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Mercury series features ORNL scientists

Several ORNL researchers studying mercury were prominently cited in a 3-day series of articles that wrapped up earlier this year in the *Knoxville News Sentinel*. Scientists interviewed or referenced include Environmental Sciences Division's Liyuan Liang, Baohua Gu, Scott Brooks, Teresa Mathews, Mark Peterson, John Smith, and Mike Ryon; and Biosciences Division's Steven Brown and Jeremy Smith. Interviews with ESD's Gary Jacobs and Laboratory Director Thom Mason highlighted the value of ORNL mercury research. The 12 articles in the series can be viewed at http://blogs.knoxnews.com/munger/2012/01/wrap-up-on-mercury-project.html.

In a paper published earlier this year in the Proceedings of the National Academy of Sciences, ESD's Liyuan Liang and Baohua Gu (L to R) and other team members reported that compounds from decayed organic matter can either remove or help produce certain mercury forms that support the production of neurotoxic methylmercury in environments lacking in oxygen. The research is among the ORNL projects cited in the series.

Secretary of Energy tours MDF

Secretary of Energy Steven Chu visited the new Manufacturing Demonstration Facility on February 15, stopping first for discussions with ORNL energy storage researchers and officials from key industry partners, battery manufacturers A123 Systems and Dow Kokam.

Chu then received briefings on additive manufacturing and robotics research and development under way at the MDF, and cheered on a robotics demonstration by local high school students who worked with ORNL mentors after school and on weekends during January and February to prepare for FIRST Robotics competitions.

Prior to visiting the MDF, Chu began his day at Georgia's Vogtle nuclear power plant. He then came to Tennessee for a tour of ORNL's Consortium for Advanced Simulation of Light Water Reactors, DOE's designated Nuclear Modeling and Simulation Energy Innovation Hub that uses some of the world's most powerful computers to improve nuclear reactor design and engineering.

See pages 8–9 for additional photos from Secretary Chu's visit and other activities taking place at the MDF.

Energy and Transportation Science Division's Claus Daniel (L) briefs Secretary Chu on energy storage technologies made possible through new advanced battery manufacturing facilities within the MDF. ORNL will compete this spring to lead DOE's Energy Innovation Hub focused on advanced batteries and electrical energy storage, a five-year $120 million project.

In the Spotlight

ORNL microbiologist Richard Hurt is a member of the ENIGMA and the Mercury Science Focus Areas. He specializes in bridging gaps in genomes and developing protocols for improved extraction of DNA and RNA to obtain more complete results from interesting bacteria and microbial communities.

Richard Hurt

Richard recently used his new protocols to fill in the missing pieces of a bacterial genome that researchers at other institutions had failed to complete. "By studying the DNA surrounding 'intractable' gaps in the *Desulfovibrio desulfuricans* genome, I was able to identify a common source of difficulty and complete the genome," he explains. "This led to a general process for determining the DNA sequence that worked and works in many other organisms." This part of his work is under invention disclosure by ORNL and under consideration by the journal *Nature Methods*.

He's working to do the same for other difficult genomes. "I find workable solutions to difficult problems by parsing complex molecular systems into their basic parts so sources of difficulty become apparent and solvable," he says of his methods.

ENIGMA (Ecosystems and Networks Integrated with Genes and Molecular Assemblies) is the largest project for the Genomic Sciences Program at DOE and involves more than 20 national labs and university partners. Their goal is to understand how microbial communities function and communicate. Figuring this out has far-reaching consequences to forward research in bioremediation, carbon sequestration, and climate change. The mercury SFA is a multidisciplinary, multi-institutional effort to understand the behavior of mercury in the environment and particularly to decrease the production of methylmercury, which can cause neurological and autoimmune diseases.

Richard worked in private sector biotech for several years before returning to ORNL in 2010 (he had worked here earlier). "I learned to identify knowledge gaps in our capability and find working processes to solve them," he says. "The hope is to design a broadly applied technology that will be in use for a long time."

Richard has a Ph.D. in microbiology and biochemistry from the University of Tennessee–Knoxville.

BESC research makes journal cover

Research from the BioEnergy Science Center at ORNL was featured in January on the cover of the *Journal of Proteome Research*. ORNL researchers, including EESD Associate Laboratory Director Martin Keller, Biosciences Division's David Graham, and Chemical Sciences Division's Richard Giannone and Robert Hettich studied how the proteins of a bacterium named *C. obsidiansis* responded to different carbon sources. The microorganism, first discovered by BESC researchers in a Yellowstone hot spring, could play a role in the development of a cheaper biofuel production process.

EESD aims to deliver high-impact outcomes through Launch Initiative

In October 2011, the Office of the Laboratory Director issued a call for a new LDRD-funded program specifically targeting near-term, transformative impact through the successful deployment of ORNL technologies.

The LDRD Launch Initiative call drew a total of 46 proposals from ORNL researchers, leaving the review committee challenged to identify those with the highest potential for producing disruptive new solutions to real-world technical problems. Comprising senior leadership team members, the committee selected five projects, four of which are led or co-led by Energy and Environmental Sciences Directorate researchers.

Transparent and Durable Superhydrophobic Thin Film Technology. Co-PIs are Chemical Sciences Division's Tolga Aytug and Measurement Science and Systems Engineering Division's John Simpson.

Active, Composite Material for Prevention and Treatment of Fouled Surfaces. Co-PIs are Biosciences Division's Mitch Doktycz, David Allison, Scott Retterer, and Steve Allman.

NanoFermentation: Low-Cost Nanomaterials for PV Devices. Co-PIs are Materials Science and Technology Division's Chad Duty and Pooran Joshi; Biosciences Division's Tommy Phelps and Ji-Won Moon; and Measurement Science and Systems Engineering Division's Lonnie Love.

Real-Time Aqueous and Vapor Phase VOC Field Sensor. Co-PIs are Environmental Sciences Division's Dave Watson and Chemical Sciences Division's Jun Xu.

One-Stop Information Shop: Personalized Content Recommendations is the fifth project, led by Computational Sciences and Engineering Division's Songhua Xu.

Each of the project teams has been assigned an industry mentor to help guide the technology toward a high-impact outcome. When the first year of funding winds down in September 2012, the Review Committee will select one or two of the LDRD Launch Initiative projects to receive a second round of funding.

Building excitement

Later this year the Maximum Energy Efficiency Building Research Laboratory (MAXLAB) is scheduled to open on Bethel Valley Road, a $20.2 million DOE investment through the 2009 American Recovery and Reinvestment Act. MAXLAB will consist of a main research facility for controlled study and advancement of building envelopes and heating/ventilation/air conditioning (HVAC) systems, as well as two flexible research platforms for testing of full-scale light commercial buildings, including enclosures, equipment, and whole-building diagnostics and controls under natural exposure.

Broad in scope and capabilities, these new facilities represent just one Building Technologies Research and Integration Center initiative making headlines at ORNL these days with recent boosts in supercomputing, novel project funding, and collaborative opportunities.

- On February 10, GE Appliances announced the opening of its GeoSpring™ Hybrid Water Heater manufacturing facility in Louisville, Kentucky. Rolling off the assembly line for the first time domestically, the GeoSpring™ was developed through a Cooperative Research and Development Agreement between ORNL and GE. Compared with a conventional 50-gallon tank water heater, it uses 50 percent less energy and is more economical to operate. The GeoSpring™ has been available nationwide to consumers through national and local retailers and plumbing distributors since November 2009.

The GeoSpring™ Hybrid Water Heater was developed through a CRADA between ORNL and GE.

- A Director's Discretionary allocation for 500,000 core-hours on the Jaguar supercomputer was recently granted to a BTRIC-led team to support the development of a generalized, automated building energy model (BEM) tuning methodology that enables models of buildings to reproduce measured data from the buildings by selecting best-match input parameters in a systematic, automated, and repeatable fashion. The team has also submitted two peer-reviewed proposals for additional time that are pending release. Research efforts are expected to dramatically enhance the energy-saving impact of BEM, including DOE's flagship model EnergyPlus.

- BTRIC researchers will soon apply their comprehensive knowledge of buildings and energy use to non-civilian facilities. The Office of the Assistant Secretary of Defense for Operational Energy Plans and Programs has awarded ORNL's joint proposal with Lawrence Berkeley National Laboratory and United States Pacific Command approximately $6 million over the next three years for research geared at improving the energy efficiency of military expeditionary outposts and forward operating bases. ORNL is the technical lead on the project.

- Valuable partnerships are growing stronger with efforts launched in January to establish a CRADA with the Air Barrier Association of America, which represents stakeholders in the building enclosure industry including manufacturers, suppliers, distributors, architects, engineers, contractors, researchers, testing and audit agencies, consultants, and building owners. ORNL is already a partner with ABAA in evaluating the cost and performance of eight generic types of air barriers, a project that resulted in the implementation of stricter air sealing language in model codes in 2011.

- Earlier this year, BTRIC researchers completed a year-long evaluation of initial ground source integrated heat pump prototypes based on data collected at two ZEBRAlliance research houses. The units use half the energy of conventional equipment, provide space conditioning and water heating from a single heat pump, and were developed under a CRADA with ClimateMaster. Prototypes redesigned to resolve all technical issues and fit in the same cabinet as like-capacity standard units will be installed in ZEBRAlliance houses for testing in March, and ClimateMaster plans to launch its new 'Trilogy' product line based on the technology.

Ground source integrated heat pump

"With buildings accounting for 40 percent of our primary energy use, reducing energy consumption in buildings is necessary to achieve a sustainable clean energy future," said BTRIC Director Patrick Hughes. "These are just a few examples of how ORNL is tackling the challenge by supporting development of advanced building technologies, whole-building and community integration, and improved energy management during building operations."

Watch for more comprehensive articles on the new MAXLAB and flexible research platforms in future issues of the EES Quarterly as construction nears completion.

> "...reducing energy consumption in buildings is necessary to achieve a sustainable clean energy future..."
>
> BTRIC Director Patrick Hughes

A $20.2 million DOE investment through the 2009 American Recovery and Reinvestment Act, the MAXLAB is scheduled to open later this year.

Image analysis tool reveals clues to retinal cancer

Researchers at St. Jude Children's Research Hospital, using an image analysis tool developed at ORNL, discovered that a deficit in Rb, a gene that suppresses retinoblastoma tumors, plays a role in retinal cancer. Retinoblastoma, a cancer that usually develops in children age 2 or younger, results from a mutation in a gene controlling cell division.

The specialized tracing algorithms enable neurobiologists to analyze nerve cells and detect retinal abnormalities in mice at the cellular level.

"Previously, this was a very time-consuming and labor-intensive process," said Measurement Science and Systems Engineering Division's Ryan Kerekes. "Existing commercial software tools were not tuned to this particular data and produced too many tracing errors." Other tools can analyze only a few cells in sufficient detail, he said, whereas the ORNL tool is sufficiently accurate to analyze thousands of developing neurons.

The results showed that horizontal neurons deficient in Rb exhibited abnormalities in the organization of their dendrites (branches of neurons) within a certain number of days after birth.

Ryan, along with MSSED's Shaun Gleason and Mahmut Karakaya, developed the software and the automated tool that traces the dendritic arbor, the intricate network of branches emanating from each neuron. Researchers use the tracing tool to draw a line along each branch in the neuron's network, measuring its length, angle, and other parameters.

The image analysis work at ORNL is supported by seed money and by St. Jude. Overall project funding comes from the National Cancer Institute, National Institutes of Health, Fogarty International Research Collaboration Award, American Cancer Society, Research to Prevent Blindness Foundation, and American Lebanese Syrian Associated Charities.

Statistical study tracks patterns of rainfall extremes

A statistical study of rainfall patterns in India shows that although there is no evidence that rainfall extremes are increasing uniformly over the entire region, the spatial variability of rainfall extremes has increased steadily.

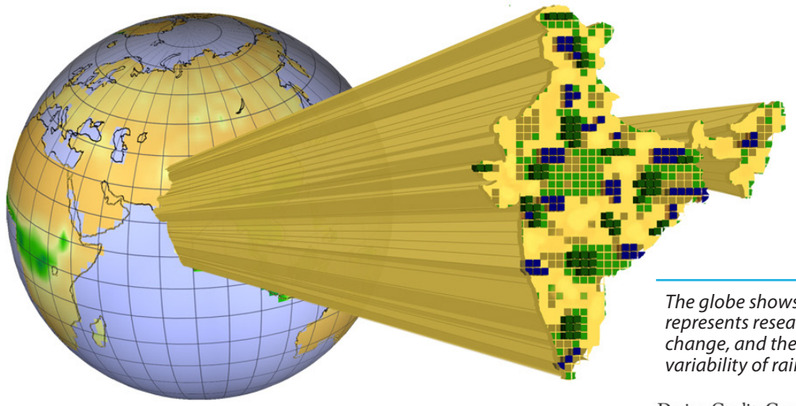
The study uses statistical methods designed especially for modeling extreme values and the associated uncertainties. "Our research suggests that one needs to be aware of different characterizations of extremes and that these characterizations require both interpretability and statistical rigor," said PI Auroop Ganguly, formerly of ORNL and now at Northeastern University.

Auroop, Environmental Sciences Division's Shih-Chieh Kao, and researchers from the Indian Institute of Technology and Temple University used their statistical methodology to analyze data provided by the India Meteorological Department from 1,803 stations between 1951 and 2003.

Not only global-scale issues but also local and regional phenomena such as urbanization and deforestation are important factors, Auroop said. Statistical observations offer complementary insights to current physics-based computer models, especially if the goal is to understand climate and rainfall variability at local to regional scales. In previous work, Shih-Chieh and Auroop showed that although models do reasonably well at characterizing precipitation extremes at large spatial scales, uncertainty increases at localized scales, especially in the tropics.

"The kinds of insights generated from this study can be used as methods for model diagnostics and can help address science gaps," said Shih-Chieh. The methodology used can be applied in any part of the world.

The research team includes members from diverse disciplines: civil engineering, climate studies, computer science, and statistics. The idea for the research was initiated when all the researchers were working at ORNL. It was funded by ORNL's Laboratory Directed Research and Development Program, the National Science Foundation, and the Department of Science and Technology of India.



The globe shows rainfall values and represents research focused on global climate change, and the India map shows the spatial variability of rainfall extremes.

Design Credit: Geneva Hill

Advanced fuel cell technology surfaces with cost-savings and performance benefits

Successful multi-year collaborations with industry, universities, and other national labs have enabled the development and industry demonstration of an ORNL-developed technology for advancing next-generation fuel cells.

Several years of scientific study followed by assessment and scale-up work that began in 2007 have culminated in researchers establishing the viability of a novel nitriding approach in conjunction with an ORNL-developed ferritic stainless steel alloy for use with thin stamped bipolar plates.

The design basis of the alloy, Fe-20Cr-4V, evolved from studies of protective nitride surface layer formation on more expensive titanium-base and nickel-base alloys, to implementation in low-cost iron-base alloys. Unlike many conventional stainless steels, this ferritic alloy contains vanadium that during thermal treatment aids the formation of a protective nitride coating with properties that support both excellent corrosion resistance and electric conductivity.

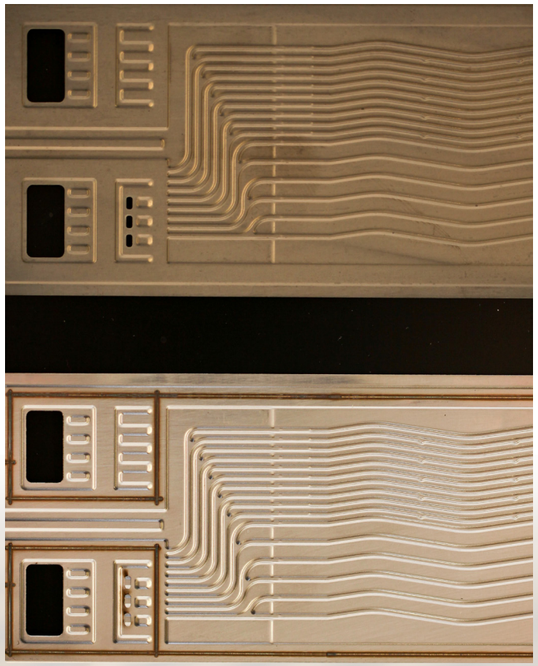
"With the unique coating properties, the thin stamped nitrided metallic bipolar plate provides a low-interfacial-contact and corrosion-resistant surface with no observed performance decline attributable to the plates," said ORNL team leader Mike Brady, Materials Science and Technology Division, summarizing findings from extensive studies of corrosion resistance, electrical properties, and more than 1000 hours of single-cell fuel cell evaluation under cyclic conditions.

In addition to results indicating performance comparable to or better than current technologies, the alloy is much less expensive to manufacture than graphite, a material commonly used to form bipolar plates. Its thinness (less than 0.1 mm) also enables greater overall fuel cell power density.

"Because the plates are so thin compared to graphite, more can be added to the fuel cell stacks for high power density in automotive or other applications," said Mike. He explained that typically, one hundred or more bipolar plates are employed inside a proton exchange membrane fuel cell stack, the device that chemically converts energy from hydrogen into electricity. Each plate electrically connects the anode of one cell to the cathode of another to produce a useful voltage.

In 2011, General Motors Research Laboratories conducted manufacturing and fuel cell assessments using the ORNL-developed nitrided alloy, further supporting promising properties previously identified by ORNL and others. Using current GM stamping practices and plate design, the nitrided material was manufactured into a state-of-the-art automotive bipolar plate and found to be amenable to laser welding assembly. Under the GM relative humidity cycling, single-cell fuel cell performance evaluation (500–1000 hours of operation), the nitrided bipolar plates maintained low contact resistance and the proton exchange membrane exhibited only trace levels of metal ion contamination, consistent with good corrosion resistance under fuel cell operating conditions.

Mike is currently working with GM to complete a journal article on the test results, scheduled for publication in early 2012. Other ORNL researchers involved in the project include Energy and Transportation Science Division's Todd Toops and Josh Pihl, and MSTD's Peter Tortorelli, Karren More, Harry Meyer, and Phil Maziasz.



Close-up of bipolar plates made of ferritic alloy, nitrided variety (top) and non-nitrided.

Energy & Environmental Sciences

MDF
Manufacturing Demonstration Facility

Opening doors to new opportunities, new interests in advanced manufacturing

ORNL's Manufacturing Demonstration Facility has been a popular destination lately, showcasing unique resources that support America's challenge to revitalize manufacturing in the United States.

"We've got to seize this moment of opportunity. We can't let it slip away," President Barack Obama said on February 15, reiterating his State of the Union Address vision for a strong economy built on American manufacturing and American jobs.

The President's comments came the same day the MDF received a visit from Secretary of Energy Steven Chu, who tops a long list of recent visitors interested in the ORNL energy storage, additive manufacturing, and robotics research and development capabilities located at the MDF.

The facility also served as home base to students and teachers from eight local high schools that gathered at the MDF during much of January and February to prepare for the FIRST Robotics Competition. A nationwide event that promotes science and engineering for high school students, the competition has also provided a platform for ORNL researchers to educate high school students on advanced manufacturing.

Secretary Chu examines a component developed using additive manufacturing techniques.

MSTD's Ryan Dehoff talks with a delegate member from Kirtland Air Force Base.

Associate Laboratory Director Martin Keller talks with former Congressman Zach Wamp during a visit with colleagues.

Every day after school and on weekends, a number of ORNL researchers mentored the students who were charged with transforming a box of parts into functioning robots. Under watchful eyes, the students applied manufacturing techniques to develop prototypes and create working components and systems as part of their robots.

In early March, more than 50 high schools participated in the Smoky Mountains Regional FIRST Robotics Competition at the Knoxville Convention Center. Of the eight teams who worked with ORNL researchers at the MDF, Knoxville Catholic High School and Seymour High School finished in the top 10. Hardin Valley Academy received the Engineering Excellence award, Oak Ridge High School received the Rookie All Star award, and Webb School received the Woodie Flowers Finalist award. Founded by Segway® inventor Dean Kamen, FIRST Robotics combines the excitement of sport with the rigors of science and technology to create a unique varsity Sport for the Mind™.

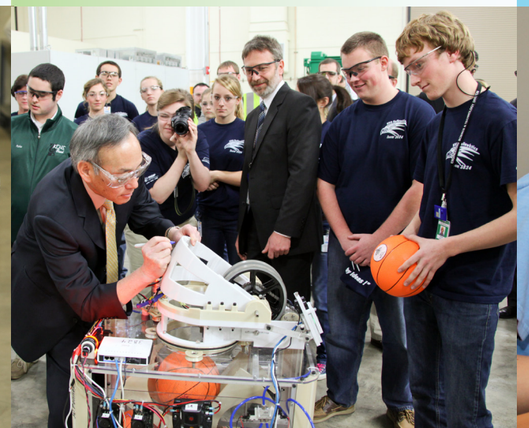
FRC
FIRST® Robotics Competition

Knoxville Catholic High School students finished 4th among 54 participating schools at the Smoky Mountains Regional Competition.

Students from Oak Ridge, Hardin Valley, Gibbs, Catholic, Farragut, Seymour, Webb and the STEM Academy worked with ORNL researchers to prepare for the FIRST Robotics Competition.

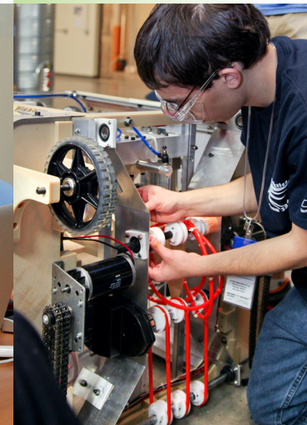
Kids of all ages converged on the MDF for the competition kickoff, which included hands-on robotic demonstrations.

Secretary Chu signs a contestant in the FIRST Robotics Competition.



When building the robots, participants were challenged to learn and apply sophisticated software.

Students made final touches to their creations before packaging the robots for competition.



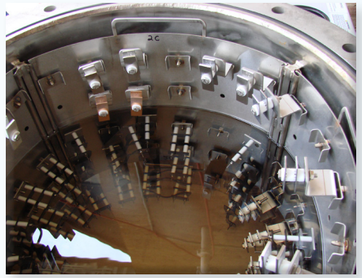
Results shared on compatibility of elastomers, plastics with higher ethanol fuel blends

Energy and Transportation Science Division's Mike Kass and Tim Theiss recently presented a Webinar lecture on the results of ORNL-led studies evaluating the compatibility of fueling infrastructure materials with test fuels representing aggressive formulations of ethanol-blended gasoline, ranging from 10 to 85 percent ethanol. Hosted by the National Renewable Energy Laboratory and advertised by the Petroleum Equipment Institute, the presentation was well received with more than 70 participants representing fueling dispenser, component, and materials manufacturers and interested government agencies.

During the Webinar, participants learned that the intermediate levels of ethanol (10 to 17 percent) produced the highest volume swell for the majority of the elastomers. Fluid permeation decreased dramatically with higher ethanol concentration. For several specimens, exposure to 85 percent aggressive ethanol did not produce noticeable swelling, though it was enough to extract plasticizers and cause embrittlement. In contrast, most of the plastic materials were not as dramatically impacted with exposure to the test fuels, but a few did exhibit noteworthy changes. For instance, a nylon specimen shrank by 8 percent after drying, and the vinyl ester and polyester resins swelled by over 20 percent with exposure to blends containing 25 percent ethanol.

"The information may play a critical role in designing new infrastructure systems to handle intermediate levels of ethanol-blended gasoline," said Mike. He added, "The data will also help to advance the development of adequate retrofit kits for the existing infrastructure, which will enable higher levels of ethanol to be sold."

ORNL research efforts are in collaboration with National Renewable Energy Laboratory and Underwriters Laboratories, supporting the Intermediate Ethanol Blends Program funded by DOE's Office of Energy Efficiency and Renewable Energy's Biomass and Vehicle Technologies Programs. In addition to Mike and Tim, ORNL researchers who participated in the materials compatibility studies include Materials Science and Technology Division's Steve Pawel and Chris Janke.



During compatibility testing, materials specimens were exposed to the test fluid(s) in a large stainless steel tank with stainless steel hardware (stir chamber), then subjected to multiple tests after fluid exposure.

Collaboration produces titanium sheet from affordable powder

ORNL, in collaboration with AMETEK and the Commonwealth Scientific and Industrial Research Organisation in Australia, has successfully developed and demonstrated the production of titanium sheet from affordable powder with properties comparable to those of conventional wrought sheet. The goal of the effort is to develop a low-cost method for producing thin gauge titanium via roll compaction and hot rolling that could be used in heat exchanger, desalination, chemical, and other industrial applications. The process and feedstocks are independent of conventional titanium manufacturing, and may therefore not be affected by titanium market cycles that result in high prices and long lead times to product delivery. The next stage of this joint research effort will test a full heat exchanger package that, if successful, will enable a more energy-efficient desalination process to become economically feasible.

After compaction and hot rolling, affordable titanium powder is converted into titanium sheet for industrial applications.

ORNL technology designed to improve prosthesis fitting, function

A soldier returning from war who has lost a leg could lead a more active lifestyle with the help of Measurement Science and Systems Engineering Division's Boyd Evans and John Mueller, who are perfecting a portable, wearable system to measure walking patterns that can be applied to real-world activities in a variety of settings.

They are collaborating with Center for the Intrepid at Brooke Army Medical Center to improve prosthesis performance for young soldiers. Wounded soldiers tend to be between ages 18 and 25, need a prosthetic that will last a long time, and be active so they are putting more stress on their healthy limbs.

"Lower-leg amputees in the military population are typically young, athletic and, besides their injuries, in top physical condition," John said. "For this reason, most military patients want to remain active and in some cases return to active military duty. We are looking at how we can improve prosthesis fit, alignment, and function."

Additionally, Boyd and John want to develop a gait analysis system that can be used outside of a confined laboratory setting. Typically, motion-capture gait analysis is performed in a large, multimillion dollar laboratory using controlled conditions and limited activities.

"The goal of our research is to use the recent advances made in video game technology to develop inexpensive tools for amputee rehabilitation," said Boyd. "This will allow advanced rehabilitation techniques to both be used in smaller clinics and be taken outside the clinic. The sensors we are using in our device are the same inexpensive sensors that smart phones and video game controllers like the Wii use to determine orientation. We are also developing an app-like clinical interface to monitor patient motion that will work on smart devices like the iPhone or iPad."

To monitor the motion and force of walking patterns, Boyd and John are collaborating with BAMC to utilize inertial measurement units and other sensors that can be strapped onto segments of a subject's leg, such as the thigh, calf, and foot. The data collected from the IMU transfer to a computer, and algorithms calculate the motions and forces associated with specific joints.

To test the effectiveness of IMUs, they use a robot leg, which has been programmed with data from a walking person. They plan on going to the Gait and Motion Analysis Laboratory at Center for the Intrepid in a few months to test their system on a human subject with a prosthetic and a healthy leg.

If the prosthesis is not fitted or aligned correctly, it could affect a patient's walking patterns, resulting in "asymmetric" gait. These abnormal gait patterns can increase the stress on the healthy limb, leading to problems later in life such as arthritis.

"We have high expectations for this system once it is fully developed," said John. "We think it will improve the prosthetic fitting and aligning process and help lower the risk of chronic joint disease in this group of wounded warriors."

A subset to this overall project, "Using Kinect for Xbox 360 and Computer Vision to Analyze Human Gait," won the Siemens Competition for Math, Science and Technology in early December. The multi-camera Kinect is connected to a computer that uses body-tracking algorithms to measure how different parts of the leg move when someone's walking. Summer interns Cassee Cain and Ziyuan Liu, who worked with Boyd and John, received the top Siemens team award for their project.

Boyd and John's work represents an overall collaboration with Otto Bock Healthcare and Center for the Intrepid. Also representing MSSED, Randy Lind is developing an advanced platform to measure the forces associated with motion, and Nance Ericson and Ethan Farquhar are integrating the entire system to incorporate wireless data collection.

MSSED's Boyd Evans and John Mueller(L-R) are working to improve prosthetic fitting and design for young military amputees.

Carbon emissions rise following financial crisis

Global carbon dioxide emissions rebounded in 2010 to an all-time high, after a decline in 2009 attributed to the global financial crisis.

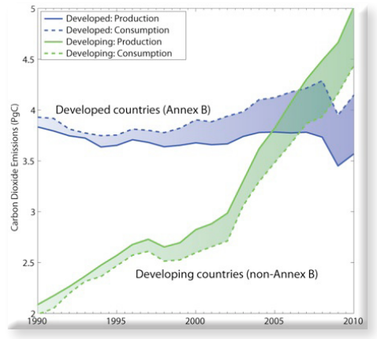
Research supported by the Carbon Dioxide Information Analysis Center at ORNL reports record-high emissions of 9.1 billion tons of carbon in 2010 compared with 8.6 billion tons in 2009. In emerging economies, CO_2 emissions also rose in 2010. There, emissions associated with consumption of goods and services increased by 6.1% in 2010, the first time these countries had higher consumption-based emissions than developed countries.

"Previously, developed countries released more carbon dioxide, but that's no longer true due to emerging economies such as China and India," said Environmental Sciences Division's Tom Boden of CDIAC.

The research cites three factors for the rapid CO_2 rebound: strong emissions growth in emerging economies, a return to emissions growth in developed economies, and an increase in the fossil fuel intensity of the world economy. The oil crises in 1973 and 1979 reduced the use of oil and increased the use of natural gas, resulting in a drop in CO_2 emissions. There is no indication the same thing is happening during this go-round, the researchers said.

"The global financial crisis did not impact major developing countries such as China and India like it did the United States and the European nations," Tom said. "Also, some negative effects on sectors such as transportation in international trade are over or have subsided."

The work is an effort of the Global Carbon Project of the Earth System Science Partnerships to provide regular analyses of global carbon sources and sinks. CDIAC is funded by the DOE Office of Science.



For the first time, in 2009, developing countries surpassed developed countries in consumption-based carbon dioxide emissions. The shaded region represents the difference between developed and developing consumption-based and production-based carbon dioxide emissions.

Understanding the hydropower renewable energy resource

Around since the early 1900s, hydropower dams and facilities currently provide 6 percent of our nation's energy and in 2010 generated 60 percent of the country's electricity from renewable energy. To better understand the existing resources and determine how new technologies can be applied to improve power generation, DOE tapped ORNL's Water Power Technologies Program in 2010 to lead the National Hydropower Asset Assessment Program, the first comprehensive assessment in 20 years.

"The NHAAP presents a new assessment of hydropower assets and a new integrated database constructed from available federal and nonfederal sources to describe the current state of the country's hydropower infrastructure (e.g., age, type, ownership), power generation patterns, and hydrologic conditions," said Environmental Sciences Division's Brennan Smith, program manager for the Water Power Technologies Program.

For example, NHAAP provides access to detailed information on the existing fleet of 2,400 hydropower dams and the capacity and technology being used by 5,300 hydrologic units in use today. Approximately 4,400 of the hydrologic units are non-federally owned and provide 56 percent of the existing capacity. Of this fleet, no significant capacity upgrades have been observed in the last 25 years, and approximately 50 percent of the hydro turbines in the US are older than 50 years.

"NHAAP makes it possible to trend US hydropower production and capacity and identify upgrading opportunities to stabilize and increase power generation, together helping maximize strategic decisions on this renewable energy resource," said Brennan. For more information please see http://hydropower.ornl.gov/.

Melton Hill Dam

Making Connections

ORNL hosted General Motors officials Gary Smyth and Jim Rainbolt on January 24 and 25. The guests toured numerous facilities at the main campus and NTRC to learn more about transportation-related research capabilities and collaborative opportunities in vehicle and fuel technologies, materials sciences, neutron sciences, high performance computing, and advanced manufacturing. Pictured here is Energy Partnerships Director Ray Boeman, left, with GM's Gary Smyth inside the Carbon Fiber and Composites Research Laboratory.

Pictured left to right, DOE AAAS Fellow Kelly Visconti toured the Carbon Fiber Technology Facility recently with Energy Materials Program's Alan Liby and Craig Blue and CFTF Director Lee McGetrick. On assignment from the Energy Efficiency and Renewable Energy Advanced Manufacturing Office, Kelly also visited the new Manufacturing Demonstration Facility to learn about its core technologies.

Energy and Transportation Science Division's Xiaobing Liu visited China with a delegation of mayors or senior officials from eight US cities in December. This visit was organized by DOE for its US-China Clean Energy for Sustainable Cities program. The delegation met with senior government and city officials in Beijing, as well as US and Chinese companies, to promote US businesses and advance the widespread adoption of advanced energy technologies in cities in China and the United States.

ORNL's Advanced Manufacturing Program hosted a two-day workshop in February focused on state-of-the-art additive manufacturing. The event included presentations and an open panel discussion from industry representatives and analysts, subject matter experts, and leading researchers. Topics included multi-material 3-D printing, metal-based additive manufacturing, emerging technologies in digital manufacturing, commercial and medical applications, and the future of additive manufacturing. Pictured below, Boeing's Mike Hayes speaks to participants on additive manufacturing in aerospace.

Employee Excellence

Jerry Tuskan

Jerry Tuskan, ORNL Distinguished Scientist in the Biosciences Division, has been named Forest Biotechnologist of the Year. His peers within the Forest Biotechnology Partnership, an international group of forestry and biotechnology professionals, selected Tuskan, the fourth scientist to win this award. The award is given to the forest biotechnologist who best exemplifies responsible uses of forest biotechnology and actively promotes science, dialogue, and stewardship through his work. He earned his doctorate in genetics from Texas A&M University, master's in forest genetics from Mississippi State University, and bachelor's in forest management from Northern Arizona University.

Ken Tobin

Ken Tobin, director of the Measurement Science and Systems Engineering Division, has been elected an Institute of Electrical and Electronics Engineers Fellow for his contributions to computer vision technology instrumentation and measurement. Ken was named a Corporate Research Fellow in 2003 for his contributions to the field of applied computer vision research that addressed industrial and economic competitiveness, biomedical measurement science, and national security. He has authored and co-authored more than 135 publications and currently holds 10 US patents with three additional patents pending in areas of computer vision, photonics, radiography, and microscopy. In 2010, Ken received an R&D 100 Award for his work in content-based image retrieval applied to both industry and biomedicine.

Environmental Sciences Division's Keith Kline and Virginia Dale have won the National Biodiesel Board's 2012 "Eye on Biodiesel Award" in the category of Innovation. The award was presented at the National Biodiesel Conference and Expo on February 8 in Orlando. Each year the National Biodiesel Board recognizes individuals who make a difference to the biodiesel industry and the communities that biodiesel seeks to improve. The Innovation award goes to the individuals, organization, or company with the best idea, new product, research results, invention, or marketing strategy to further biodiesel.

During the 2011 Patent and Key Contributor Awards ceremony, Energy and Transportation Science Division's Bill Partridge and Jim Parks received dual recognition for developing fuel-in-oil technology that was patented in 2010 and then received the 2011 Federal Laboratory Consortium National Award for Excellence in Technology Transfer. The technology was developed in a DOE-funded cooperative research and development agreement between ORNL and Cummins and has been licensed for commercial development to Da Vinci Emissions Services. ETSD's Sam Lewis and Maggie Connatser were recognized for their contributions to a patent related to Raman imaging of fingerprints. This patent was issued based on ORNL work, led by Chemical Sciences Division's Linda Lewis, which enables detection of fingerprints that could not be resolved with conventional methods.

In late 2011, a cross-directorate team filed invention disclosure S-124,305 and #201102745, "Novel Materials and Processes for Minimizing Core Losses in Stators." According to team members, the materials processes and unique stator design using novel grain-oriented silicon steel will result in a significant reduction in core power losses in a motor stator compared with conventional designs using stacked non-oriented steel sheets. In electric machines, the stator iron functions as both mechanical support and return path for magnetic flux. Inventors include Energy and Transportation Science Division's John M. Miller, Curt Ayers, and Tim Burress and Computer Science and Mathematics Division's Balasubramaniam Radhakrishnan.

In December, Biosciences Division awards were presented to the following: Steve Brown received the Science Award for Junior Staff; Scott Hamilton-Brehm received the Post-Graduate Award; Sara Jawdy received the Technical Support Award; and Carmen Foster received the Administrative Award.

Environmental Sciences Division's Daniel Hayes is among the 41 international scientists who contributed to an article published in the science journal *Nature* in December. It concluded that carbon trapped in the top few meters of permafrost soils across nearly 19 million square kilometers of northern regions could be released at a rate of about two to five times greater than previous estimates. A warming climate causes permafrost to thaw, rendering this frozen carbon vulnerable to decomposition and emissions to the atmosphere. A significant amount of this carbon could be released as methane, which is about 22 times more potent as a heat-trapping greenhouse gas than carbon dioxide. The article is available in its entirety at http://www.nature.com/nature/journal/v480/n7375/full/480032a.html

Melanie Mayes

Environmental Sciences Division's Melanie Mayes received the Young Alumni Award from the Chair of the University of Tennessee Department of Earth and Planetary Sciences for her "success in research and strong support for the department, through student mentoring and collaborative research projects and grants."

Biosciences Division's Loukas Petridis, Roland Schulz, and Jeremy C. Smith used the Jaguar supercomputer to determine that lignin collapses to form clumps even at high temperatures, rather than only during the cool-down phase as previously believed. The study provides fundamental knowledge that is required to understand the pretreatment process and rationally improve biofuel production. The research is published in the *Journal of the American Chemical Society*, http://pubs.acs.org/doi/abs/10.1021/ja206839u.

Yilu Liu

In a recent article in the *Knoxville News Sentinel*, University of Tennessee Chancellor Jimmy Cheek credited Energy and Transportation Science Division's Yilu Liu for UT's selection as a National Engineering Research Center. An electrical engineer specializing in smart-grid technologies in electrical power production and distribution, Yilu is the UT-ORNL Governor's Chair for power electronics. Her work focuses on developing new and better ways to monitor and understand the flow of electrical energy through the nation's power grid.

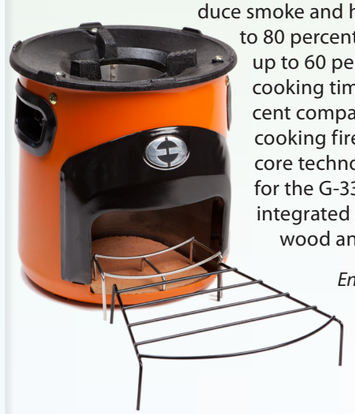
Former Environmental Sciences Division employees Steve Lindberg and Jack Calvert have received one of the 2011 Haagen-Smit Prizes for their paper, "Mechanisms of mercury removal by O_3 and OH in the atmosphere," (*Atmospheric Environment*, 39: 3355-3367). The Haagen-Smit award is named in honor of Arie Jan Haagen-Smit, a Dutch chemist and pioneer in the field of air-pollution and one of the original editors of the *International Journal of Air Pollution*. Read the article online at http://www.sciencedirect.com/science/article/pii/S1352231005001585.

ORNL, partners earn FLC honor for cookstove technology

ORNL, Envirofit International, and Colorado State University have won a Federal Laboratory Consortium award for excellence in technology transfer for a clean-burning cookstove designed for the developing world.

Mike Brady of ORNL's Materials Science and Technology Division led a team that identified a family of low-cost iron-based alloys with the potential to meet Envirofit's design targets. ORNL also assisted Envirofit in specifying alloy compositional tolerances needed to achieve durability targets without significantly increasing alloy cost. Other ORNL team members include MSTD's Thomas Rosseel and Larry Walker (retired), Energy and Transportation Science Division's Tim Theiss and David Stinton (retired), and Tech Transfer's Joe Marasco, Alex DeTrana, and Frank Damiano.

To date, more than 150,000 Envirofit G-3300 stoves have been sold in the developing world. These stoves reduce smoke and harmful gases by up to 80 percent, reduce fuel use by up to 60 percent, and reduce cooking time by up to 50 percent compared with traditional cooking fires and stoves. The core technology developed for the G-3300 has now been integrated across six models of wood and charcoal stoves.



Envirofit G-3300 stove

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Quality counts in everything we do. Not only is our commitment to excellence in science and technology recognized by our colleagues and customers, but by our community as well.

According to *Science and Engineering Indicators 2012*, a biennial report prepared by the National Science Foundation, "Scientist" ranked 2nd in the public's perception for prestige occupations (firefighter ranked #1) and ranked 3rd (behind military and teachers) for contributions to the well-being of society.

Take credit for the quality job you do every day and remember . . . your neighbors are watching!