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NEWSLETTER OF *Oak Ridge National Laboratory's Energy and Environmental Sciences Directorate*

New research house provides flexible field analysis

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

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

The Yarnell Station house gives researchers flexibility in validating the capabilities of new and emerging energy-efficient technologies. Earlier this year, the house was put into service for the first time when a team from the Building Technologies Research and Integration Center (BTRIC) transitioned a NORDYNE prototype variable-speed air-source integrated heat pump from experimental facilities to Yarnell Station. NORDYNE is an ORNL Cooperative Research and Development Agreement (CRADA) partner.

At the unoccupied house, researchers have implemented a data acquisition system that collects data at regular intervals while the heat pump operates in a residential setting.

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

ORNL also partners with the Tennessee Valley Authority (TVA) and the Electric Power Research Institute on TVA's Campbell Creek research project, which established a unique facility that evaluates the effectiveness of residential construction and efficiency technologies in a controlled environment. The three Campbell Creek homes include

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OAK RIDGE National Laboratory

in focus letter

Buildings Program Director Patrick Hughes discusses advancements in building energy efficiency through industry partnerships and cross-discipline teamwork.

The first buildings-related R&D conducted at ORNL dates to the 1970s, and the ORNL Building Technologies Program has supported a number of offices within the US Department of Energy (DOE) since the formation of the department. Today, these programs include the Building Technologies Office, Federal Energy Management Program, Weatherization and Intergovernmental Programs Office, and Sustainability Performance Office.

We have come a long way since the 1970s when 20–30% of homes had no attic or wall insulation, windows were single pane with only 40% of homeowners using seasonal storm windows, and 30% of homeowners simply closed off rooms in the winter. Now, through better technology, equipment and appliance standards, building energy codes, and a host of other interventions, building energy consumption per unit of floor space has declined about 15% over the last two decades, while comfort, electronic conveniences, productivity, and life quality have all increased. Although the emphasis of the ORNL buildings program has varied over the years, building energy efficiency has been our common theme from the beginning, and there is much yet to be done.

Through the ORNL Energy and Transportation Science Division, the ORNL Building Technologies Research and Integration Center (BTRIC), and their predecessor organizations, four targeted buildings research areas have evolved and demonstrated sustained technical leadership for more than 30 years. These Centers of Excellence include building envelope research, building equipment research, systems and building integration, and technologies deployment. BTRIC is also a DOE-designated National User Facility that draws users from more than 100 industry and university partnerships—most of them repeat users, and some many times over.

The buildings program mission is to deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in building energy efficiency and, in doing so, create economic opportunity for the nation. Much of the credit for the buildings program's success in pursuing this mission is because of our extensive engagement with industry. Working with our industry partners allows us to benefit from their business discipline and market knowledge and helps keep our research commercially relevant by translating science into technology and, finally, into market products that reduce building energy consumption.

The buildings program vision is to bring cost-effective technologies and practices to market by applying ORNL's multidisciplinary science and technology expertise and state-of-the-art facilities to Cooperative Research and Development Agreements (CRADAs) with industry. In ORNL buildings program CRADA collaborations, the industry partner is generally self-funded and DOE funds ORNL contributions, for which industry investment exceeds DOE's. The technology readiness level advances more quickly by virtue of our engagement with industry partners, and DOE sponsors expect that our initiatives will yield new products in the market within five years. In addition to the 20 active CRADAs currently in our buildings portfolio, other valuable tools for accelerating new technologies to market have been work for others and user agreements.

The ORNL buildings program is well positioned for the future. The $20.2 million MAXLAB project (competitively awarded under the American Recovery and Reinvestment Act) has enabled us to strategically expand our building energy efficiency laboratory capabilities and update existing research apparatus. The core BTRIC research staff has expertise spanning all the essential elements—science and technology innovation; development expertise; and knowledge of manufacturer, supply chain, utility, architect and engineer, construction contractor, and building owner motivations.

There is a trend toward addressing the kinds of building energy efficiency solutions that require strong multidisciplinary teams to be successful. Project teams that combine core BTRIC research staff, industry partners, and highly specialized researchers from ORNL's signature strength areas (materials science, high-performance computing, neutron imaging, and advanced manufacturing) have collaborated with excellent early results. The new University of Tennessee–ORNL Governor's Chair for High-Performance Energy Practices in Urban Environments (or Governor's Chair for Energy + Urbanism, for short) is expected to

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Team Leader
Suzy Fowler

Publication Director
Katie Elyce Jones

Editors
Wendy Hames and
Charlie Horak

Graphic Designer
LeJean Hardin

Newsletter Committee
Kim Askey, Meghan Drake,
Penny Humphreys, Katie Elyce Jones,
Jennifer Palmer, Tamara Rogers,
and Sara Shoemaker

Photographers
Colby Earles, Genevieve Martin, and
Jason Richards

in the spotlight

Philip Enquist, Credit: SOM

Urban planning Governor's Chair will collaborate with ORNL to integrate sustainable living and the city environment

Philip Enquist, partner in charge of urban design and planning and leader of the City Design Practice at Skidmore, Owings, and Merrill (SOM), has been named the 16th University of Tennessee (UT)–ORNL Governor's Chair. SOM is among the world's leading urban planning, architecture, and engineering firms, and its City Design Practice is the world's most highly awarded urban planning group.

Enquist, with the support of a select research team—including many designers at the firm who specialize in sustainable urbanism and high-performance buildings—will serve as Governor's Chair for High-Performance Energy Practices in Urban Environments and will be affiliated with and administer projects through the UT College of Architecture and Design.

"Skidmore, Owings, and Merrill has erected the tallest man-made structures in the world, created advanced building technologies and material systems, and been central to the planning of cities across the world," said Scott Poole, dean of the College of Architecture and Design.

Poole noted that by 2015, more than 80% of the United States population will live in urban areas. This creates multiple environmental challenges that will be solved by a combination of cultural shifts and technological advances in the fields of regional planning, architecture, engineering, and the building sciences.

"Our clients—who span private developers, government agencies, and public-private partnerships—understand the need for projects to conserve resources, contribute to ecosystem health, and be resilient in the face of climate uncertainty," Enquist said. "The more knowledgeable we as a design team are of current science and energy research, the more effectively we can help clients develop transformative solutions."

The Governor's Chair will use ORNL's Building Technologies Research and Integration Center, which aims to push new energy-efficient building products to the market. SOM's team will promote innovative energy practices for new and existing buildings in urban areas, foster interdisciplinary collaboration, create the foundation for new UT graduate programs, and develop new models for the contemporary construction industry.

"Building-scale innovations are immensely important in the transition to a carbon-neutral world," Enquist said. "However, even the most sustainable building, with low embodied energy and net-positive operations, is limited in its impacts if it's removed from an urban context and its residents use carbon-intensive transportation. Integration between buildings and the urban environment to optimize the system is key."

Enquist's global experience includes city revitalization throughout China, the Canary Wharf Master Plan in London, and National Planning Development Strategies for the Kingdom of Bahrain. He has also led numerous planning strategies for projects in the United States, including the Chicago Central Area Plan and the District of Columbia Height Master Plan Modeling Analysis.

"For the Beijing Central Business District East Expansion, we showed how to reduce energy consumption within the district by 50%, water consumption by 48%, and landfill waste by 80%," Enquist said.

In Guangzhou, China, SOM's design of the Pearl River Tower—designed to be the world's highest performing super-tall building—leverages the building site and the tower's curved shape to drive energy performance and uses wind turbines, integrated photovoltaics, radiant cooling, underfloor air ventilation, and daylight reflectors to operate the building at 30% less energy than similar structures in China.

Enquist also leads SOM's pro bono initiative to develop a 100-year design vision for the Great Lakes and St. Lawrence River region.

"We are honored to have this opportunity to collaborate with the leading researchers and design educators of ORNL and UT, who represent a powerful combination of expertise and resources," Enquist said. "Nearly every research area at ORNL can inform our team's work around energy and urbanism."

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provide many additional opportunities to build multidisciplinary teams and expand programs from the buildings scale to those of communities, cities, regions, and beyond.

The ORNL buildings program has generated nine R&D 100 Awards and a long list of successful products that are on the market and are saving energy in real buildings. To keep ORNL staff, sponsors, industry partners, and other collaborators informed of our program's activities and accomplishments, we launched a quarterly newsletter in June of this year. The first issue of *Building Technologies Update* can be viewed from our newly updated website, Innovations in Buildings, at www.ornl.gov/buildings.

Directorate projects win five out of eight ORNL R&D 100 Awards

Projects from Energy and Environmental Sciences Directorate researchers won five of ORNL's eight R&D 100 Awards in the 2014 awards competition.

Continuously Variable Series Reactor, or *CVSR*, was developed by ORNL, SPX Transformer Solutions, Inc., and the University of Tennessee. ORNL inventors were Aleksandar Dimitrovski and Burak Ozpineci.

CVSR is a high-power magnetic amplifier that controls power flow in power systems. Conditions constantly change during the operation of power systems. A single CVSR provides smoothly variable alternating current (ac) circuit impedance, while multiple coordinated CVSRs installed throughout the power system provide full power system control. CVSR's unique design helps to ensure full use of power system assets, increased reliability and efficiency, and effective use of renewable resources.

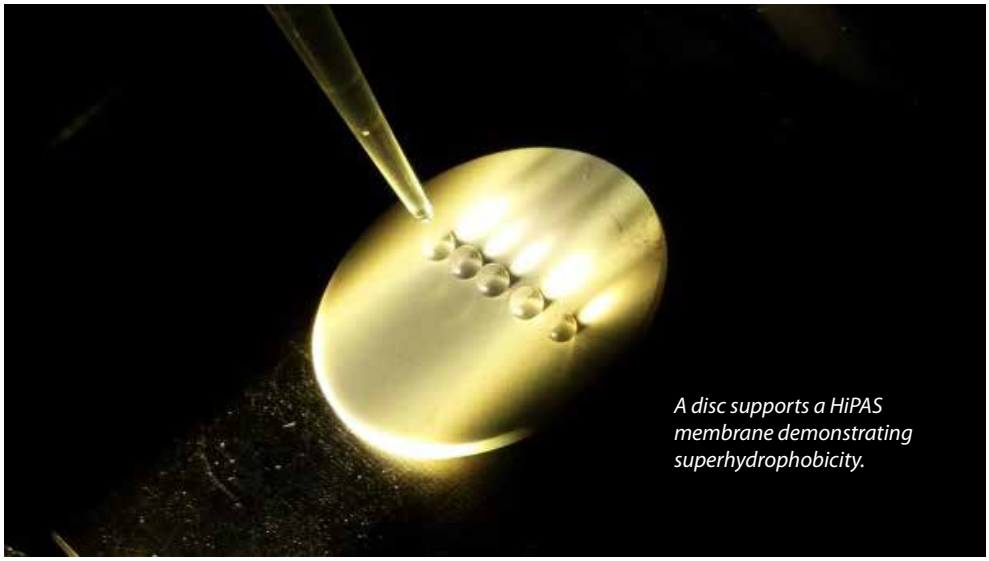
The research was funded by DOE's Advanced Research Project Agency–Energy (ARPA-E) under the Green Electricity Network Integration program.

High-Performance Silicon Carbide-Based Plug-In Hybrid Electric Vehicle Battery Charger was jointly developed by ORNL, Arkansas Power Electronics International, the University of Arkansas, and Toyota. ORNL team members were Laura Marlino, Nance Ericson, Shane Frank, and Chuck Britton.

This onboard battery charger technology for plug-in hybrid electric vehicles incorporates silicon carbide devices to provide 10 times the power density of current commercial charging systems, while delivering more efficient, higher-power throughput for faster charging times. In addition, the charger significantly increases the vehicle's range, and the battery pack can be charged from any available single-phase ac power outlet, allowing for cheaper off-peak hour charging while promoting a decreased dependence on expensive fossil-based fuels.

The project was funded through an ARPA-E award.

Ionic Liquid Anti-Wear Additives for Fuel-Efficient Engine Lubricants was developed by ORNL, General Motors Research and Development Center, Shell Global Solutions, and Lubrizol Corp. ORNL principal investigators were Jun Qu, Huimin Luo, Sheng Dai, Peter Blau, Todd Toops, Brian West, and Bruce Bunting.



A disc supports a HiPAS membrane demonstrating superhydrophobicity.

The technology employs a group of ionic liquids that can be mixed with common lubricating oils to form a nanostructured protective film on bearing surfaces that effectively reduces friction and wear. This ionic lubricant technology has the potential to save the United States millions of barrels of oil each year.

The research was sponsored by DOE's Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Office.

The RF-DPF Diesel Particulate Filter Sensor was developed by Filter Sensing Technologies Inc. in collaboration with ORNL and the Massachusetts Institute of Technology. The ORNL team consisted of James Parks II, Vitaly Prikhodko, and John Storey.

The RF-DPF is a radio frequency–based sensor and control system used to measure the amount, type, and distribution of contaminants on filters. This technology provides rapid real-time assessment of soot on diesel particulate filters, which allows greater precision in filter control, thereby reducing fuel consumption and greenhouse gas emissions. The RF-DPF can be used with light- and heavy-duty diesel vehicles and could enable longer filter life and overall system cost savings.

The project was funded by Filter Sensing Technologies Inc. and the DOE Vehicle Technologies Office.

Super-Hydro-Tunable HiPAS Membranes were developed by ORNL inventors Michael Hu, Matthew Sturgeon, Ramesh Bhave, Brian Bischoff, Tolga Aytug, and Tim Theiss.

This new class of membrane products can selectively separate molecules in the vapor/gas phase and perform liquid-phase separations, which could be especially useful in reducing the price of bioethanol, ethanol–gasoline blend fuels, and drop-in fuels from bio-oil processing. The membrane acts as an energy-efficient alternative to the distillation process by using a superhydrophobic or superhydrophilic surface to separate molecules. The membrane's larger pore sizes and architecture advantages drive never-before-achieved flow rates across membranes, sustaining characteristics key to repetitive or continuous operation under high pressures and temperatures. In addition to their potential in biofuel-based economies, these membranes could have a broad impact in the chemical, pharmaceutical, petrochemical, and gas separation industries.

This project was supported by ORNL's Laboratory Directed Research and Development Program and by DOE's Office of Energy Efficiency and Renewable Energy, Bioenergy Technologies Office.—*Chris Samoray*

ORNL climate researchers contribute to prestigious international, national climate reports

(From left): CCSI contributors to the NCA report are Benjamin Preston, Thomas Wilbanks, Virginia Dale, Steve Fernandez, and Peter Thornton. Preston and Wilbanks are also coordinating lead authors of the IPCC WG II report.

It has been a busy year for climate scientists around the world and at home. ORNL Climate Change Science Institute (CCSI) researchers numbered among the hundreds of authors who have prepared two major climate reports: the Intergovernmental Panel for Climate Change (IPCC) Working Group II (WG II) and National Climate Assessment (NCA) reports.

Intergovernmental Panel for Climate Change report

Thomas Wilbanks and Benjamin Preston are coordinating lead authors of the IPCC WG II report, which was released in Japan on March 31. The report found that climate change isn't just a problem for future generations—it also impacts humans in the present day.

Changing climates—whether from natural variability or anthropogenic sources—are putting water supplies under stress and the world's food supply at risk. These impacts hold serious implications for the poorer nations of the world, potentially leading to mass migrations and violent conflict over limited resources.

Since issuing its 2007 report, the IPCC has found evidence that governments and businesses around the world are making extensive plans to adapt to potential turmoil created by climate change. The IPCC reports, including WG II's report, are expected to carry considerable weight next year as world leaders try to craft a new global warming treaty.

Preston, CCSI deputy director, is one of three coordinating lead authors for Chapter 16, "Adaptation Opportunities, Constraints, and Limits," of the WG II report. The chapter assesses the latest research on the opportunities and barriers associated with using adaptation, or actions taken to help communities and ecosystems cope with changing climate conditions, as a strategy for climate risk management.

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ORNL partners with automakers to supercharge design process

Researchers from ORNL and General Motors (GM) are working together to create an advanced method to design more efficient fuel injectors. Leveraging the power of ORNL's Titan supercomputer and computational tools first developed for fusion reactors, researchers are accelerating the pace of innovation.

"The standard design optimization process is very time- and labor-intensive," said ORNL researcher Sreekanth Pannala. "As a result, it is not possible to fully investigate the numerous geometry and operating parameters and truly optimize the injector design for best fuel efficiency."

Through supercomputing, iterative designs can be evaluated autonomously and simultaneously with a wide variety of parameters, including different nozzle quantities and types and variations in pressure and temperature. This approach can reduce design development time from months to weeks.

DOE's Advanced Scientific Computing Research Leadership Computing Challenge (ALCC) recently awarded GM 15 million computing hours on Titan. A similar project with partner Ford Motor Company to identify combustion instability and enable advanced engine design received an ALCC award of 17.5 million hours.

These projects are part of ORNL's greater goal of creating an advanced toolset for optimizing vehicles through high-performance computing. The computational frameworks developed for the fuel injector and combustion projects will be made available to the automotive industry.

In addition to the ALCC awards, the GM and Ford projects were funded by the DOE Vehicle Technologies Office Advanced Combustion Engine R&D program with support for phase-one work from the Oak Ridge Leadership Computing Facility, which is funded by the DOE Office of Science.—*Kim Askey*

ORNL and GM researchers are using Titan to create an advanced method to design more efficient fuel injectors.

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Wilbanks, an ORNL Corporate Fellow, is one of two coordinating lead authors for Chapter 20, "Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development." He is also lead author of the WG II Summary for Policymakers and the Technical Summary. Chapter 20 states that climate change is a growing threat to sustainable development and calls for the development of "climate-resilient pathways." Such pathways combine mitigation and adaptation, which reduce the severity of the effects of climate change, with actions that improve the capacities of institutions to resolve tradeoffs for effective risk management.

National Climate Assessment report

CCSI scientists, including Wilbanks, Steve Fernandez, Peter Thornton, Virginia Dale, and Preston, were among the 240 authors who contributed to the third NCA report. Released on May 6, the report is an important resource for communicating the science and impacts of climate change in the United States and helps policy makers form decisions on climate change–related issues by providing information on past, present, and future climate trends based on technical reports.

"The Global Change Research Act of 1990 requires an NCA assessment report at least every four years. The report is produced by the 13 federal agencies that make up the US Global Change Research Program and is written by experts drawn from local, state, and federal governments, academia, and the private and nonprofit sectors," said Jack Fellows, CCSI director.

The 2014 report found that not only is the global climate changing but also that the source of change in the past 50 years has been predominantly the burning of fossil fuels.

Wilbanks was heavily involved in the creation of the NCA report. He researched the human impacts of climate change, how change will affect infrastructure, and how humans can adapt. He led the *Climate Change and Energy Supply and Use* technical input report, co-led the *Climate Change and Infrastructure, Urban Systems, and Vulnerabilities* technical input report, was lead author of chapters 4 (Energy Supply and Use) and 11 (Urban Systems, Infrastructure, and Vulnerability) of the NCA report, and advised the authors of chapter 28 on adaptation.

Senior ORNL researcher Fernandez co-led the preparation and submission of the *Climate Change and Infrastructure, Urban Systems, and Vulnerabilities* technical input report with Wilbanks.

Thornton, CCSI Ecosystem and Carbon Cycle research theme lead, was a lead author for chapter 15, "Interactions of Climate Change and Biogeochemical Cycles," which states that human activities have increased carbon dioxide by more than 30% over background levels and more than doubled the amount of nitrogen available to ecosystems.

Dale, an ORNL Corporate Fellow, coauthored chapter seven, "Forests," which finds that climate change is increasing the vulnerability of the nation's woodlands to wildfires, insect infestation, drought, and disease.

Preston contributed to the fifth chapter of the *Coastal Impacts, Vulnerabilities, and Adaptation* technical input report. The chapter finds that changes in the environment associated with human development compromise the ability of the coasts to provide a multitude of benefits, including food, clean water, jobs, recreation, and protection from storms.

CCSI's contributors to the NCA report are supported by the Office of Biological and Environmental Research in DOE's Office of Science and Office of Energy Efficiency and Renewable Energy.—*Justin Kaffka with reporting by Dawn Levy*

ORNL researcher is working to predict electric power blackouts before they happen

The largest power outage in United States history, the 2003 Northeast blackout, began with one power line in Ohio going offline and ended with more than 50 million people without power throughout the Northeast and the Canadian province of Ontario. Despite the apparent failure of the electric grid during such cascading events, blackouts aren't necessarily grid failures; they often are the result of automated protection measures to ensure that power surges or downed power lines don't damage trees, people, appliances, or other parts of the grid.

In the past, utility engineers have used static models of local electric grids to aim for single-contingency, worst-case scenario protection strategies rather than dynamic, real-time solutions to a unique grid disturbance. Through advanced modeling and computer simulation, Travis Smith and fellow R&D staff members in the ORNL Power and Energy Systems Group are developing tools to improve grid protection operation analysis and prediction under different scenarios—not only for familiar events like equipment failures, energy shortages, or extreme weather, but also in anticipation of

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ORNL, Cincinnati receive 2014 Innovation Award at RAPID conference

ORNL and Cincinnati Incorporated received the 2014 Innovation Award for their collaboration on large-scale additive manufacturing at RAPID, a leading industry conference on additive manufacturing, rapid technologies, 3D printing, and scanning. The award recognizes the most innovative new products or services exhibited at RAPID that are judged to have the greatest potential impact on the industry. ORNL's Lonnie Love delivered the keynote speech at RAPID 2014, which took place June 9–12 in Detroit.

Professor Denis Cormier of Rochester Institute of Technology presents the Innovation Award to Rick Neff of Cincinnati Incorporated and Brian Post of ORNL's Manufacturing Demonstration Facility at RAPID in June.

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influxes of renewable energy sources and "smart" grid components, such as communication devices and sensors, which both pose new protection challenges.

"We're integrating existing tools to do an even better job at what they already do," Smith said. "We eventually want to feed real measurements from the grid into the model, which for utilities means a faster response time because they can plan for individual scenarios."

For decades, utility planning engineers have used the Power System Simulator for Engineering (PSSE) or comparable software to plan utility infrastructure and power distribution. PSSE executes dynamic simulations of power transmission so engineers can analyze and optimize the grid's performance. Once planning engineers plan the grid, protection engineers must design protection strategies based on that plan.

"Protection engineers ask, 'If something goes wrong, if there's a fault, can we isolate one part of the system?" said Smith, who worked as a protection engineer and consultant for more than 15 years before coming to ORNL.

To simulate faults, or changes in electric current that typically indicate something has gone wrong on the grid, protection engineers use Computer Aided Protection Engineering (CAPE) software. However, predicting the protection strategy needed for any number of events—from a tree felling a power line during a storm to an abrupt rise or fall in consumer demand—is a much heavier computational burden than planning for the system to work under normal conditions.

"When protection engineers look at the grid, they are studying it under static conditions," Smith said. "So they simulate a fault to see what happens, but that simulation is not taking into account real-time dynamics on the grid."

In the end, grid protection relies on a string of automated protective relays, devices placed on transmission lines and substations. If a relay registers a disturbance, such as a drop in voltage, it will trip a switch and shut off local power. More often than not, protective relays are older electromagnetic devices that cannot transmit data to the utility company.

"Technicians often have to physically go to the substation and pull out a data file to understand what happened," Smith said.

High-voltage transmission lines.

When the first hours of a blackout are spent investigating what caused the outage, it can be difficult to prevent adjacent relays from tripping and creating further problems. For real-time solutions, Smith is developing a detailed protection program for ORNL's consolidated PSSE/CAPE software that analyzes changes in parameters such as current, voltage, frequency, and impedance to coordinate protective relays into a low-impact protection strategy as an event is occurring. He is refining the program and investigating the impact of renewable energy on grid protection using models of the Eastern Interconnection (EI), one of the nation's major grids, for the years 2008–21. The models are provided by the Eastern Interconnection Reliability Assessment Group, which analyzes and forecasts EI transmission conditions.

"The program script is automated so it can quickly analyze all the contingencies and provide a guidebook for a range of circumstances," Smith said.

One of the biggest R&D challenges is related to the size of the computational problem, which slows simulation times. For models that simulate the grid 5 to 10 years from now, an infusion of wind energy, small-system energy storage devices, and communicating sensors makes the amount of computation even more daunting, and simulation time steps shrink from milliseconds to microseconds to detect viruses or cyber attacks.

"Once you have a faster, smarter grid, you need protection for a faster, smarter grid," Smith said. "I'm working with computer scientists at ORNL to see if we can push the model to run faster than real-time speeds so we can predict what will happen before it happens."

While Smith says he currently might be "the only person in the world using this kind of program right now," he predicts that utility companies worldwide will adopt real-time protection analysis in the next few years. It will happen "soon, if we see a large blackout," Smith said. "We'll zoom into the model using EMT (electromagnetic transients), see what is happening among protective relays, and run higher resolution time step simulations to solve the problem before it gets out of hand."

This research is funded by the DOE's Office of Electricity Delivery and Energy Reliability Advanced Modeling Grid Research Program.—*Katie Elyce Jones*

ORNL team first to fully sequence bacterial genome important to fuel and chemical production

Sagar Utturkar, coauthor of high-rating biotechnology paper, in the team's ORNL lab.

ORNL researchers are the first team to sequence the entire genome of the *Clostridium autoethanogenum* bacterium, which is used to sustainably produce fuel and chemicals from a range of raw materials, including gases derived from biomass and industrial wastes.

The ORNL work was funded by LanzaTech, a biotechnology company based in Illinois with an innovative carbon recycling process. LanzaTech's gas fermentation platform uses proprietary microbes for efficiently converting carbon-rich waste gases and residues into useful fuels and chemicals.

Successfully sequencing *Clostridium autoethanogenum*—classified as a complex, class III microbe because of its many repeating units of DNA bases—has been of significant interest to the biotechnology industry. A *Biotechnology for Biofuels* paper coauthored by ORNL's Steve Brown and Miriam Land, University of Tennessee doctoral student Sagar Utturkar, and collaborating LanzaTech researchers generated a top-5% rating from Altmetric, an online rating system that measures the volume and value of recognition an article receives from research communities and media outlets.

"With the complete genomic sequence, we will have a better understanding of the microbe's metabolism and mutations that will enable LanzaTech to make modifications to the wild-type, or naturally occurring, strain for optimizing the conversion of waste into fuel," Brown said. "Our ORNL lab has a lot of experience sequencing genomes, and we have the analytic capability to tackle this project."

The research team sequenced the more than 4.3 million base pairs of DNA that make up the organism's genome using RS-II long-read sequencing technology developed by Pacific Biosciences (PacBio).

Although long-read sequencing technologies still struggle with high error rates, they promise to advance the biotechnology industry by making it possible to sequence microorganisms with many repeating sequences, such as *Clostridium autoethanogenum*, within a reasonable amount of time at reasonable cost. The ORNL team performed a greater number of reads and used data algorithms to correct for errors associated with the long-read technology.

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The Arcam A2X platform.

ORNL CRADA partner Arcam launches a new nickel superalloy process tested at Manufacturing Demonstration Facility

Arcam—a company that "provides cost-effective additive manufacturing solutions for the production of metal components"—has launched a process for Arcam Nickel Superalloy 718, a high-performance nickel chromium alloy for use in its Arcam A2X platform, an electron beam melting (EBM) system.

Arcam and ORNL have been working together through a Cooperative Research and Development Agreement on the EBM additive manufacturing powder bed process using DOE's Manufacturing Demonstration Facility. In this collaboration, the machine's processing parameters were determined in order to optimize component geometry and microstructure and materials properties. Parts made using the new process were displayed by Arcam at the RAPID industry conference in June.

The inaugural class of the Energy Efficiency and Renewable Energy Advanced Manufacturing Internship Program, which completed several hands-on projects at ORNL's Manufacturing Demonstration Facility, was recognized at a closing ceremony with representatives from participating organizations: (left to right) ORNL Research Systems Group Leader Lonnie Love, Pellissippi State Community College Vice President of Academic Affairs Ted Lewis , DOE Advanced Manufacturing Office Director Mark Johnson, ORNL Director Thom Mason and (right to left) US Rep. Chuck Fleischmann, Deputy Secretary of Energy Daniel Poneman, and (fourth from right) Oak Ridge Associated Universities President and CEO Andy Page.

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The team also compared the RS-II long-read results to two short-read technologies, concluding that the short-read technologies were unable to sequence the entire genome because of the bacterium's repetitive sequences, as expected.

"In our paper we compared three generations of sequencing technologies and explained why the long-read technology was able to finish the genome," Brown said. "Now, ORNL is independently looking at six different organisms using PacBio to compare and contrast experiences using this technology."

The project also revealed information about the genetic history of *Clostridium autoethanogenum* through short DNA sequences known as CRISPR systems, which retain genetic mutations such as those created during a viral infection that are subsequently passed on to future generations of a microbe. CRISPR systems are important indicators of strengths and vulnerabilities that biotechnology companies like LanzaTech look for when genetically modifying a microbe.
—*Katie Elyce Jones*

Manufacturing Demonstration Facility supports Wounded Warrior training program in advanced manufacturing

The Energy Efficiency and Renewable Energy Advanced Manufacturing Internship Program is a pilot skills-training program for returning service members and Wounded Warriors. The six-week pilot concluded on August 15 with a ceremony at Pellissippi State Community College in Knoxville, Tennessee at which Deputy Secretary of Energy Daniel Poneman addressed the 24 participants and discussed the importance of advanced manufacturing to US industry.

"To meet the evolving needs of the advanced manufacturing industry and keep us on the path towards a thriving 21st century economy, we have to get people trained and into the workforce," Poneman said. "The Advanced Manufacturing Internship shows how industry, government, and academia can join together to tackle critical national challenges and create the workforce we need for the future."

Within its first few days, the pilot program received more than 120 inquiries, leading to 73 applications from across the United States. The pilot group included 15 Army, Navy, and Marine veterans; 3 active duty personnel; 2 reservists; 3 FIRST Robotics students; and 2 undergraduate engineering students.

The program, which will begin an expanded 12-month pilot this fall, gives participants an accelerated, hands-on introduction to the field of advanced manufacturing through a combination of classroom and laboratory activities. Participants complete several hands-on projects at ORNL using DOE's Manufacturing Demonstration Facility, including the opportunity to design and print in 3D.

The program is facilitated through a partnership among Oak Ridge Associated Universities, the DOE Advanced Manufacturing Office, Pellissippi State Community College, and ORNL.

ORNL researchers develop "Autotune" software to make it quicker, easier, and cheaper to model energy use of buildings

ORNL buildings researchers Jibonananda Sanyal and Joshua New are developing software that will automatically calibrate models for simulating building energy use.

There are many ways to save energy in residential and commercial buildings. There are products that use less energy for lighting, heating, and cooling; 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, 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 Sanyal of ORNL's Building Technologies Research and Integration Center, a DOE user facility that develops new building technologies and provides unique capabilities for evaluating products and whole-building systems for market.

In 2010, 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 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 heating, ventilation, and air conditioning systems; water heating; lighting; weather interaction; 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 preretrofit 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 Autotune methodology uses multiparameter optimization techniques, in combination with big data mining–informed artificial intelligence agents, to automatically modify software inputs so that simulation output matches measured data," New said.

"Instead of having a human change the knobs, so to speak, the Autotune methodology does that for you," Sanyal said.

To develop their Autotune software, New and Sanyal used DOE supercomputing and computational resources—including ORNL's 27-petaflop Titan supercomputer and the National Institute for Computational Sciences' Nautilus system—to perform millions of EnergyPlus simulations for a range of standard building types, with generated data totaling hundreds of terabytes. On Titan, the team has been able to run annual energy simulations for more than half a million buildings in less than one hour using more than a third of Titan's nearly 300,000 CPU cores in parallel.

Additionally, they worked with building technology experts to identify about 150 of the most important parameters. By focusing on those, they can reduce computational load while still ensuring highly accurate results. The software uses machine learning algorithms to "learn" successful versus unsuccessful paths to optimization. In this way, if similar building input parameters are introduced later, the software optimizes the results more quickly by cutting out what didn't work before.

While programmatic guidelines for tax rebates and utility incentives often require an error rate below 30% when calibrating building models to monthly utility bills, Autotune's fully automated process has routinely calibrated models to an error below 1% on all building types tested. With such precision, an overnight Autotune process is far less costly than the time it would take an expert to manually calibrate a model.

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.

"We had to use supercomputing resources to create all the metadata used to train the software, but the Autotune software that will be available to the public doesn't require all these high-performance resources," Sanyal said. "We commonly run the software on a laptop."

This project was funded by the Building Technologies Office in the DOE Office of Energy Efficiency and Renewable Energy.—*Katie Elyce Jones*

Curbing greenhouse gas emissions with CO_2-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 carbon dioxide (CO_2) refrigerant systems and new refrigerant molecules, Brian Fricke, ORNL researcher with the Building Technologies Research and Integration Center in the Energy and Transportation Science Division, 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 CO_2. As a refrigerant, CO_2 is nearly ideal because it is nonflammable and nontoxic, doesn't affect the ozone, and has low global warming potential. CO_2 isn't perfect, though.

Because of its thermodynamic properties, as well as the operating pressures and temperatures involved in refrigeration, CO_2 tends to work more efficiently in cold climates, where it can be cooled by outside air. In warmer climates, such as the southern United States, it's more difficult to cool CO_2, and more energy is required to operate the refrigeration system.

The tests Fricke conducts aim to address this problem. One option he suggests is a cascade system, which in addition to using CO_2, also incorporates a traditional refrigerant such as R404A. R404A is efficiently cooled by warm outside air and can then be used to cool the CO_2. While R404A has a large global warming potential, a cascade system restricts it to a mechanical room in the back of a supermarket, where leakage risk is small and the quantity of R404A required is less.

"In warmer climates, CO_2 uses more energy, but it doesn't have anywhere near the environmental impact of leaking refrigerant," Fricke said. "If you're using CO_2 in the refrigeration system, that's CO_2 confined in the refrigeration cycle and not in the atmosphere. So, that's CO_2 that you've pulled out of the atmosphere, and it's not contributing to global warming as a greenhouse gas."

In addition to investigating CO_2's refrigeration qualities, Fricke has collaborated with Honeywell Inc. to study another replacement refrigerant for R404A that, unlike CO_2, could be used in an R404A system. To add another jumble to the refrigerant-naming-mix, the refrigerant Fricke is working on with Honeywell is a hydrofluoroolefin, or an HFO, called N40.

"CO_2 is only going to get more and more popular as time goes by," Fricke said. "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 the DOE Building Technologies Office. ORNL has cooperative research and development agreements with Honeywell and with refrigeration systems manufacturer Hillphoenix.—*Chris Samoray*

Brian Fricke examines a sample container in refrigeration research chamber.

BTRIC science seminars feature cutting-edge research

In fiscal year 2014, the Building Technologies Research and Integration Center (BTRIC) kicked off its Science Research Seminar Series—featuring state-of-the-art building technologies research—to promote BTRIC's extensive range of capabilities and to encourage lab-wide collaboration opportunities. The following researchers presented their projects in various areas of expertise:

- Ayyoub Momen, "Advancements in Building Equipment Technologies: Flexible Energy Storage and Advanced Cooling Systems"
- Kyle Gluesenkamp, "Sorption Heat Pumps for a Sustainable Economy"
- Teja Kuruganti, "Buildings to Grid Integration: Retrofit Control Techniques for Peak Reduction and Energy Efficiency Improvements"
- Omar Abdelaziz, "Accelerating the Transformation of Building Energy Efficiency"
- Patrick Geoghegan, "Altering the Course of Heat Transfer Through Additive Manufacturing"
- Joshua New, "Software vs. Reality: Bridging the Gap"
- Simon Pallin, "Probabilistic Energy and Durability Assessment in Buildings Design"
- Brian Fricke, "Reducing the Energy and Environmental Footprint of Commercial Refrigeration"
- Roderick Jackson, "Radically Transforming Buildings Through Integrated Energy Systems"
- Diana Hun, "Effect of Improved Building Envelope Air Sealing on Energy, Moisture Durability, and Indoor Quality"

Patrick Geoghegan displays additively manufactured heat exchanger components for more efficient combustion engines. New additive manufacturing techniques for heat transfer was the topic of his BTRIC science research seminar.

For more information on these seminar topics, please visit http://web.ornl.gov/sci/buildings/research/seminars/.—*Sara Shoemaker*

ORNL, CERC-BEE Building Technologies showcased during DOE visits to China

During a tour of the China Academy of Building Research (CABR) facility in Beijing, China in June, ORNL's Building Technologies projects were demonstrated for David Danielson, DOE's Assistant Secretary for Energy Efficiency and Renewable Energy, and Daniel Kritenbrink, Deputy Chief of Mission at the US Embassy 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 China trip, Secretary Moniz met with 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 and self-adhering materials that improve the airtightness of commercial and residential structures to reduce energy consumption by decreasing heating and cooling loads. The water-repelling material developed by ORNL and Dow Chemical is incorporated into cool roof coatings so they can 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 GSHP systems, for which ORNL industry partner ClimateMaster manufactures components. The CERC-BEE collaboration includes characterizing the in situ performance of these technologies in the CABR facility and at other demonstration sites, which could lead to additional innovation, invention, and technology improvement.

ORNL building technologies will lead six new DOE-funded projects and participate in two others

ORNL will participate in eight new projects awarded by the DOE Building Technologies Office, six of which ORNL building technologies research teams will lead. ORNL will partner with industry, academia, and other national laboratories to advance early-stage, breakthrough, energy-efficient solutions for buildings and homes. ORNL's postnegotiation awards are expected to total just shy of $6 million, with about $4 million for ORNL research.

Incubator projects to improve heating, ventilation, and air conditioning, water heating, sensors and controls, and building energy modeling include:

- ORNL with Sandia National Laboratories and University of Maryland—A high-performance refrigerator that uses a novel rotating heat exchanger to shorten energy-wasting defrost cycles.
- ORNL with Richman Surrey and the University of Tennessee—Improving energy efficiency in small and medium commercial buildings by nonintrusively monitoring the health of energy-consuming equipment and enabling corrective action.
- The University of Florida, ORNL, and Stony Brook University—A gas-fired combined water heater, dehumidifier, and cooler that uses a membrane-based open absorption cycle to cool and dehumidify indoor air and recover the latent energy of the moisture to heat domestic hot water.

Frontier projects to address energy efficiency in advanced clothes dryers, windows, and building thermal insulation include:

- ORNL with GE Appliances—Development of a prototype highly energy-efficient ultrasonic clothes dryer that uses ultrasound transducers to raise clothes fiber moisture into a fine mist that is easily removed by modest airflow at room temperature, resulting in low levels of lint.
- ORNL with Sheetak—An energy-efficient ventless thermoelectric clothes dryer that uses low-cost, solid-state, thin-film heat pump modules integrated into the dryer drum, enabling direct application of heat to the clothes, a low-temperature lift across thin-film, and low recirculation airflow rate.
- ORNL with NanoPore and Firestone Building Products Co.—Development of a composite polyisocyanurate foam board insulation that encapsulates premanufactured modified atmosphere insulation panels (a low-cost form of vacuum insulated panel).
- ORNL with VELUX Design and Development Company USA—A material composed of very small hierarchically structured porous silica particles that can be processed and poured between panes of glass, enabling highly insulating glazing units for windows and skylights without distorting or hazing the view.
- PPG Industries with the ORNL Manufacturing Demonstration Facility—Improving highly insulating vacuum-insulated glazings by lowering the manufacturing costs with a fabricate-on-demand process, improving edge sealing, pillar design, and the evacuation process.

US Secretary of Energy Ernest Moniz and Assistant Secretary for Energy Efficiency and Renewable Energy David Danielson made separate visits this summer to Beijing, China and to the CABR facility, where select ORNL Building Technologies projects are being evaluated as part of the US–China CERC-BEE collaboration.

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a "builder house" that is typical of how the majority of homes in the subdivision were built; the builder house serves as a monitored comparative baseline for the multiple-instrumented evaluations of energy efficiency and solar technology upgrades at the other two houses.

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

The common denominator among all of these research houses—Yarnell Station, Campbell Creek, and ZEBRAlliance—is that they were held unoccupied during the research period so that controlled experiments could be conducted. In addition to natural exposure to weather, an average occupant effect on energy use was imposed during experiments so that the technologies being characterized experienced realistic loads, operating conditions, and interactive effects. Human occupancy is simulated using process control to cause actions such as hot water draws and lights turning on and off.

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

Your own energy "island"? ORNL microgrid could standardize small, self-sustaining electric grids

When ORNL researcher Yan Xu talks about "islanding," or isolating, from the grid, she's discussing a fundamental benefit of microgrids—small systems powered by renewables and energy storage devices. The benefit is that microgrids can disconnect from larger utility grids and continue to provide power locally.

"If the microgrid is always connected to the main grid, what's the point?" Xu said. "If something goes wrong with the main grid, like a dramatic drop in voltage, for example, you may want to disconnect."

Microgrids are designed not only to continue power to local units such as neighborhoods, hospitals, or industrial parks but also to improve energy efficiency and reduce cost when connected to the main grid. Researchers predict an energy future more like a marketplace in which utility customers with access to solar panels, battery packs, plug-in vehicles, and other sources of distributed energy can compare energy prices, switch on the best deals, and even sell back unused power to utility companies.

However, before interested consumers can plug into their own energy islands, researchers at facilities such as ORNL's Distributed Energy Control and Communication (DECC) lab need to develop tools for controlling a reliable, safe, and efficient microgrid.

To simulate real scenarios where energy would be used on a microgrid, DECC houses a functional microgrid with a total generation capacity of approximately 250 kilowatts (kW) that seamlessly switches on and off the main grid.

This grid includes an energy storage system that generates 25 kW of power and uses 50 kW hours of energy built from second-use electric vehicle batteries, a 50 kW- and a 13.5 kW-solar system, and two smart inverters that serve as the grid interfaces for the distributed energy emulators. Programmable load banks that mimic equipment consuming energy on the grid can provide sudden large load changes and second-by-second energy profiles.

"A microgrid should run an automated optimization frequently, about every 5 to 10 minutes," Xu said.

To optimize grid operations, microgrid generators, power flow controllers, switches, and loads must be outfitted with sensors and communication links that can provide real-time information to a central communications control.

"Microgrids are not widely deployed yet. Today, functional microgrids are in the R&D phase, and their communications are not standardized," Xu said. "We want to standardize microgrid communications and systems so they are compatible with the main grid and each other."

Now two years into the inception of ORNL's microgrid project—"Complete System-Level Efficient and Interoperable Solution for Microgrid Integrated Controls," or CSEISMIC—the microgrid test bed at DECC is functional and employs an algorithm developed at ORNL that directs automatic transition on and off ORNL's main grid.

Xu said the next year will focus on getting the energy management system (EMS)

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ORNL partner Local Motors shares 3D vehicle printing and micromanufacturing technology from downtown Knoxville to the White House

President Obama speaks to Jay Rogers, CEO of Local Motors, at the White House Maker Faire event.

Since Local Motors partnered with ORNL in March, the vehicle manufacturer—which relies on consumer cocreation and micromanufacturing for rapid delivery to market—has opened a new storefront in downtown Knoxville; awarded a 3D Printed Car Design Challenge winner with involvement from ORNL and Cincinnati Incorporated; and visited the White House along with Craig Blue and Lonnie Love of ORNL's Manufacturing Demonstration Facility.

In May, Local Motors moved its first mobi-factory, or mobile factory, to a Knoxville Old City parking lot, opened a Market Square storefront, and began searching for about 20,000 square feet in the Hardin Valley area to build a microfactory. At the ribbon cutting event for the new Market Square retail location, Knoxville Mayor Madeline Rogero and other community leaders expressed the importance of being a central hub for this technology.

The company awarded the winner of its 3D Printed Car Design Challenge

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running. The EMS will drive optimization by allowing microgrid components to fluctuate operation based on parameters such as demand and cost.

"The EMS may, for instance, tell the PVs [solar cells] how much power to generate for the next 5 to 10 minutes based on the time of day and energy demand," Xu said.

The CSEISMIC team has long-term goals of partnering with industries to conduct field demonstrations of standardized grid prototypes.

"As soon as microgrids are standardized and easy to integrate into the main grid," Xu said, "we'll start seeing them in areas with a high penetration of renewables and high energy prices."

This project is funded by the DOE Office of Electricity Delivery and Energy Reliability Smart Grid Program.—*Katie Elyce Jones*

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at the beginning of June. The winning design inspired the first fully 3D printed car—which Local Motors manufactured at the Association for Manufacturing Technology's International Manufacturing Technology Show in Chicago in September with assistance from ORNL and partner Cincinnati Incorporated, using its Big Area Additive Manufacturing machine.

On June 17, Local Motors CEO Jay Rogers spoke with President Obama about the company's partnership with ORNL in large-scale additive manufacturing during the inaugural White House Maker Faire event to promote creativity and encourage invention. ORNL's 3D printing technology was further represented by Blue and Love, who support Science, Technology, Engineering, and Mathematics, or STEM, outreach in FIRST Robotics.

Along with local engagement and national notice, Local Motors' unorthodox business principle—its products are codesigned by a community open to anyone who wants to participate and share—received private-sector validation when GE Appliance announced a partnership the companies said "will pair cocreation and micromanufacturing to build and commercialize the next evolution of various GE products." GE is now planning a microfactory on the University of Louisville Belknap Campus in Kentucky.

ORNL-UT partnership through Bredesen Center yields first graduates, new transportation science focus

ORNL Director Thom Mason (seated, at left) and former Tennessee Governor Phil Bredesen sign certificates for the Bredesen Center's first two graduates, Vincent Kandagor and Scott Curran (standing, from left) while center Director Lee Riedinger (at right) watches.

ORNL researchers Scott Curran and Vincent Kandagor became the first students to earn their doctoral degrees through the Bredesen Center for Interdisciplinary Research and Graduate Education at the University of Tennessee (UT). ORNL and UT are leveraging their combined resources through the Bredesen Center in a unique education and workforce development program that brings an interdisciplinary focus to advancing energy science and engineering.

"The interdisciplinary aspect of the Bredesen Center was very attractive in terms of broadening my field of knowledge and bridging my interests in mechanical and environmental engineering," Curran said. "The link between ORNL and the University of Tennessee with the Bredesen Center made a lot of sense in being able to focus my doctoral research on a cutting-edge research area that I was already engaged in while being able to take classes at UT."

Kandagor previously worked with ORNL on the artificial retina project and contributed to ORNL materials science research while earning his new degree through the Bredesen Center.

"We're awfully proud of Scott and Vincent," said Bredesen Center Director Lee Riedinger. "They both transferred into our program once we'd started and were able to really shine, to really do some positive things."

Curran focuses on pushing the efficiency limits of internal combustion engines in his position with ORNL's Fuels, Engines, and Emissions Research Center (FEERC). Curran worked with Robert Wagner, FEERC director and joint faculty member with the Bredesen Center, to establish a new transportation science focus for the Bredesen PhD program. Wagner described the transportation thrust as providing "a multidisciplinary foundation for addressing the goals of reduced energy use and associated emissions from all aspects of transportation.

"Scott's research and accomplishments while in the Bredesen Center are an excellent example going forward of the value of a multidisciplinary approach to the complex challenges of the next generation of transportation," Wagner continued.

The Bredesen Center Energy Science and Engineering doctoral program was founded in January 2010 by former Tennessee Governor Phil Bredesen in partnership with UT and ORNL.—*Kim Askey*

ORNL inventors (from left) Chaitanya Narula, Brian Davison, and Martin Keller with Vertimass chairman William Shopoff display new technology that converts ethanol into a hydrocarbon blend-stock.

Vertimass licenses ORNL biofuel-to-hydrocarbon conversion technology

Vertimass LLC, a California-based start-up company, has licensed ORNL technology that converts ethanol into a hydrocarbon blend-stock for use in transportation fuels.

The ORNL technology offers a new pathway to biomass-derived renewable fuels that can lower greenhouse gas emissions and decrease US reliance on foreign sources of oil.

"Vertimass is very pleased to be partnering with ORNL to commercialize this revolutionary technology that can broaden the market for alternative fuels," said Vertimass chairman William Shopoff. "We see this technology as a significant step in moving the United States toward energy independence."

The technology, developed by ORNL's Chaitanya Narula, Brian Davison, and Associate Laboratory Director Martin Keller, uses an inexpensive zeolite catalyst to transform ethanol into hydrocarbon blend-stock. The resulting liquid is compatible with existing engine technologies and the fuel distribution infrastructure.

"This technology is a pathway to overcome the ethanol blend-wall," Narula said. "The blend-stock can be mixed into gasoline at higher concentrations than ethanol's current limit of 10%; plus, it can be added to diesel and jet fuel."

The potential impact of the newly licensed technology received coverage from media, including Green Car Congress, *Biomass Magazine*, and Phys.org. Vertimass plans to move from laboratory scale to a commercially available technology within four to six years.

The ORNL research was supported by the DOE Bioenergy Technologies Office. Initial funds were from the ORNL Laboratory Directed Research and Development and Technology Innovation programs and from the BioEnergy Science Center, which is supported by the DOE Office of Science.—*Morgan McCorkle and Kim Askey*

ORNL partners with diesel manufacturers to increase engine efficiency

ORNL is collaborating with nine US diesel engine manufacturers to address an industry-wide problem in a key emission control component. Exhaust gas recirculation (EGR) coolers reduce the temperature of recirculated gases in diesel engines, which increases engine efficiency and reduces nitrogen oxide emissions. Over time, soot and unburned fuel foul the EGR cooler and limit its function. According to ORNL researcher Michael Lance, these deposits "have the thermal conductivity of Styrofoam." The result is an efficiency loss of 1–2%, which can mean millions of gallons in wasted fuel each year across the commercial vehicle sector.

Lance uses neutron tomography, microscopy, and other nondestructive methods to gain a better understanding of fouling and corrosion in EGR coolers. Researchers from ORNL's Fuels, Engines, and Emissions Research Center contribute to the effort by characterizing the composition of soot deposits. Diesel manufacturers provide the real-world components for evaluation, and the research results are available to the engine manufacturing industry.—*Kim Askey*

Bioenergy expert Ragauskas named UT-ORNL Governor's Chair

Arthur Ragauskas

Arthur Ragauskas, an authority in bioenergy, was named UT–ORNL Governor's Chair for Biorefining earlier this year. Ragauskas's appointment is based in the UT Department of Chemical and Biomolecular Engineering and the UT Institute of Agriculture's Department of Forestry, Wildlife, and Fisheries. He will serve in ORNL's Biosciences Division and as a member of the DOE BioEnergy Science Center (BESC).

Ragauskas came to UT and ORNL from the Georgia Institute of Technology, where he was a professor of chemistry and biochemistry and a researcher in the Institute of Paper Science and Technology. His many honors include the American Chemical Society's Award for Affordable Free Chemistry; the Gunnar Nicholson Gold Medal Award from TAPPI, an arm of the American Paper and Pulp Association; fellow of the American Association for the Advancement of Science; Fulbright Distinguished Chair in Alternative Energy from 2008 to 2009; and visiting fellow at ORNL in 2013, during which he worked on a carbon fiber initiative.

Ragauskas's research is important to uncovering ways to convert biomass to biofuels, biopower, and biomaterials. Specifically, his work focuses on converting plant matter such as lignocellulose, found in the cell walls of energy crops, into biofuels. He also works to uncover applications of bio-based chemicals and materials for use in areas ranging from health care to packing material. As a founding member of BESC, Ragauskas served as the lead scientist of the Georgia Tech team researching the in-depth cell wall characterization of pretreated switchgrass and poplar biomass.

Ragauskas said he plans to collaborate with UT students and faculty and ORNL research scientists to develop biorefining research programs.

"The renewable biofuels enterprise is moving toward the development and commercialization of biomaterials from biomass feedstocks, largely to improve the cost of biofuel production," said Martin Keller, associate lab director for energy and environmental sciences. "UT and ORNL have a strong role in the basic and applied research needed to accelerate the economic viability of this approach, and Dr. Ragauskas brings to both institutions an international reputation and skill set that will help strategically position us for this new phase in renewable fuels and biomaterials research."—*Morgan McCorkle*

Leaders in additive manufacturing explore defense applications in three-day summit

Almost 200 participants from industry, academia, and government met at ORNL to discuss the potential of using additive manufacturing technologies and practices for defense manufacturing. Attendees were invited to tour both the Carbon Fiber Technology Facility and the Manufacturing Demonstration Facility. The three-day event was hosted by Craig Blue, director of the ORNL Advanced Manufacturing Program.

"The summit served as a great opportunity to bring together all aspects of the additive manufacturing value chain—ranging from manufacturers to end users to STEM educators, who are a critical component for enhancing US competiveness and innovation in the revitalization of American manufacturing," Blue said.

Gerald A. Tuskan

Tuskan named Corporate Fellow for distinguished career in biosciences

Gerald A. Tuskan, a distinguished scientist in the Biosciences Division, has been named an ORNL Corporate Fellow. Among the lab's highest honors, the corporate fellow designation recognizes a researcher's significant accomplishments and continuing leadership in scientific, engineering, and technological fields.

Tuskan's research focuses on the genetic basis of tree growth and development, including collaborations on the genome sequences of poplar and, more recently, eucalyptus biofeedstocks. In 2012, he was the fourth award recipient of the Institute of Forest Biotechnology's Forest Biotechnologist of the Year.

Tuskan received a bachelor's degree in forest management from Northern Arizona University, a master's in forest genetics from Mississippi State University, and a doctorate in genetics from Texas A&M University. He has written 154 journal articles, with 7,975 citations.

ORNL, DOE publication wins international communication competition "Best of Show"

The DOE Biological and Environmental Research (BER) publication *Research Priorities for Tropical Ecosystems Under Climate Change* won "Best of Show" in the Society for Technical Communication International Summit Competition. Team members of ORNL's Biological and Environmental Research Information System (BERIS)—who served as rapporteurs, writers, editors, and designers—prepared the report for publication by DOE BER. BERIS team awardees include Kris Christen, Holly Haun, Sheryl Martin, Marissa Mills, Judy Wyrick, Betty Mansfield, Brett Hopwood, and LeJean Hardin. ORNL's Richard Norby was a contributing writer. Other awardees included contributors from DOE BER and representatives of participating governmental and academic institutions.

Hydropower Asset Assessment Program wins ORNL SEA Award

ORNL's National Hydropower Asset Assessment Program, led by the Environmental Sciences Directorate's Hydrologic Systems Analysis team leader Shih-Chieh Kao and Energy-Water Resource Systems group leader Brennan Smith, received a 2014 Significant Event Award. Members of the team receiving the award are Kao, Smith, Shelaine Hetrick, Boualem Hadjerioua, Yaxing Wei, Kevin Stewart, Scott DeNeale, Ryan McManamay, Nicole Samu, Mark Bevelhimer, Dilruba Yeasmin, Fayzul Pasha, and Abdoul Oubeidillah.

Robert Wagner, Fuels, Engines, and Emissions Research Center director, will receive the American Society of Mechanical Engineers 2014 Internal Combustion Engine Award in October.

Sindhu Jagadamma received the Environmental Sciences Division's Outstanding Postgraduate Researcher Award in recognition of her research in soil carbon biogeochemistry and her work to better understand terrestrial carbon dynamics and improve incorporation of mechanistic processes in global carbon cycle models.

Alex Johs received the Stanley I. Auerbach Award for Excellence in Environmental Sciences for his work with the Molecular Environmental Process team in molecular biophysics related to the mechanism of protein mediated metal transformation reactions.

Rebecca Efroymson received the Holroyd Award, a science alumni award from La Salle University for leadership in the field of science, positive impact on the community, and commitment to the university's values.

Patents introduce new clean energy technologies or tools

"Lithium sulfide compositions for battery electrolyte and battery electrode coatings," US patent 8,597,838. ORNL inventors are Chengdu Liang and a team of researchers.

"System to continuously produce carbon fiber via microwave assisted plasma processing," US patent 8,679,592. ORNL inventors are Terry White, Felix Paulauskas, and Timothy Bigelow.

"Orthogonally referenced integrated ensemble for navigation and timing," US patent 8,686,804. ORNL inventors are Stephen Fulton Smith and James Anthony Moore.

"Multi-layered, chemically bonded lithium-ion and lithium/air batteries," US patent 8,722, 256. ORNL inventors are Chaitanya Narula, Jagjit Nanda, Brian Bischoff, and Ramesh Bhave.

"Treatment of cardiovascular disorders using the cell differentiation signaling protein Nell1," US patent 8,722,625. ORNL inventor is Cymbeline Culiat.

"Light-weight analyzer for odor recognition," US patent 8,726,719. ORNL inventors are Arpad Vass and Marcus Wise.

"Mitigated-force carriage for high magnetic field environments," US patent 8,729,996. ORNL inventors are Gerard Ludtka, John Wilgen, and Bart Murphy.

"Apparatus and method for carbon fiber surface treatment," US patent 8,741,395. ORNL inventor is Felix Paulauskas.

"Lignin-derived thermoplastic co-polymers and methods of preparation," US parent 8,748,537. ORNL inventors are Amit Naskar, Tomonori Saito, Joseph Pickel, Frederick Baker, Claude Clifford Eberle, Robert Norris, and Jonathan Mielenz.

"Microbially-mediated methods for synthesis of non-oxide semiconductor particles," US patent 8,759,053. ORNL inventors are Tommy Phelps, Robert Lauf, Ji Won Moon, Adam Rondinone, Lonnie Love, Chad Duty, Ilia Ivanov, and Claudia Rawn.

"Electric machine and current source inverter drive system," US patent 8,760,105. ORNL inventor is John Hsu.

Oak Ridge National Laboratory
Energy and Environmental Sciences Directorate
P.O. Box 2008
Oak Ridge, TN 37831

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Jeffrey Munk, building technologies researcher, examines a heat pump water heater, which is part of the new appliances and equipment laboratory in ORNL's Maximum Building Energy Efficiency Research Laboratory (MAXLAB). This new facility will be used for evaluating next-generation appliances and equipment for homes and buildings with an emphasis on improving control strategies to further increase energy savings and performance.