OAK RIDGE National Laboratory

BUILDING TECHNOLOGIES Update

April 2016 Issue

ORNL team presents groundbreaking report on alternative refrigerants to DOE Sec. Moniz

Last fall, an ORNL research team led by Omar Abdelaziz with the lab's Building Technologies Research & Integration Center (BTRIC) released a report evaluating performance of air conditioners when using low-global warming potential (GWP) refrigerants under high ambient temperatures. The research identified several viable low-GWP alternative refrigerants to replace baseline hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs) while retaining cooling capacity and energy efficiency levels.

Shortly after the report's October 2015 release, Abdelaziz met face to face with US Department of Energy (DOE) Secretary Ernest Moniz and US Environmental Protection Agency (EPA) Administrator Gina McCarthy at a public event in Washington DC, to explain the report's findings. Why the rush? The Obama administration required hard data on this issue before the 27th Meeting of the Parties to the Montreal Protocol (MOP 27), which was to take place in Dubai in early November 2015.

The Montreal Protocol has proven tremendously effective at accomplishing its original goal—repairing the ozone layer by accelerating the transition away from ozone-depleting refrigerants—and is now seen as a model for international cooperation to accelerate the transition away from high-GWP HCFC and HFC refrigerants. However, a key technical concern that has arisen in negotiations over the US amendment to the Montreal Protocol is whether low-GWP refrigerants can perform as well under high ambient temperatures.

BTRIC's Omar Abdelaziz (left) explains ORNL's work in climate-friendly refrigerants to DOE Secretary Ernest Moniz (right) and EPA Administrator Gina McCarthy (white jacket).

The timely release of Abdelaziz's report allowed it to be highlighted during the October 15 Washington event, which was held to announce new US public-private actions representing the nation's commitment to implementing its own amendment if adopted by the international community (see the White House fact sheet at: https://www.whitehouse.gov/the-press-office/2015/10/15/fact-sheet-obama-administration-and-private-sector-leaders-announce). Abdelaziz also presented the report's findings at MOP 27, where building support for the US amendment began in earnest.

The ORNL work was conducted transparently under intense international scrutiny, guided by a panel of international technical experts from Brazil, China, Egypt, India, Italy, Japan, Peru, Saudi Arabia, and the United States. The panel also included representatives from the United Nations Environment Programme (UNEP) and the United Nations Industrial Development Organization (UNIDO).

The work was closely scrutinized because several influential countries in hot climates were skeptical that air conditioners using low-GWP alternative refrigerants would perform well, and the amendment can not be adopted without their support. "We were under a tight deadline to finish the report," said Abdelaziz about the study that began earlier in 2015. "To be able to support the nation's proposal for affecting global decisions on environmental issues with accurate and informative data was our top priority."

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BTRIC joins CaloriCool as alternative refrigerant experts

Omar Abdelaziz and his team will participate in DOE's Caloric Cooling Consortium (CaloriCool™). This new consortium, in partnership with the private sector and universities, will focus on the development of alternative forms of refrigeration technologies—caloric cooling rather than systems based on the vapor compression cycle.

ORNL will provide expert system-level support, advanced magnetocaloric system designs, and additive manufacturing of caloric materials for optimized generator designs for the consortium, which will be led by Ames Laboratory. CaloriCool is one of four consortia that make up DOE's Energy Materials Network (EMN) announced in February 2016.

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Because chlorofluorocarbons (CFCs) and HCFCs are known to be potent ozone-depleting substances, the Montreal Protocol requires developed nations to move away from them in favor of HFCs. However, the existing rules allow developing countries to use CFCs and HCFCs for a longer period of time before being required to make the transition to HFCs. According to the US amendment, all countries are required to transition away from CFCs, HCFCs, and HFCs under the same time frame, which targets an 85% reduction by 2035 compared with a 2014-2016 average baseline.

ORNL and DOE began the High-Ambient-Temperature Evaluation Program for Low-GWP Refrigerants in March 2015. The program evaluated nine low-GWP refrigerants that could replace HCFC R-22 and HFC R-410A in air-conditioning equipment used in areas with high ambient temperatures such as the Middle East and parts of Asia and North Africa. The team evaluated the refrigerants in two mini-split—or ductless—air conditioners, which are commonly used throughout the region.

"It was thought that the soaring temperatures of 100°F to 130°F in these areas can cause air-conditioner performance degradation when using the alternative refrigerants. The goal of the research was to determine if similar or better energy efficiency and cooling capacity could be achieved with other low-GWP refrigerants compared to baseline refrigerants R-22 and R-410A," Abdelaziz said.

Representatives from two of ORNL's cooperative research and development agreement (CRADA) partners, Honeywell and Hillphoenix, accompanied Abdelaziz to Washington. The Honeywell and ORNL collaboration led to Solstice N40™, a new hydrofluoroolefin (HFO) blend drop-in replacement for R-404A in existing supermarket refrigeration hardware. Solstice N40 has 67% lower GWP and increases energy efficiency by 10%. The Hillphoenix and ORNL collaboration led to Advansor™, a CO_2-based supermarket refrigeration system that can be used for new and replacement installations. Compared with traditional R-404A systems, Advansor saves 25% on energy and 75% on greenhouse gas emissions over its life cycle. Both Solstice N40 and Advansor were recognized as R&D 100 Award finalists in 2015.

The DOE Building Technologies Office (BTO) sponsored ORNL's costs within the two CRADA collaborations; Honeywell and Hillphoenix were self-funded. BTO also sponsored ORNL's high-ambient alternative refrigerant evaluation study and report, which can be accessed at http://energy.gov/sites/prod/files/2015/10/f27/bto_pub59157_101515.pdf. Additional information is available in "Evaluation of Alternative Refrigerants for High Ambient Applications," published in the conference proceedings of the 2016 ASHRAE Winter Conference.

EERE Industry Day at ORNL showcased technology and innovation

ORNL hosted the first EERE Industry Day event, which was sponsored by several offices under the DOE Office of Energy Efficiency and Renewable Energy (EERE). Industry Day also served as the platform for unveiling ORNL's novel 3D-printed energy-sharing project, the Additive Manufacturing Integrated Energy (AMIE) demonstration.

About 350 people and 44 exhibitors participated in the Industry Day technology showcase that included more than 90 facilitated networking meetings in building and vehicle technologies and advanced manufacturing.

EERE Assistant Secretary David Danielson opened the 2-day event, along with representatives from Congress, academia, industry, and EERE program offices, and later took part in several sessions, presentations, and activities. The purpose of Industry Day was to discuss ways to advance science and technology through collaborations across ORNL, the University of Tennessee, and local and national industry.

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From top, EERE Assistant Secretary David Danielson addressed about 350 participants at the kickoff of EERE Industry Day, hosted by ORNL. Danielson also launched some initiatives during the event, including the JUMP crowdsourcing website. The AMIE demonstration was also unveiled during the event.

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The kickoff concluded with BTRIC's Roderick Jackson, principal investigator of the AMIE project, introducing the vision behind AMIE in a speech that asked "What If?" and positioned the novel energy-sharing research initiative as the next major step in rapid innovation that will most likely change the way the world thinks about generating, using, storing, and sharing electricity. He followed his remarks by demonstrating AMIE for the first time before an audience. The team also debuted the AMIE project video, available at https://goo.gl/TDXXDQ.

During the second day of the event, Danielson announced the winners of the Buildings Crowdsourcing Community Campaign initiated in March 2015: James Rowland, Mark Walter, and Matthew O'Kelly in the Equipment and Appliances category; Jim White in Sensors and Controls; and Rod Stucker in Envelope Technologies. Danielson then launched the next crowdsourcing initiative, called JUMP (Join in discussion, Unveil innovation, Motivate transformation, and Promote technology to market), in collaboration with DOE and several national laboratories and industry partners. Since Industry Day, ORNL's Melissa Lapsa, director of the BRTIC, and her team were awarded additional funding from DOE-BTO to expand the JUMP crowdsourcing initiative to include Argonne National Laboratory, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, and Pacific Northwest National Laboratory for expanded technology-to-market impact. Learn more at http://web.ornl.gov/jump and see article on p. 9.

Danielson also announced the new $20 million Small Business Vouchers (SBV) Pilot, http://www.SBV.org, DOE's Laboratory Economic Impact Initiative designed to assist more than 100 small businesses developing technologies in advanced manufacturing, buildings, vehicles, wind, water power, bioenergy, fuel cells, geothermal, and solar. Winners of the first round of SBV applicant companies were selected in 2016, and two more rounds of funding opportunities will begin later in the year.

In addition to Danielson, Industry Day guests included Thom Mason, laboratory director; Chuck Fleischmann, US Congressman representing Tennessee's Third District; Johnny Moore, ORNL Site Office manager, DOE Office of Science; David Millhorn, University of Tennessee executive vice president; Brian Lee, design partner with Skidmore, Owings & Merrill LLP (SOM); Anne Clawson, manager of government programs and partnerships, Alcoa; Rick Boyd, president of manufacturing operations, Clayton Homes; Rick Spears, founder and president, Tru-Design; and John Makinson, director of research and development, Hexagon Lincoln.

ORNL's Johney Green, Energy and Transportation Science Division director, served as the event's master of ceremonies. Keynote speakers and other guests included Roland Risser and Karma Sawyer, DOE Building Technologies Office; ORNL's Thomas Zacharia, Jesse Smith, Mike Paulus, and Martin Keller; Jay Rogers, Local Motors; Phil Enquist, SOM; Ed Steinebach, Eagle Bend Manufacturing; Scott Martin, Hillphoenix; Carey Chen, Cincinnati Incorporated; David Howell, DOE Vehicle Technologies Office; Dan Henderson, Caterpillar; Tracy Albers, Rapid Prototyping and Manufacturing; Sunita Satyapal, DOE Fuel Cell Technologies; Joyce Yang, EERE; Mark Johnson, DOE Advanced Manufacturing Office; and Reuben Sarkar, DOE deputy assistant secretary for transportation.

EERE Industry Day was sponsored by the Building Technologies, Advanced Manufacturing, and Vehicle Technologies Offices.

MAI insulation project moves toward higher R-value

BTRIC's Kaushik Biswas analyzes small-scale MAI foam composites in a multi-transducer heat flow meter apparatus.

Current commercially available insulation materials yield R-6 per inch or less with no major improvements in thermal performance since the 1970s. In collaboration with Firestone Building Products and NanoPore, a BTRIC project team led by Kaushik Biswas and Andre Desjarlais continues to research prototype composite foam boards with modified atmosphere insulation (MAI) cores.

MAI is a new-generation vacuum insulation panel (VIP) that has the same thermal performance as traditional VIPs but can be produced at approximately 50% of the cost. MAI panels are 6 to 7 times more insulating than current, commercially available insulation materials. The objective of this project, funded by a DOE funding opportunity announcement (FOA), is to develop 2-inch-thick composite polyisocyanurate board insulation with MAI that has an R-value of 25 (R-12 per inch).

The first-generation prototype boards were created by attaching 12 MAI panels to a 4 by 8 ft sheet of 0.5-inch high-density foam substrate in a 3 x 4 array with spacing in between the MAI panels. The spacing allows for cutting the board to the needed length or for fastening the composite board to the building wall or roof without piercing embedded MAI cores and losing the vacuum. The panels were then fed through a standard polyisocyanurate foam board manufacturing line for encapsulation by the foam, creating an insulation board with an overall thickness of 2 inches. Two, 4 by 8 ft composite boards were then used to fabricate a wall assembly test specimen for measuring thermal

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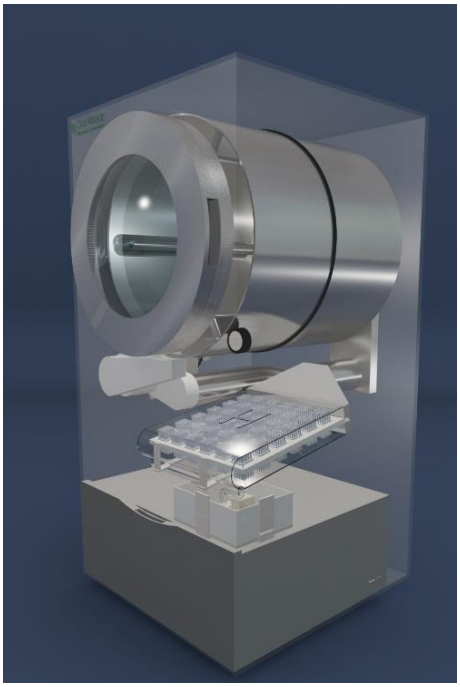
performance in ORNL's large hot box. The hot box analysis, per ASTM C1363, yielded an R-value of 21.6 h-ft2-°F/Btu (or R10.8 per inch), exceeding the team's expectations for the first prototype. A second-generation design that increases the overall area coverage of the MAI panels by reducing the spacings will be produced in March 2016, and higher thermal performance is expected.

Publications based on the research include "A Protocol for Lifetime Energy and Environmental Impact Assessment of Building Insulation Materials," published in Environmental Impact Assessment Review and "Insulation materials for commercial buildings in North America: An assessment of lifetime energy and environmental impacts," published in Energy and Buildings.

This project is sponsored by DOE-BTO. The team of ORNL, Firestone, and NanoPore was competitively awarded the funding in September 2014 under a BTO FOA.

BTRIC develops novel, energy-efficient thermoelectric clothes dryer technology

A collaborative effort between ORNL and Sheetak, Inc., has resulted in prototypes of a novel thermoelectric (TE) clothes dryer that is energy efficient and has a potentially short payback period. The solid-state heat pump technology is expected to deliver an energy factor greater than 6 lb/kWh, a major improvement over current electric resistance dryers, which perform at only 3.73 lb/kWh.



Novel thermoelectric clothes dryer could yield a 38% reduction in energy use in current dryers, which could save 356 TBtu of energy per year.

A research team led by BTRIC's Kyle Gluesenkamp built two prototypes to investigate two configurations: (1) a drum-integrated model that reduces the temperature lift of the heat pump and lessens the impact of lint and (2) an air-based model that has a shorter drying time but comparable efficiency.

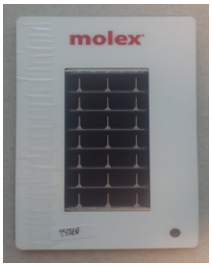
In the drum-integrated prototype, TE heat pump operation was simulated using electric resistance heaters and a chilled water coil. The inner drum surface heats clothes by conduction, causing moisture to evaporate, which passes through to the cool (exterior) side of the drum where it condenses and drains off. In the full TE version of this prototype, drum-integrated TE modules would cool the drum exterior while simultaneously heating the drum interior.

The air-based prototype has TE elements fully implemented. Humid air leaving the drum is cooled by passing over the cold side of the TE modules, resulting in water condensation that is drained off. The cooled air is then heated by passing over the hot side of the thermoelectric modules so it can re-enter the drum as hot, dry air. This air-based configuration is expected to dry clothes in less than 30 minutes with an energy factor above 6. So far, preliminary analyses have achieved a dry time of 40 minutes and an energy factor of 4.8.

The potential impact of the new technology is significant. A 38% reduction in energy consumption in current drying methods could save 356 TBtu of energy per year nationwide. By leveraging cost-reducing TE technologies developed by Sheetak, the team is targeting an installed price premium of $80. This would mean a payback period of only 2.5 years for customers. And because no venting is needed, the unit is simpler to install than current dryers.

Not least among the potential benefits of the new dryer technology are positive impacts to the economy. Sheetak is a US-based company, and production of 15 million high-tech modules for American consumers has significant potential for job creation in domestic manufacturing up and down the supply chain. According to the American Council for an Energy-Efficient Economy, utility savings garnered from the new dryers would allow consumers to spend more on products and services from sectors of the economy other than energy, where the job multipliers and positive impact on the general economy are greater.

ORNL and Molex working to make low-cost wireless sensors a reality



Low-cost wireless sensors are designed to peel and stick virtually anywhere to collect and send data to a receiver.

Efforts to bring ORNL's wireless sensor platform to market are on track and proceeding as planned. Last year, ORNL signed a CRADA with Molex, a premier international electronics manufacturer, with the goal of making low-cost wireless sensors commercially available for buildings applications (for background information see Clean Energy Newsletter, No. 5, p. 10).

By September 2015, Molex had produced functional prototypes of the peel-and-stick wireless sensors. The prototype, measuring 4.75 x 3 x 0.23 inches, is self-powered by a tiny photovoltaic (PV) cell that harvests energy from artificial indoor lighting to energize a tiny rechargeable battery. The sensor platform is designed to have very low power requirements, and the PV and battery are sized to last through long periods when lighting could be shut off (such as over a weekend). The platform also includes integrated circuitry for sensor signal processing, onboard computation, wireless communication, and an antenna.

The functionality of the node is optimized to measure temperature, humidity, and light. The ultralow-power smart sensors collect and send data to a receiver, which can capture data from many different peel-and-stick nodes and provide information to the controls of the energy-consuming system. ORNL has applied for a US patent for this unique energy-saving technology.

The ORNL/Molex team will next develop updated functional prototypes that satisfy the specific application requirements of an original equipment manufacturer (OEM). By May 2016, Molex will provide 200 samples for an *in situ* field evaluation of a supermarket refrigeration control system that receives inputs from the new peel-and-stick sensors.

The objectives of the CRADA are to achieve greater than an order of magnitude in cost reduction and provide market access to this new technology. If commercially available at the target price, endless application possibilities exist. Some of the teams' previous work with thermal processing and its practical applications can be found in the ECS Journal of Solid State Science and Technology, the IEEE Journal of the Electron Devices Society, and in a chapter of Additive Manufacturing: Innovations, Advances, and Applications. Improving the control of energy-consuming systems reduces energy consumption and utility bills. The wireless sensor platform is expected to pay for itself in only a few years through lower utility bills.

ORNL's effort within the CRADA collaboration is sponsored by DOE-BTO; Molex is self-funded.

Autotune software now open source

Building energy models show great promise for enabling private businesses to more effectively identify and estimate potential cost savings of reduced energy consumption measures in existing buildings. However, this promise remains largely unfulfilled, because models of existing buildings are unreliable unless calibrated so they correlate well with measured energy usage or other data from the actual building.

Calibrating models is currently cost prohibitive because it is an "art" that requires significant manual effort by an experienced, skilled professional. Autotune, as the name implies, automatically calibrates the model of an existing building to measured data from the building using weather files over the data interval (for background information, see researcher publications "Scalable Tuning of Building Models to Hourly Data" in Energy Journal and "Calibrating Building Energy Models Using Supercomputer Trained Machine Learning Agents," Journal of Concurrency and Computation: Practice and Experience).

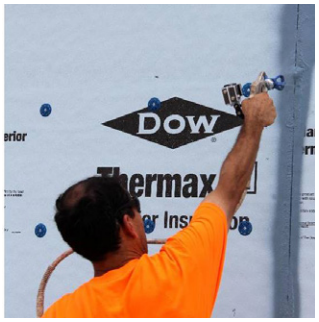
Autotune is now available as an open source software program and can be accessed at https://github.com/ORNL-BTRIC/Autotune. Private-sector businesses can now incorporate Autotune into their software products. So far, companies that offer (1) estimation and scheduling software for building energy retrofit contractors and (2) cloud-based computing resources to speed up building energy modeling by 100 to 10,000 times are actively integrating Autotune into their products and services.

The Autotune development team was led by BTRIC researcher Joshua New and included Jibonananda Sanyal. "The businesses integrating Autotune into their products, and the customers of these businesses, will be able to cheaply and quickly identify energy and cost savings potentials for your building using new 'zero-or-low touch' audit and simulation technologies" said New.

Autotune automatically calibrates models to building energy use data, a capability often explained to MAXLAB visitors in the Visualization Lab.

The emerging software products and services will be able to suggest cost-effective ways to adapt or retrofit residential and commercial buildings to make them more comfortable and energy efficient. Development of Autotune was funded by DOE-BTO.

ORNL CI-ReClad, Tunation teams help bring energy-saving technologies to market



Dow's THERMAX Wall System is the focus of Team CI-ReClad, part of EERE's Lab-Corps initiative.

Photo provided by Dow Chemical.

Lab-Corps is a DOE pilot program designed to accelerate the transfer of clean-energy technologies developed in the national labs to the marketplace. The National Renewable Energy Laboratory (NREL) hosted the first Lab-Corps cohort, which included 14 technologies from 8 national laboratories. ORNL was represented by Team Continuous Insulation-ReClad (CI-Re-Clad) and Team Tunation, both associated with building technologies projects.

Team CI–ReClad, in a partnership with Dow Chemical Company, researched ways to update an existing Dow product, THERMAX Wall System (TWS) with practical retrofit reclad application refinements. TWS combines the components of air, vapor, and water-resistive barriers while providing continuous thermal insulation. The integration and constructible details of these components benefits the building architect, contractor, and owner by reducing retrofit complexity, time, and cost.

Given the large amount of energy existing buildings consume, a cost-effective retrofit technology would greatly reduce energy consumption. Currently, few technologies existing in the marketplace fill this niche. Team CI-ReClad is assessing technologies that enables TWS to fill this niche and endeavors to learn how to better serve the retrofit market. Team CI-ReClad also studied study the commercialization potential of the updated system.

Diana Hun with ORNL's BTRIC is the project lead for Team CI-ReClad along with Som Shrestha and Mahabir Bhandari. Linda Jeng from Dow Chemical is the industry mentor. According to Hun, lessons learned from this Lab-Corps project will likely be implemented as part of the next round of research efforts under the U.S.-China Clean Energy Research Center-Building Energy Efficiency.

Team Tunation builds its solutions from Autotune, a software technology that will allow energy service companies to cheaply and quickly identify the energy- and cost-saving potential for commercial and residential buildings. It uses new "zero touch" audit and simulation technologies to cost-effectively learn and adapt a building model in real time. By reducing costs, Tunation will allow small- and medium-sized businesses to afford these services, expanding the market and ultimately reducing the nation's energy bill. Through Lab-Corps, the team hopes to learn more about what it takes to build a successful business, working closely with industry to identify any potential roadblocks.

With Autotune's https://www.ornl.gov/news/ornl-developed-building-efficiency-software-now-available recent debut on https://github.com/ORNL-BTRIC/Autotune GitHub, Team Tunation's job is to market Autotune's capabilities and accessibility so that it becomes widely known and used among energy service professionals. "Tunation aspires to tune every building in the nation," said BTRIC's Joshua New.

New serves as project lead and BTRIC's Jibonananda Sanyal as entrepreneurial lead for Team Tunation. Aaron Garrett contributes as software developer, and Varun Singh, Facebook product manager, serves as the team's industry mentor.

The Lab-Corps teams produced a video for each project, which can be viewed at http://web.ornl.gov/sci/buildings/media/videos/.

BTRIC partners with Emerson to develop new cold-climate heat pump

Cold-climate heat pump research could result in up to 70% energy savings.

People in cold climates who heat with electricity could realize savings of up to 70% with a new heat pump developed by BTRIC researchers and Emerson Climate Technologies. The tandem compressor system, developed through a CRADA, is effective at temperatures down to -13°F according to the research led by Bo Shen of BTRIC's Whole-Building and Community Integration group.

Using the lab's Heat Pump Design Model and EnergyPlus program, the research team conducted an exhaustive technology survey to select energy-efficient and cost-effective components, and Emerson optimized their compressor technology for cold-climate applications. A unit employing the chosen technology was analyzed at an occupied house in Ohio. The homeowner realized savings of more than 40% compared with the baseline heat pump during a month with an average ambient temperature of 20°F.

Emerson is promoting the design features developed by the team to the US OEMs that use Copeland compressors. Details about equipment selection, development, and testing have been published in proceedings of several heat pump and refrigeration conferences in the last two years.

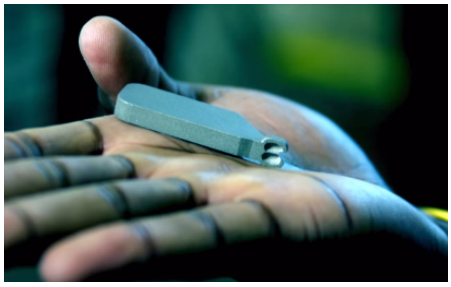
DOE-BTO sponsors ORNL's effort within the CRADA; Emerson is self-funded.

GLIDES technology delivers efficient energy storage

Ground Level Integrated Diverse Energy Storage (GLIDES) is a unique energy storage technology inspired by enormous pumped hydro energy storage systems but that is scalable to the needs of a small commercial building. Either electrical or thermal energy can be stored, and both can be retrieved later in the form of electrical energy. GLIDES has the potential to be low cost and have a higher round-trip efficiency (RTE) than electrical battery, pumped hydro, or compressed-air energy storage. Led by BTRIC's Ayyoub Momen, a team of researchers successfully achieved proof of concept of this exciting first-of-its-kind technology for buildings.

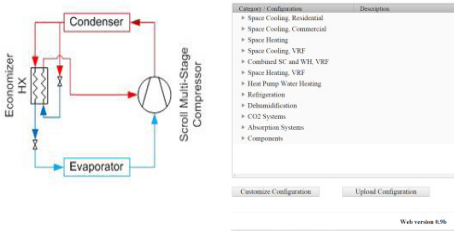
At the heart of GLIDES is a pressure vessel with air on top and water on the bottom. Electricity is stored by driving a positive displacement water pump to increase pressure in the vessel. Thermal energy is stored through heat exchange, which increases the temperature and pressure in the pressure vessel. Stored energy is released by directing high-pressure water from the pressure vessel through a Pelton turbine to drive an electric generator. The BTRIC team developed the storage system to be scalable and easily dispatched and to have both high and low charge and discharge rates. The technology uses the world's smallest Pelton turbine buckets, which are 3D printed. Preliminary data mirrored predictions from a theoretical model and achieved a thermodynamic RTE of 93%. The team then added the active heat transfer loop to the system and was able to improve this value by 4–5%.

Research to date has been funded internally by ORNL through the Laboratory Directed Research and Development program. However, several organizations within DOE and other sponsoring agencies, as well as industry, are showing interest in sponsoring GLIDES R&D programs aimed at applications at various scales. Research details are available in the proceedings of the ASME 2015 International Mechanical Engineering Congress & Exposition. The team recently released a video explaining and demonstrating GLIDES: https://youtu.be/CVf7KHLXDIE.



ORNL's GLIDES project features the world's smallest Pelton turbine buckets, which are 3D printed and used to generate unique, low-cost high RTE storage technology.

Web-based DOE/ORNL Heat Pump Design Model released



The new HPDM web interface, also developed by BTRIC, expands the tool's online accessibility.

DOE/ORNL's Heat Pump Design Model (HPDM), a hardware-based vapor-compression system research and design tool originally developed in the mid-1970s, remains cutting edge through continuous evolution. HPDM is actively used by industry for designing products and in research collaborations between ORNL and firms developing equipment to achieve industry-leading efficiency levels. Replacement refrigerants for CFCs and HCFCs were selected in part based on analysis using HPDM, and currently lower GWP replacements for HFCs are being evaluated experimentally and with HPDM. DOE's minimum efficiency standards for some product categories are based in part on analysis using HPDM. The nation's largest compressor manufacturer continues to use HPDM as the engine for its system design tool used by OEMs worldwide.

BTRIC researchers released an update of the web-based version of HPDM in February 2016. Using the online interface generates the required input file, executes the application, and summarizes the results on the user's browser. The updated HPDM can be accessed at http://hpdmflex.ornl.gov/hpdm/wizard/welcome.php.

Trane commercial RTU R&D sees 20% energy efficiency increase

Trane Commercial Systems and BTRIC have coaxed 20% greater performance out of a baseline commercial rooftop air-conditioning unit (RTU) with the potential for even better efficiency by switching refrigerants. Through a CRADA, BTRIC and Trane conducted an exhaustive technologies survey to select energy-efficient and cost-effective components, according to BTRIC's Bo Shen. Predicted annual energy savings for cooling of small office buildings at 16 US locations ranged from 44 to 48% compared with a baseline system.

Details on the collaboration's development of the RTUs are available in publications from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the International Refrigeration and Air Conditioning Conference, and ORNL reports. Trane and ORNL are now investigating using DR-55 as a promising low-GWP refrigerant to replace R-410A. The DOE-BTO sponsors ORNL's effort within the CRADA; Trane is self-funded.

BTRIC wins part of large Grid Modernization Initiative

DOE's Grid Modernization Initiative is a large, crosscutting effort sponsored by several offices within EERE and by the Office of Electricity Delivery & Energy Reliability. DOE recently concluded the Grid Modernization Lab Call process and announced awards totaling $220M over three years. ORNL will receive a total of about $22M over the three years, with about $11M of it in fiscal year 2016.

ORNL's buildings team was central to the lab receiving the funding as $5.3M of the $11M received in 2016 will be from DOE-BTO. This will result in several exciting new projects. For example, as part of the "connected loads" project, ORNL will develop and demonstrate low-cost, low-touch retrofit sensing and control technologies to increase the operational flexibility of building loads to improve energy efficiency, reduce peak demand, and provide transactive services enabling increased renewable power supply on the customer side of the utility meter. And as part of the "connected neighborhoods" project, DOE and ORNL will partner with Southern Company's "Neighborhoods of the Future" initiative. Two 50-home subdivisions (one in Georgia and one in Alabama) will be used to showcase the latest building energy efficiency, renewable energy, and buildings-to-grid integration technologies.

Magnetocaloric refrigeration team studies fabrication methods

MCM particles before they are processed into heat exchangers.

A household refrigerator-freezer based on the magnetocaloric effect is being developed under a CRADA between GE Appliances and ORNL, and early results suggest an energy savings of 25% over baseline vapor-compression-based units is feasible. With this concept, magnetocaloric materials (MCMs) are alternately demagnetized to reduce temperature and magnetized to increase temperature. A water-based secondary fluid is used to transfer heat from the refrigerator-freezer cabinets to MCMs—and ultimately to the home's indoor air.

BTRIC researchers Ayyoub Momen, Omar Abdelaziz, and Ed Vineyard (formerly of BTRIC) are addressing the major research challenge of how to manufacture MCM heat exchangers with low secondary fluid pressure drop. The team has investigated three techniques: sintering, 3D printing, and magnetic stabilization and has made progress on all fronts. They found a method to successfully sinter three different MCM alloys, which opens the door to fabrication of microchannels using a conventional manufacturing process.

The team also successfully 3D printed fine tungsten powder without applying heat at the last stage of the printing, indicating that the same heatless printing approach might be feasible on MCM particles. Experiments to print MCMs at room temperature are under way. In addition, the team fabricated a three-stage magnetocaloric regenerator through the magnetic stabilization process and sent it to GE for evaluation. The researchers are now fabricating a four-stage generator using MCM particles.

DOE-BTO sponsors ORNL's effort within the CRADA; GE Appliances is self-funded. The team's research on magnetocaloric refrigeration has been published in the proceedings of the ASME 2014 International Mechanical Engineering Congress & Exposition.

BTRIC completes national evaluations for Weatherization Assistance Program

In September 2015, DOE announced the release of two national evaluations of the Weatherization Assistance Program (WAP). Managed by ORNL, the peer-reviewed evaluations analyzed WAP's program year (PY) 2008, which is reflective of both a typical year in WAP operations and its operations during PY 2010. The evaluations provide insight into the unique program administered by DOE in the national effort to create jobs and promote

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BTRIC developed the two Weatherization Works national evaluation documents for WAP from vast amounts of data from 34 reports. The documents contain evaluations in seven areas.

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economic recovery as part of the American Recovery and Reinvestment Act of 2009 and are the most comprehensive, detailed analyses of WAP and its operations conducted to date.

"The results from the national evaluations demonstrate that weatherization provides cost-effective energy savings and health and safety benefits to American families," says Mark Ternes, ORNL's program manager for the Weatherization and Intergovernmental Program (WIP). "Because of the dedication of the entire WAP network, the evaluations demonstrate that this is a program that works."

According to the 2008 Retrospective Evaluation, the program weatherized about 98,000 housing units, resulting in program-wide, energy cost savings of $420M (in 2013 dollars) over the lifetime of the measures. For every dollar invested in weatherization in PY 2008, $4.72 was generated in energy and nonenergy benefits. The program weatherized more than 340,000 units in PY 2010, saving a total of $1.2B in energy costs. In addition to analyzing the energy and nonenergy savings and cost effectiveness of the program, process assessments were performed as part of evaluations of program administration, training, client and weatherization staff satisfaction, and deferrals, as well as other programmatic and special topics. Results from the two evaluations are contained in 34 reports.

WAP is a component of WIP, which operates under the DOE EERE office. Evaluations of the program provide insight into the opportunities for policy and practice enhancement that will allow WAP to build on its successful history of improving families' lives while saving energy. In addition to supporting WAP by performing periodic evaluations of the program, ORNL develops and maintains a suite of energy-auditing tools for use within the program and performs analyses to guide program policies. More about ORNL's efforts in support of WIP are available at http://weatherization.ornl.gov/index.shtml.

ORNL partners with national labs, industry to make innovative energy-efficient solutions a reality

Following the success of DOE's first Buildings Crowdsourcing Community Campaign, EERE Assistant Secretary David Danielson launched a second crowdsourcing platform called JUMP during the lab's Industry Day event in September 2015. "With JUMP, ORNL is engaging directly with industry partners, developing crowdsourcing campaigns to address pressing industry challenges and accelerate the next generation of energy-efficient building technologies," said Melissa Lapsa, director of BTRIC and JUMP project lead.

In November 2015, four other national laboratories joined the JUMP initiative: Argonne National Laboratory, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, and Pacific Northwest National Laboratory. With the five labs engaged, JUMP will be leveraging a variety of technical expertise and networking across the building sector. The JUMP expansion and the specific calls for innovation will be announced on April 12 at the Clean Energy Trust Summit in Chicago.

ORNL has three open calls for innovation sponsored by industry partners United Technologies Research Center and IntelliChoice. Through these calls, ORNL is working to identify solutions for energy-efficient building technology solutions and applications. The goal of JUMP is to solicit innovative solutions to the pressing energy-efficiency challenges identified by industry partners and then develop a roadmap for collaboration among the innovators and industry partners.

Winning submitters could qualify for cash awards, in-kind technical support, prototype development, and the opportunity for future collaboration. For more information and updates on JUMP, visit http://web.ornl.gov/jump.

EMPLOYEE EXCELLENCE

- ASHRAE recognized **Omar Abdelaziz** and **Som Shrestha** with a Distinguished Service Award, which honors members who have served ASHRAE faithfully and with distinction on committees or have otherwise given freely of their time and talent on behalf of the society. ASHRAE also recognized **Brian Fricke** with an Exceptional Service Award.
- **Ayyoub Momen** was recognized during the 2015 UT-Battelle Awards Night as Best Early-Career Researcher.
- BTRIC's **Melissa Lapsa** served on a panel during the Next South Conference and Career Fair, which is dedicated to those seeking careers in sustainability and corporate responsibility.
- At the annual Federal Energy Management Program (FEMP) awards banquet, **Julia Kelley**, group leader, Residential and Commercial Energy Efficiency (RCEE) group, and two other individuals received the Special Directors Award for their work organizing the Energy Exchange, FEMP's largest yearly training event.
- **John Shonder** received ASHRAE's 2015 Crosby Field Award for his work on a paper about Federal Energy Performance Contracts, which was the highest rated paper presented at a technical session.
- BTRIC's **Mahabir Bhandari**, Whole-Building and Community Integration group, was elected to a second term on the National Fenestration Rating Council board of directors.

Abdelaziz

Shrestha

Fricke

- **Mini Malhotra**, RCEE group, achieved Elsevier Outstanding Reviewer status for the journals Renewable and Sustainable Energy Reviews and Energy Policy for 2015.
- Numerous members of the AMIE demonstration team, led by BTRIC's **Roderick Jackson**, Building Envelope Research Systems group leader, received ORNL Significant Event Awards, including the following BTRIC/Buildings staff: **Kaushik Biswas**, **Heather Buckberry**, **Tony Gehl**, **Jennifer Hill**, **LaTonya Jordan**, **Melissa Lapsa, Sara Shoemaker** (subcontractor), **Ed Vineyard**, and **Johney Green**, ETSD director.
- The following BTRIC/Buildings support staff were recognized with ETSD Exceptional Effort Awards for their role in the successful Industry Day: **Karen Triplett, Dolynn Loy**, **Teresa Williams**, **Kathryn Lord**, and **Charlotte Franchuk** (subcontractor).

VISITS AND EVENTS

China Green Building Council visits BTRIC

- A delegation from the China Green Building Council visited ORNL last November. China accounts for about 50% of all new building construction in the world, and this is expected to continue for the foreseeable future. Chinese buildings also consume less energy per unit floor area than US buildings by more than a factor of 4, so this was also an opportunity to learn from our guests. Patrick Hughes provided an overview of ORNL and the Buildings Program, BTRIC's Heather Buckberry provided an overview of the AMIE project, and multiple staff were involved in lab tours. Xiaobing Liu and Bo Shen assisted with the visit by serving as interpreters. A presentation was given by Zhibing Mao of the China State Construction Engineering Corporation, the largest construction firm in the world. This organization will be one of the China-side collaborators on ORNL's next US-China Clean Energy Research Center-Building Energy Efficiency project to begin in 2016.

Zhibing Mao of CSCEC and his colleagues from the China Green Building Council visited ORNL, hosted by Building Technologies Program Director Patrick Hughes (right).

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- In 2015 Tennessee State Representatives John Ragan and Chuck Fleischmann made separate visits to MAXLAB. ETSD Director Johney Green accompanied the officials through the facility where they listened to overviews on the Building Technologies Program by Patrick Hughes and selected project briefs by BTRIC researchers.
- As a follow-on from EERE Industry Day, Helen Hardin, Congressman Fleischmann's chief of staff, returned to ORNL for a more in-depth tour of BTRIC facilities led by Patrick Hughes.
- Ellen Williams, director of the Advanced Research Projects Agency-Energy (ARPA-e); Peder Maarbjerg, assistant director for external coordination for ARPA-e; and Moe Kahleel visited ORNL last fall. They met with researchers, including BTRIC's Kyle Gluesenkamp, for a roundtable discussion and toured the AMIE house, hosted by Roderick Jackson, and MAXLAB, hosted by Patrick Hughes.
- ORNL hosted members of the Tennessee Valley Authority Industrial Marketing Fall Forum, which included tours of MAXLAB, part of the BTRIC user facility.
- Last fall, ORNL hosted more than 40 visitors from the Smithsonian Institute as part of the organization's Associates Study Tour. The group toured the BTRIC facilities and the AMIE house.
- Last December, Bill Kilbride, president and chief executive officer of the Chattanooga Area Chamber of Commerce, was given a tour of MAXLAB by Patrick Hughes and other staff.
- The Honorable Sharon E. Burke toured MAXLAB and listened to presentations given by Patrick Hughes, Joshua New, Diana Hun, Roderick Jackson, and Ayyoub Momen. Burke serves on ORNL's Energy and Environmental Sciences Directorate Science Advisory Board. As part of her visit, she gave a seminar titled, "National Security, Climate Change and Energy: Informing National Policy."
- Patricia Hoffman, DOE assistant secretary, Office of Electric Delivery and Energy Reliability, visited ORNL in February for briefings and tours, which included GLIDES by Ayyoub Momen and low-cost wireless sensors and transactive controls by Teja Kuruganti, both in MAXLAB.

In January, ORNL displayed AMIE for the first time outside of ORNL at the 2016 International Builders' Show (IBS) in Las Vegas. More than 6,000 IBS participants toured AMIE, led by ORNL staff and representatives from Clayton Homes, Techmer PM/ES, Tru-Design, and SOM.

MEDIA MENTIONS AND SOCIAL MEDIA

- ORNL shines in BTO 2015 Highlights report: http://energy.gov/eere/buildings/building-technologies-office-2015-highlights.
- AMIE video graces EERE blog: http://energy.gov/eere/articles/what-makes-amie-3d-printed-home-and-vehicle-unique.
- Home Energy Magazine blog lauds AMIE at 2016 International Builders' Show: http://www.homeenergy.org/newsite2011/public/index.php/show/blog/nav/blog/id/801.
- Storify.com hosts live Twitter chat on "Bringing Energy-Saving Innovations Home": https://storify.com/ORNLbuildings/twitter-chat-bringing-energy-saving-innovations-ho.

BTRIC's Roderick Jackson grabs a selfie with students inside the 3D printed AMIE house.

My Brother's Keeper event features AMIE

As part of My Brother's Keeper Day, ORNL hosted 30 students from Austin-East High School in Knoxville, Tennessee. My Brother's Keeper is a White House initiative designed to help underrepresented minorities focus on future success in science, technology, engineering, and mathematics through community engagement.

The students learned the value of high-risk, high-reward research and the role of national laboratories in pushing the envelope for progress from BTRIC's Roderick Jackson, who later led the group on a tour of the 3D printed AMIE project (displayed on the quad for the event). Then, nine ORNL staff members, including ETSD Director Johney Green, participated in a "speed-mentoring" question and answer session with the group.

A total of 11 national labs participated in the My Brother's Keeper event championed by DOE Secretary Ernest Moniz. Check out video coverage of the event at https://www.youtube.com/watch?v=3JKJTp7_HMM.

During EERE Industry Day at ORNL, the Additive Manufacturing Integrated Energy project was demonstrated for the first time, which was part of the event kickoff. Learn more about this novel approach to integrated energy systems and innovations in building envelope research at www.youtube.com/watch?v=RCkQBIFJRN4. Visit the AMIE project website at www.ornl.gov/amie.

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.

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