

Energy & Environmental Sciences Quarterly

Published by Oak Ridge National Laboratory

No. 1 2011

This is the first newsletter of our newly formed Energy and Environmental Sciences Directorate (EESD) at Oak Ridge National Laboratory. We intend to publish this newsletter quarterly to highlight the research in our organization that leads to new knowledge and technologies in areas of critical importance to the nation, such as energy efficiency and security, bioenergy, climate change, environmental management, transportation, and homeland and national security. Our work is supported primarily by the Department of Energy's Office of Science through the Office of Biological and Environmental Research and the Office of Energy Efficiency and Renewable Energy. In addition, we perform research and development supported by other offices of the Department of Energy as well as by other federal and state institutions, and the private sector.

This report features selected research highlights by our scientists and engineers during the first quarter of FY 2011. It also summarizes the recognition and awards received by our researchers, and provides descriptions of our latest scientific initiatives. You can learn more about EESD by visiting our web site at (<http://www.ornl.gov/sci/ees/>). Have fun reading through this quarterly report.

Best regards,
Martin



Telltale of two diesels

An estimated \$1 billion in lost revenue each year is fueling an effort by Oak Ridge National Laboratory to prevent fuel tax evasion.

Through funding by the Federal Highway Administration and support from Pilot Oil Corporation, a research team from the Energy and Transportation Science Division (ETSD) and the Measurement Science and Systems Engineering Division (MSSSED) is developing a system to reveal incidents of fuel dilution and mixing.

"The system will be able to determine the legitimacy of the movements and fuel loading and unloading, thereby enabling shippers and regulators to better track the disposition of taxed and non-taxed petroleum-based products," says project manager Gary Capps, with ETSD's Center for Transportation Analysis.

Non-taxable diesel is dedicated to residential heating, industrial use, or other off-road purposes while diesel used for on-road transportation is taxed. Fuel tax is allocated to the Highway Trust Fund that in turn is apportioned to states for highway projects.

...non-taxable diesel is dedicated to residential heating, industrial use, or other off-road purposes while diesel used for on-road transportation is taxed.

Prototype fuel marker sensor

Team member Tim McIntyre, MSSSED, explains that to distinguish the two, red dye is added to non-taxable fuel at terminal rack facilities as it's loaded from bulk storage tanks into tanker trucks for delivery to retail stations or bulk users.

"Despite the dye, bootleg mixing and distribution continues and commercial fuel supplies are being corrupted by blending taxed and untaxed fuels and even adding waste streams such as used engine oils," says Tim. "The system can help reduce or prevent the problem and make an immediate, positive impact on consumer transportation."

MSSSED-developed optical sensors used to detect fuel level are an important component that works in tandem with the system's other technologies including trailer-to-tractor communications devices developed by ETSD to track vehicles and petroleum movement in real-time. A unique fluorescence marker technology developed by ETSD helps verify the pedigree of the fuel at each step of the process, while captured information is fed wirelessly to ETSD researchers for thorough analysis using evidential reasoning techniques.

In addition to Gary and Tim, key researchers include MSSSED's David West and Duncan Earl, and ETSD's Pat Hu, Oscar Franzese, Shih-Miao Chin, Ho-Ling Hwang, Mary Beth Lascurain, Maggie Connatser, and Sam Lewis. Advanced field testing at the Transportation Research Center in East Liberty, Ohio is scheduled for this spring. Watch for updates in future issues.

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Over 50 vehicles were aged on mileage accumulation dynamometers at subcontractor facilities like the one shown here. Additional vehicles were aged on a closed test track.

ORNL research impacts EPA E15 decisions

In October 2010, the Environmental Protection Agency (EPA) announced partial approval of the Growth Energy waiver, allowing use of E15 in light-duty vehicles beginning with model year 2007. Three months later, EPA announced a second ruling to allow use of E15 in light-duty vehicles model year 2001 and newer. E15 fuel contains 15 percent ethanol and 85 percent gasoline.

The decisions are based largely on results from the Intermediate Ethanol Blends Test Program, co-led and funded by DOE's Office of Energy Efficiency and Renewable Energy's Biomass and Vehicle Technologies Programs. Through technical support from ORNL and the National Renewable Energy Laboratory (NREL), the program concentrated on determining the feasibility of using intermediate ethanol blends in the existing vehicle fleet to increase renewable fuel consumption.

"ORNL and NREL researchers collaborated extensively with DOE, EPA, industry, and other experts regarding the development and implementation of the test program," said ORNL team lead Brian West, Energy and Transportation Science Division. ETS researchers, with support from ORNL's Bioenergy Program and Materials Science and Technology Division, led the Lab's testing efforts.

ESD hosts National Geographic JASON students

National Geographic's JASON project students spent a week at ORNL recently, meeting Environmental Sciences Division's Paul Hanson, Colleen Iversen, and Jeff Warren and visiting ORNL Climate Change Science sites. Their interviews will become part of a multimedia 5th-8th grade teaching curriculum available through JASON to schools across the country. The JASON project connects students with scientists and researchers in real- and near-real time, virtually and physically, to provide mentored, authentic, and enriching science learning experiences. Using multiple platforms and technologies, JASON and its partners create these connections including award-winning, standards-based classroom curriculum developed with National Oceanic and Atmospheric Administration, NASA, National Geographic Society and others; after-school and out-of-school activities; camp experiences; and exploration programs for museums, aquariums, libraries, and community centers. Learn more at <http://www.jason.org/public/whatis/start.aspx>

Photovoltaic manufacturing collaborations launched

As part of ORNL's American Recovery and Reinvestment Act (ARRA) funded materials work, three new cooperative projects have been launched in photovoltaic manufacturing. The winning partners for the cooperative research opportunity are Global Solar Energy, Ferro Corporation, and Ampulse Corporation. ORNL will contribute \$300,000 to the combined efforts from ARRA funding received through DOE's Office of Energy Efficiency and Renewable Energy Industrial Technologies Program. Industrial partners will contribute another \$380,000 toward the projects through cost-share.

Power in small packages

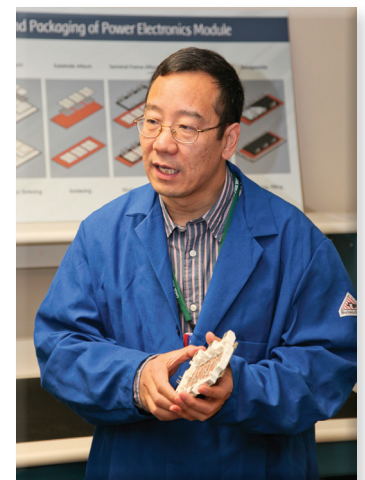
ORNL is expanding its transportation research capabilities with the introduction of an Advanced Power Electronics Packaging lab and suite of technologies to advance the power electronics module inside next-generation electric vehicles.

Small enough to fit in one hand, the module plays a large role in the operation of an electric vehicle. It is the building block for the power inverter and charging systems, while regulating voltage, speed, and the motor's torque level.

"The lab will enable greater exploration of the power electronics module, focusing primarily on materials, structure, and processing," said ORNL researcher Zhenxian Liang, Energy and Transportation Science Division.

According to Zhenxian, finding the right combination of these three can lead to a power electronics module that offers superior electrical performance and thermal management, higher temperature operation, and greater power density. "For consumers this translates into a more efficient, reliable, and affordable electric vehicle."

Located at NTRC, the Advanced Power Electronics Packaging lab is part of ORNL's Power Electronics and Electrical Power Systems Research Center.



Advancement of the electric vehicle relies largely on improving the power electronics module. A sample is held here by ORNL researcher Zhenxian Liang.

Weakening nature's defenses may strengthen biofuels production

A team of ORNL scientists have discovered that a new line of switchgrass can produce more ethanol per acre than produced by non-modified switchgrass.

Biosciences Division's Jonathan Mielenz, Choo Hamilton, and Miguel Rodriguez conducted fermentation testing on genetically-modified switchgrass developed by Sam Roberts Noble Foundation (NF) researchers. Compared to conventional switchgrass, the transgenic version where only one gene was turned off caused it to contain about 15% less lignin – essentially the plant's natural, strengthening glue.

ORNL research showed that the changes that decreased the lignin also weaken the plant structure, known as recalcitrance. Compared to non-modified switchgrass, the new version's "softer" structure enables less-resistant fermentation at lower temperatures, and requires up to one-quarter the level of costly enzymes needed for processing. Under identical processes, the transgenic line produces approximately one-third more ethanol than conventional switchgrass, ultimately benefiting both feedstock growers and the biofuel industries such as transportation.

Complete study results are recorded in the paper, "Genetic manipulation of lignin reduces recalcitrance and improves ethanol production from switchgrass," published in February by the Proceedings of the National Academy of Sciences. <http://www.pnas.org/content/early/2011/02/04/1100310108.full.pdf>. The paper is coauthored by Jonathan, Choo, and Miguel and a team of researchers from NF and Georgia Institute of Technology. Research was supported by the Department of Agriculture and the DOE Office of Science through ORNL's BioEnergy Science Center.

MAXLAB to become reality

ORNL was awarded \$20.2 million in American Recovery and Reinvestment Act funding for a Maximum Energy Efficiency Building Research Laboratory – or MAXLAB – to conduct research on the systems design, integration, and control of new and existing buildings. The project consists of three structures: a new research facility of approximately 17,800 gross square feet for the controlled study of building envelopes and HVAC systems; and two flexible research platforms for the testing of full-scale building enclosures and systems under natural exposure.



Biosciences Division's Jonathan Mielenz, pictured, Choo Hamilton, and Miguel Rodriguez conducted fermentation testing on genetically-modified switchgrass developed by Sam Roberts Noble Foundation (NF) researchers.

Ethanol feedstock study: Land use change minimal

A recent study by ORNL researchers indicates that corn ethanol production for U.S. consumption has resulted in minimal displacement of crop exports and land previously under other crops. The findings are in contrast to the assumption that these indirect effects are large and would lead to new problems, such as global deforestation, if farmers in other parts of the world convert forest and other lands to make up for reductions in U.S. exports - a process known as indirect land use change.

"The findings help underline how, at this time, corn supply meets demands for ethanol production, consumer and livestock consumption, and exports without the need to convert large amounts of new land," said ORNL researcher Gbadebo Oladosu, Environmental Sciences Division (ESD). Gbadebo co-authored the study's final report entitled, "A Decomposition Analysis of U.S. Corn Use for Ethanol Production from 2001-2008," along with ESD's Keith Kline, Rocio Uria-Martinez, and Laurence Eaton.



Study supports development of multipurpose, sustainable agronomic land use systems.



Slot-die coating equipment to advance battery materials processing

Industrial Technologies Program has installed equipment for a pilot slot-die coating line. The new equipment will support work of ORNL and four CRADA partners: A123 Systems, Dow Kokam, Planar Energy Devices, and Porous Power Technologies. It will allow ORNL to investigate coating and curing of materials for advanced batteries. Colloidal chemistry of battery electrode dispersions will be optimized for improved cycle life, increased performance, and reduced irreversible capacity loss.



Slot-die coating equipment

Heat pump design model framework enhanced

DOE's Building Technologies Program recognizes ORNL as its Center of Expertise for building equipment research. To sustain this position and strengthen its core capabilities, ORNL has added an enhanced modeling framework to its Heat Pump Design Model. The framework is a component-based, flexible, steady-state simulation tool which can be used to link steady-state component models in any manner to simulate complicated vapor compression systems like multi-split variable refrigerant flow system, multi-stage vapor injection system, vapor compression coupled with desiccant system, etc. With further advancements, the enhanced framework will eventually enable the Building Equipment Research Group to conduct steady-state simulations for most of the HVAC equipment.

ORNL receives smart grid cyber security awards

ORNL recently won two multi-year awards from DOE's Office of Electricity Delivery and Energy Reliability and is a partner with Sypris Electronics on another. These awards are worth about \$7 million over the next three years and will enable the development of systems to guard against power outages caused by vulnerabilities within the grid. Involved in this effort are a number of technologies, including advanced radio frequency technology and cyber security vulnerability detection of smart grid components and systems. In addition, ORNL will receive \$150,000 per year for three years to participate in a Cyber Analysis Center led by the Electric Power Research Institute.

FreedomCAR & Fuel Partnership recognizes neutron imaging research

Through the powerful neutron science capabilities at ORNL, and supported by the lab's materials and vehicle technology expertise, neutron imaging is providing first-of-kind data on soot and other particulates deposited in the exhaust gas recirculation (EGR) cooler and the diesel particulate filter (DPF). It's helping explain where, when, and under what conditions the deposits occur in both devices; and in the case of the DPF, the impact of various fuel types and effectiveness of the regeneration technique. EGR and DPF research using neutron imaging is featured in the 2010 highlights of the FreedomCAR & Fuel Partnership among DOE and U.S. auto manufacturers. The work is supported by DOE's Office of Energy Efficiency and Renewable Energy.

Key researchers involved include Hassina Bilheux, Neutron Scattering Sciences Division; Michael Lance, Materials Science and Technology Division; Scott Sluder, Todd Toops, and Charles Finney, Energy and Transportation Science Division.



Delivering first-class testing

Energy and Transportation Science Division staff based at NTRC recently completed DOE-funded dynamometer testing on five U.S. Postal Service (USPS) electric vehicles. Each vehicle is produced by a different manufacturer. During simulated driving on the dynamometer, researchers gathered data to characterize each vehicle's efficiency while driven through various drive cycles. From ORNL, the vehicles were transported to Washington, D.C. for field evaluation. ORNL's research contribution is part of a multi-lab/industry partnership to support USPS, which operates one of the nation's largest vehicle fleets.



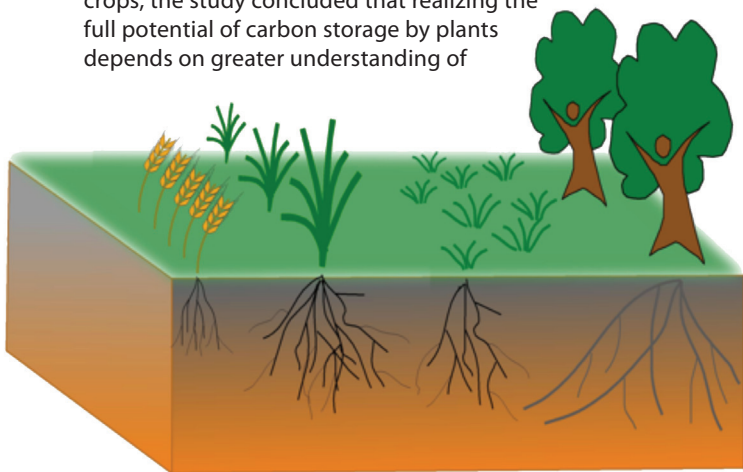
U.S. Postal Service electric vehicle on dynamometer

Exploring the plant's dual role in reducing GHG

While mankind steps-up efforts to reduce greenhouse gases, land plants continue to help clean the air – naturally. In a recent study, a team of ORNL and Lawrence Berkeley National Laboratory scientists assessed opportunities for harnessing the innate roles of plants in carbon storage and greenhouse gas mitigation.

“Phytosequestration: Carbon Biosequestration by Plants and the Prospects of Genetic Engineering,” co-led by Environmental Sciences Division’s Stan Wullschleger, and Biosciences Division’s Udaya Kalluri and Gerald Tuskan, examined the process during which carbon captured by plants through photosynthesis is partitioned proportionally to the plant’s growth above and the roots below ground. Within the global carbon cycle, plants can serve as potential feedstock for biofuels (offsetting fossil-fuel greenhouse gases) and through the sequestration of carbon from roots into long-lived carbon-rich soil pools.

Designed to stimulate discussion and new exploration for enhancing carbon sequestration of bioenergy crops, the study concluded that realizing the full potential of carbon storage by plants depends on greater understanding of



plant, microbial, and soil biology. This understanding can be gained through traditional genetics and advanced molecular techniques.

Aggressive plans that may include land management, crop breeding, and biological process strategies could conceivably mitigate greenhouse gas emissions equivalent to 5-8 gigatonne of carbon by 2050.

...carbon captured by plants through photosynthesis is partitioned proportionally to the plant’s growth above and the roots below ground.

CTA projects make national impact

ORNL’s Center for Transportation Analysis (CTA), Energy and Transportation Science Division, completed two major projects that support DOE, Department of Transportation (DOT), and Environmental Protection Agency (EPA) efforts to enable more efficient, clean, safe, and affordable transportation in America.

CTA prepared the Freight Analysis Framework version 3 (FAF3) database, a DOT Federal Highway Administration freight data product composed of U.S. domestic and international freight flows for calendar year 2007. FAF3 includes information on the amount and types of goods that move by land, sea, and air between large metropolitan areas, states, and regions across the country. With this information, public and private sectors can better understand freight movement and target scarce resources to improve operations or increase capacity.

EPA and DOE released the 2011 Fuel Economy Guide, providing consumers estimated mileage and fuel cost information for model year 2011 vehicles. Through oversight of ORNL’s David Greene, CTA and the University of Tennessee have produced the book since 2000. The team also maintains the online site, fuelconomy.gov.

Introducing four new projects to support ITP’s steel portfolio...

I

Moving super-bainitic steels to the marketplace is focused on deployment of an ORNL-developed 3Cr alloy and will advance an American Society of Mechanical Engineers boiler code case for the alloy.

2

Achieving Gen III advanced high strength steels objectives using accumulative roll bonding to produce novel ferrite-austenite microstructures will demonstrate this novel process technique on carbon steel and then advanced alloys.

3

Improved processing of high alloy steels for wear components in energy generation systems, transportation, and manufacturing systems will explore improvements in wear component performance through hot isostatic pressing.

4

Wireless monitoring of steel manufacturing/fabrication facilities will baseline energy consumption in steel mills using electric arc and basic oxygen furnaces, then quantify the energy efficiency gains enabled by the use of wireless sensor networks.

Employee Excellence



Amit Goyal

Materials Science and Technology Division's Amit Goyal, an ORNL high temperature superconductivity and energy efficient materials researcher, has been named the R&D Magazine 2010 Innovator of the Year. Now in its 10th year, the award recognizes leading researchers who are making significant contributions to technology.

ORNL's Parans Paranthaman, Chemical Sciences Division, Energy Efficiency and Electricity Technologies' Dominic Lee, and Tech Transfer's Frank Damiano and Mark Reeves teamed with

National Renewable Energy Laboratory (NREL) researchers to develop a technology that offers promise in flexible, highly efficient, low cost, and durable photovoltaic materials. Flexible Thin-Film Solar Photovoltaics on RABITS has been licensed to Ampulse Corporation and received the 2011 Federal Laboratory Consortium Award for Excellence in Technology Transfer. The ORNL-developed Rolling Assisted Biaxially Textured Substrate (RABITS) is a flexible metal foil that provides a platform for an entire generation of today's high-temperature superconducting materials and products. RABITS, combined with NREL's work in depositing crystalline silicone onto various substrates, increases efficiency, decreases cost, and is a flexible material. These criteria meet the needs of Ampulse, a venture-backed startup organization in Golden, Colorado.



Jessy Labbé

The Lorraine region of France has presented Biosciences Division's Jessy Labbé the award of Excellent Scientific Work for his research in the article, "Identification of quantitative trait loci affecting ectomycorrhizal symbiosis in an interspecific F1 poplar cross and differential expression of genes in ectomycorrhizas of the two parents: *Populus deltoides* and *Populus trichocarpa*," which ran in the journal *Tree Genetics and Genomes*. Jessy was also awarded the 2010 Young Researcher Award, presented by the National Institute for Agricultural Research (INRA), Nancy, France, and sponsored by the INRA and the Lorraine region of France. Jesse is a post-doctoral fellow and contributes to the Plant Microbe Interfaces Science Focus Area, funded by DOE-Biological and Environmental Research.

Congratulations to Energy and Transportation Science Division's Bob DeVault, inventor of the newly-patented Self-Learning Control System for Plug-In Hybrid Vehicles. A robust self-learning controller for plug-in hybrid electric vehicles, the device improves battery life and vehicle performance by maintaining the highest state of battery charge desired for as long as possible during trips beyond the battery range, given the location of known charging stations.

Energy and Transportation Science Division's Jim Parks and Bill Partridge developed the Laser-Induced Fluorescence Fiber-Optic Measurement of Fuel in Oil technology, which has been selected as a winner of the 2011 Federal Laboratory Consortium Award for Excellence in Technology Transfer. Providing fast, real-time, on-engine measurement of oil contamination by fuel, the technology enables improved engine calibration, resulting in better fuel efficiency, cleaner emissions, and engine durability. The technology is licensed to Da Vinci Emissions Services.



Jim Parks (left)
Bill Partridge
(above)

Biosciences Division's Jeremy Smith and Loukas Petridis, and Computer Science and Mathematics Division's Xiaolin Cheng have won a DOE Innovative and Novel Computational Impact on Theory and Experiment (INCITE) award of 30 million processor hours on the ORNL Cray XT Jaguar supercomputer for their project, Cellulosic Ethanol: Simulation of Multicomponent Biomass System. The proposed research aims to provide simulation models of biomass and biomass:enzyme interactions to assist in understanding biomass recalcitrance to hydrolysis and aid in engineering efforts to improve second-generation biofuel yield.

The Transportation Research Board Executive Committee has selected the paper, "Effect of Tires on Class-8 Heavy Truck Fuel Efficiency," as winner of the Pyke Johnson Award for the best paper in the area of planning and environment. Energy and Transportation Science Division's (ETSD) Bill Knee and Oscar Franzese, with the Center for Transportation Analysis, authored the paper along with co-author Lee Slezak, DOE Vehicle Technologies Program (VT). The paper presents the results of a year-long project sponsored by VT. It focuses on the analysis of some of the extensive real-world information collected, specifically on the assessment of the effect that different types of tires (i.e., dual tires vs. new generation wide-based single tires) have on the fuel efficiency of Class-8 trucks. The results show that the fuel efficiency improvement increases as the number of wide tires on the truck increases, with observed improvements of around 6 percent when either the tractor or the trailer was equipped with the wide tires, and more than 9 percent when both were mounted with these types of tires. Michelin Americas Research Company and Schrader Trucking participated in the study. ETSD's Gary Capps and Mary Beth Lascurain also contributed to the study.



Bill Knee (left) and
Oscar Franzese

Rebecca Efroymson, Environmental Sciences Division, has been appointed to serve on the new National Research Council Committee: Sustainable Development of Algal Biofuels. Rebecca's expertise in risk assessment, sustainability, and biofuels will be an important contribution to this effort.



Rebecca Efroymson

David Greene, Energy and Transportation Science Division, has been appointed to the Board of Directors of the American Council for an Energy Efficient Economy, a nonprofit, 501(c)(3) organization dedicated to advancing energy efficiency as a means of promoting economic prosperity, energy security, and environmental protection.



David Greene

Environmental Sciences Division's Esther Parish recently received a "Computing & Computational Sciences Significant Event Award" along with colleagues in two other divisions for Novel analyses of the simulation results from the Community Climate System Model 3.0 climate model. Others recognized for this award include Computational Sciences and Engineering Division's Auroop Ganguly, Nagendra Singh, and Karsten Steinhäuser; Computer Science and Mathematics Division's David J. Erickson III, Marcia Branstetter, and John Drake.



Esther Parish

Making Connections

ORNL hosts China delegation

In late 2010, ORNL and Idaho National Laboratory organized a study tour for representatives of the China National Energy Administration and Chinese bioenergy companies to visit bioenergy related sites in Nebraska, Iowa, and Tennessee, and meet with DOE and United States Department of Agriculture representatives in Washington, D.C. Environmental Sciences Division's (ESD) Yun Wu served as an official host and translator throughout the duration of the tour; ESD's Erin Webb co-lead organization of the study tour and Becky Bowman assisted with coordination of the tour and organized Tennessee events; ESD's Robin Graham, Laurence Eaton, and Keith Kline, and Biosciences Division's Brian Davison gave technical presentations highlighting ORNL bioenergy research. Other Tennessee activities for the China delegation included a tour of the DuPont Danisco biorefinery and Genera Energy switchgrass production sites in Vonore.

21st Century Truck Partnership focus of NAS visit

Members of a National Academy of Sciences panel charged with reviewing the 21st Century Truck Partnership spent a day at ORNL in February and received an update on lab research supporting this unique government/industry collaborative. The representatives are making site-visits to partners and chose also to visit ORNL, one of the National Labs heavily engaged in the program. 21st Century Truck Partnership was established to accelerate the introduction of advanced truck and bus technologies that use less fuel, have greater fuel diversity, operate more safely, are more reliable, meet future emissions standards,

and are cost-effective. Representatives from the Sustainable Transportation Program, Materials Science and Technology Division, Energy and Transportation Science Division, and Partnerships provided overviews and led tours through various labs at the main campus and at NTRC.

Martin travels with delegation to India

Biosciences Division's Madhavi Martin represented ORNL as a member of a technical delegation to India in late 2010. The delegation met with scientists from the Ministry of Renewable Energy, the Ministry of Science - Department of Biotechnology, and several representatives of Indian research institutions. While there, Madhavi participated in a workshop held in New Delhi that was organized by the Confederation of Indian Industry, "Biofuels India 2010: Sustainable Biofuels Market & Technology Development."



Madhavi Martin

Energy & Environmental Sciences Quarterly is published four times annually by Oak Ridge National Laboratory's Energy & Environmental Sciences Directorate.

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Oak Ridge National Laboratory is operated by UT-Battelle for the U.S. Department of Energy under contract DE-AC05-00OR22725.

Energy & Environmental Sciences
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FEP and partners sponsor ODS alloys workshop

ORNL Fossil Energy Program co-hosted a workshop on iron-based oxide dispersion strengthened (ODS) alloy in late 2010 in California to promote commercial and end user interest in application of ODS alloys within the fossil energy and nuclear energy arenas. The workshop created a forum for more than 30 attendees from around the world to exchange information among potential users, suppliers, component manufacturers, and research leaders.

ORNL hosts Buildings XI Conference

ORNL hosted the Buildings XI International Envelopes Conference in Florida in December, with sponsorship from DOE and the American Society of Heating, Refrigeration and Air-Conditioning Engineers. The tri-annual conference continues to be the premier conference addressing the underlying building science enabling building envelopes that are both energy efficient and moisture-durable.



Buildings XI Conference administration left to right: Energy and Transportation Science Division's (ETSD) Kim Grubb, Brenda Bush, and Teresa Williams; Angie Beach, Conference Office; and ETSD's Betty Walker.

Who Knows?

Do you know which of the following activities falls under the ORNL "Quality Counts in Everything We Do" program?



- Properly labeling lab samples
- Maintaining safe and orderly work spaces
- Cooperating with & respecting the authority of lab space managers
- Developing a Personal Performance Plan
- Mentoring junior staff and communicating expectations
- All of the above

If you answered **all of the above**, give yourself credit for the quality job you do every day and...

keep up the good work!