC’s Jibonananda Sanyal led the organization’s 2nd Annual ORNL Postdoc Research Symposium, where more than 100 senior scientists, group leaders, and directors from across the lab judged 150 paper and poster presentations. The keynote was presented by Dr. Ellen Williams, a senior adviser for ARPA-E. The well-attended, day-long symposium concluded with awards given for best talk and poster. Sanyal received a certificate of appreciation for his efforts.

ORNL participates in 11th IEA Heat Pump Conference

BTRIC staff and consultants participated in the 11th International Energy Agency (IEA) Heat Pump Conference, which is a world-industry conference held every three years under the auspices of the IEA, a non-profit organization where member-country participants cooperate in projects in the field of heat pumps and related technologies such as air conditioning and refrigeration. Those representing ORNL included Moonis Ally, Van Baxter, Brian Fricke, Melissa Lapsa, Xiaobing Liu, Jeffrey Munk, Keith Rice, Bo Shen, and Ed Vineyard. Also attending were members of the US Heat Pump National Team: Antonio Bouza (DOE and International Organizing Committee chair for the conference), Jerry Groff (Groff Associates, North American regional coordinator for the conference), Wayne Reedy (industry consultant), Karim Amrane (Air-Conditioning, Heating, and Refrigeration Institute), Dan Ellis (President of ClimateMaster), Glenn Hourahan (Air Conditioning Contractors of America), Kostas Kontomaris (DuPont Fluorochemicals), and Dutch Usselton (Lennox Industries). Dan Ellis received the Ritter von Rittinger Medal, the highest international award in the air-conditioning, heat pump, and refrigeration field. ClimateMaster is the manufacturer of the award-winning Trilogy™ 45 Q-Mode™ ground source integrated heat pump system, which resulted from a CRADA collaboration with ORNL.



Onno Kleefkens (left), senior advisor to Netherlands Enterprise Agency, and Melissa Lapsa attend the 11th International IEA Heat Pump Conference.

EMPLOYEE EXCELLENCE:



Jennifer Hill



Deborah Counce

ORNL's Jennifer Hill and Deborah Counce earned Exceptional Effort Awards from the lab's Energy and Transportation Science Division, recognizing their tireless efforts on behalf of the BTP in support of principal investigators responding to various funding opportunity announcements.

VISITS AND EVENTS:

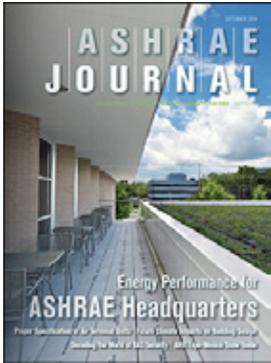
- Patrick Hughes and Ed Vineyard welcomed DOE-BTO sponsor Antonio Bouza, who toured the MAXLAB and other BTRIC equipment and appliance lab facilities.
- Mahabir Bhandari demonstrated heat transfer through different house envelope components using an infra-red camera at the Secret City Festival in Oak Ridge. The house demonstration is part of ORNL's science trailer program for educating the general public.
- Patti Garland, Julia Kelley, and Teresa Williams organized a day-long visit to ORNL for Dr. Comas Haynes on June 25. Haynes is serving this year as a joint faculty appointment from the Georgia Institute of Technology. While here, Haynes met with both BTRIC and National Transportation Research Center researchers. The day's meetings included discussions of numerous collaborative research opportunities. Haynes also conducted a seminar titled "An Exergy-Based Framework for Advanced Energy Systems Development."
- In June, BTRIC hosted 40 teachers and students as part of the UT Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks summer internship program tour. Melissa Lapsa provided a BTRIC overview, Mahabir Bhandari provided a tour of the two-story flexible research platform, Tony Gehl provided a tour of the MAXLAB Appliance Lab, and Simon Pallin provided a tour of the MAXLAB wall, air, and moisture chambers.
- Jibonananada Sanyal and Joshua New hosted the kick-off meeting of an East Tennessee chapter of the United States regional affiliate of the International Building Perfor-



From left, Patrick Hughes, Antonio Bouza (BTO), and Ed Vineyard note the new ASHRAE and R&D 100 award displays in the MAXLAB lobby.

mance Simulation Association (IBPSA), a sister organization to ASHRAE. Harshal Upadhye of the Electric Power Research Institute gave an invited talk on "Energy Efficiency Benefits of Variable Refrigerant Flow Technology" to the meeting attendees. IBPSA-USA's mission is to advance and promote the science of building simulation to improve the design, construction, operation, and maintenance of new and existing buildings in the United States.

MEDIA MENTIONS:



- **“Energy Performance for ASHRAE Headquarters”**
 The September 2014 issue of *ASHRAE Journal* featured a cover story about a paper co-authored by Xiaobing Liu. <https://www.ashrae.org/resources--publications/periodicals/ashrae-journal>
- **ORNL researchers share energy efficiency update on “The Housing Hour” radio show**
 A segment called “Smarter Home Technology Innovations” featured interviews with BTRIC’s Roderick Jackson and Philip Boudreaux. <http://www.thehousinghour.com/general/smarter-home-technology/>
- **White House blog featured ClimateMaster Trilogy™**
<http://www.whitehouse.gov/blog/2014/06/17/accelerating-green-technology-transfer-impact-american-lives>. The ClimateMaster heat pump was one of five products described as some of the most exciting breakthroughs in green technology that hold incredible potential for improving quality of life for Americans across the country.
- **ClimateMaster Trilogy™ recognized for Federal Laboratory Consortium for Technology Transfer (FLC) Award**
AltEnergyMag <http://www.altenergymag.com/news/2014/07/10/climatemasters-trilogy-40-geothermal-heat-pump-system-receives-flc-award/34002>
Plumbing Engineer <http://www.plumbingengineer.com/wp/climatemaster-receives-federal-laboratory-consortium-award/>
- **Hughes, BTRIC staff interviewed on improving building performance**
Electrical Contractor <http://www.ecmag.com/section/your-business/tightening-belt> features Omar Abdelaziz, Patrick Hughes, Teja Kuruganti, and Ed Vineyard.
- **Biswas’s roof assembly presentation mentioned in *Coatings World***
Coatings World http://www.coatingsworld.com/contents/view_online-exclusives/2014-07-30/second-biennial-international-roof-coatings-conference-gets-high-marks/ features Kaushik Biswas.
- **MAXLAB featured in Knoxville-based news story**
WATE 6 News <http://www.youtube.com/watch?v=Zwdb6mY3j0w&feature=youtu.be> features Roderick Jackson.
- **“Using Magnets to Keep Cool: Breakthrough Technology Boosts Energy Efficiency of Refrigerators”**
Energy Industry Today http://energy.einnews.com/pr_news/216699792/using-magnets-to-keep-cool-breakthrough-technology-boosts-energy-efficiency-of-refrigerators

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 or (865) 574-7267.

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