Science & Technology HIGHLIGHTS

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The Many Ways ORNL Works with Industry

Private-sector adoption of technological innovation is the ultimate success of R&D. The Energy Efficiency and Renewable Energy (EERE) and Electricity and Energy Assurance (EEA) Programs at ORNL have a record of success in transferring technologies to the private sector and continuing the growth of private business involvement in all program areas. Clearly, private businesses are attracted to activities that give them valuable results, and the number of businesses coming to ORNL each year speaks for itself.

One hallmark of ORNL's EERE and EEA Programs is the use of interdisciplinary teams with the skills to tackle problems of great complexity and scope. This integrated approach is further extended by the use of collaborative efforts with industry, academia, and other government agencies. Through these partnerships, the expertise and resources of ORNL are teamed with those of other complementary institutions in a way that often shortens the time between basic scientific discoveries and product development. Strong partnerships are used extensively by ORNL to increase the effectiveness of its development endeavors and to accelerate the adoption of resulting technologies.

This issue of *S&T Highlights* illustrates the many ways ORNL works with industry. The table gives the number of companies participating in each of several types of collaborative arrangements in several program areas. The "Other" category includes such activities as consultation and technical assistance that do not require a formal agreement.

Program	CRADA	R&D Partner	Test and Verification	User Facility	Other
Biomass	1	–	–	–	2
Buildings	1	28	8	4	13
Distributed Energy	1	27	62	–	6
Industry	18	177	46	43	–
Inventions & Innovation	–	–	–	–	57
Hydrogen	–	17	–	–	1
Hydro & Wind	–	1	6	–	–
Transportation	8	26	1	46	4
EEA	5	2	–	4	–
Total	**29**	**276**	**123**	**97**	**83**

Current collaborative efforts between industrial partners and ORNL EERE and EEA.

ORNL makes extensive use of cooperative research and development agreements (CRADAs). These agreements involve working partnerships in which ORNL and at least one private entity pool their resources to address a challenge of mutual interest. Although CRADAs do not provide funds to the private party, they are often preferred when proprietary information of the private company is used and that party hopes to gain competitive advantage as a result of the agreement. EEA's High-Temperature Superconductivity Program supports many CRADAs between manufacturers and ORNL. When the work is clearly pre-competitive, the funded R&D project is usually favored by private businesses.

User facility agreements resemble abbreviated CRADAs and are appropriate for discrete, short-term projects. The EERE program has six user facilities that are designed to serve not only ORNL staff scientists and engineers, but also researchers from industry, universities, and other laboratories. User agreements provide a brief mechanism to establish limited R&D collaborations using facilities that are optimized for specific areas of scientific investigation. They simultaneously advance national R&D and fulfill DOE missions by minimizing unnecessary duplication of effort, promoting beneficial scientific interaction, and making the most effective use of costly and, in many cases, unique equipment. ORNL's six EERE user facilities are described on pages 6-7.

The Test & Verification function is used extensively by EERE's Industrial and Distributed Energy Programs to achieve broad visibility in the private sector. This allows the demonstration of viable technology solutions to a wide variety of private business conditions. An example is provided in the article on page 4 describing novel refractory linings being tested at a paper mill in North Carolina.

ORNL also provides technology-based solutions through the licensing of its intellectual property. ORNL currently has over 100 active licenses with organizations ranging from start-ups to Fortune 100 companies to academic institutions. The Lab's Technology Transfer and Economic Development Office (www.ornl.gov/adm/tted/collaborations) works closely with licensees, particularly early-stage companies, to ensure successful commercialization.

The diversity of potential collaborative mechanisms offers private businesses extensive opportunity to capitalize on the resources and activities at ORNL.—*Dave Jamison and Marilyn Brown*

Making American Schools Energy Smart

Making K-12 schools "energy smart" is a daunting task. Rising utility costs, huge backlogs of deferred maintenance, and health litigation issues have encouraged school officials to address this issue, and requests for ORNL assistance have grown substantially.

Since 1995, ORNL has played a key supporting role in DOE's Rebuild America program, which works with communities to develop energy solutions that promote economic development. Rebuild America has grown to more than 600 partnerships nationwide, with K-12 schools participating in about a third of those. In 2000, the DOE EnergySmart Schools team was formed to concentrate on developing products, services, and an energy education component for schools (see www.energysmartschools.gov).

In many instances, ORNL's assistance has enabled school districts to take on higher-impact projects with less risk; and in most cases, the annual energy savings exceed the project cost over a period of 5 to 10 years.

An ORNL technical team is currently assisting the Oak Ridge, Tennessee, Board of Education with planning for a new Oak Ridge High School (ORHS) building through EnergySmart. An intern in ORNL's Southeast Consortium for Minorities in Engineering program is supporting the planning study by assisting with data collection and analysis. He will also prepare a procedure for students to take baseline measurements of the existing facilities scheduled for extensive upgrades. These measurements will assist with before-and-after characterization of the performance of the buildings while supporting the energy education program in the school.

To accelerate Rebuild America's impact on schools, ORNL has helped develop relationships with national associations representing school decision makers such as superintendents, business officials, teachers, and school board members. The National School Boards Association (NSBA) has formally endorsed Rebuild America/EnergySmart Schools. It is the first federal program to have received such an endorsement.

To promote energy education, ORNL has formed alliances with the National Energy Education Development Project, the National Energy Foundation, and the Alliance to Save Energy's Green Schools program. Through these arrangements, students in more than 70,000 classrooms are being educated to ensure that future decision makers know the importance of energy efficiency and renewable energy and can make informed decisions.

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Sponsor: DOE/EERE Weatherization and Intergovernmental Program

Hurricane Hunters: Learning from Roofs under Stress

One of the most comprehensive roofing investigations ever conducted of a hurricane-stricken area took place immediately after Hurricane Charley slammed into the South Florida coastline in August 2004.

Under the auspices of DOE and ORNL, investigators from the Roofing Industry Committee on Weather Issues (RICOWI)—engineers, roofing material specialists, insurance analysts, and roofing consultants—were trained by building scientists and other experts on wind damage to roofing systems. ORNL provided training and served as an umbrella under which individuals from various parts of the roofing industry could collaborate without being viewed as biased.

ORNL has worked with industry for many years to accelerate the acceptance of more energy-efficient, durable roofing systems. A major product of the post-hurricane investigation will be educational tools illustrating how to design and build more durable, energy-efficient roofs, and the serious consequences of falling short. Data gathered will be used to develop performance profiles of various roofing systems in severe wind storms. The profiles will be used to improve roof system durability, reduce waste generated by reroofing, and reduce insurance losses.

The RICOWI teams were formed in 1996, but Hurricane Charley was the first storm to strike since then with a sustained (for 1 minute) wind speed of 95 mph or more at landfall in a populated area in the continental United States. Between August 17 and 21, seven four-member teams and a ground coordination crew were deployed to the hurricane-damaged area and investigated all types of roofing systems. Each team had expertise in a specific type of roofing, such as asphalt shingles, tile, or wood. The teams inspected roofs specific to their expertise and assessed why each roof had failed or survived.

A member of the RICOWI team surveys hurricane damage to the roof of a large commercial building in Florida.

RICOWI is made up of all the major roofing associations and includes members of academia, educational and testing facilities, and others involved in roofing science. For more information about RICOWI, see www.ricowi.com. For more information on roofing research, see www.ornl.gov/sci/roofs+walls.

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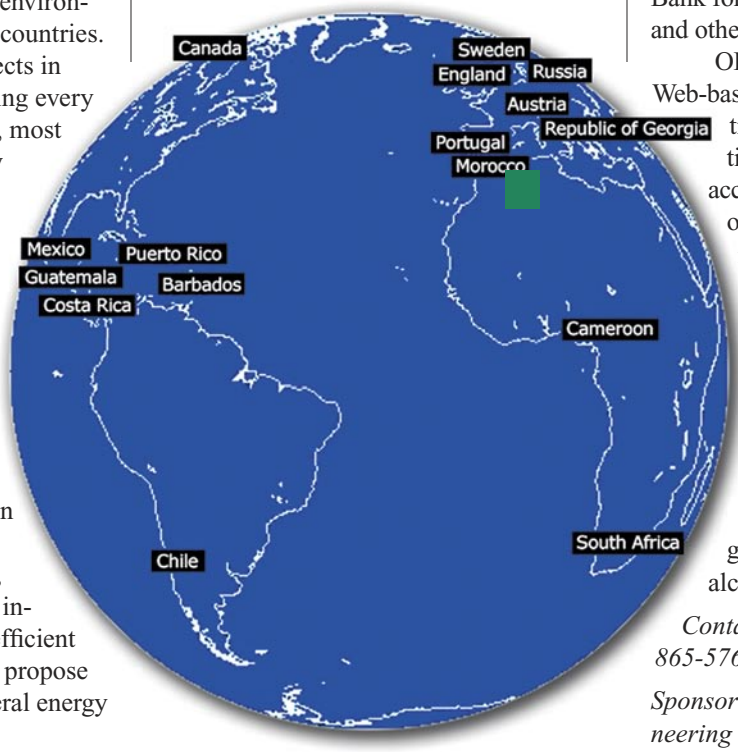
Sponsor: DOE/EERE Building Technologies Program

ORNL's Scientific Collaborations Around the Globe

ORNL has been extensively involved in international activities since the late 1950s, beginning with assistance in training experts on peaceful uses of the atom. Since the early 1970s, ORNL's international work has emphasized the basic energy sciences and energy and environmental assistance to developing countries. Since 1982, ORNL has led projects in more than 50 countries, addressing every major energy technology option, most energy policy options, and many environmental issues.

In the past 2 years ORNL has helped coordinate regional responses to oil spill detection and cleanup in the Black and Caspian Seas; design energy-efficiency projects to improve health care in Russian hospitals; develop policies and tariffs to promote energy efficiency and renewable energy in Algeria; train energy-efficiency professionals in India, the Caribbean, Ukraine, and other countries; disseminate information on American energy-efficient products to foreign markets; and propose activities for several DOE bi-lateral energy partnership agreements.

These projects include support for voluntary reductions of greenhouse gas emissions; bilateral assistance in energy efficiency and environmental efforts in cooperation with DOE, the U.S. Departments of State and Commerce, the U.S. Agency for International Development, the U.S. Environmental Protection Agency and the U.S. Trade Development Agency; and participation in multi-country technical assistance programs in collaboration with the United Nations, the World Bank, the European Bank for Reconstruction and Development, and other international organizations.



ORNL has developed and maintains a Web-based database of its international activities via a geographical information system (GIS). This collection accesses a knowledge base of the Laboratory's international projects. The information is retrievable in a user-friendly format and searchable by topic or country. The GIS helps ORNL collaborate on scientific matters as it promotes the commercialization and deployment of energy-efficient and environmentally friendly technologies.

Visit the GIS at www.ornl.gov/eere/international/internationalcollaborations.htm.

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Sponsor: ORNL EERE Program, Engineering Science and Technology Division

Refractory Linings for Black Liquor Gasifiers

ORNL's James Hemrick points out a test brick in the refractory lining of the black liquor gasifier at the New Bern paper mill.

ORNL is working with the U.S. paper industry to develop refractory materials to support a more efficient process for recovering the energy in black liquor, a waste stream of used pulping chemicals and wood. Normally, black liquor is sent to a recovery boiler where the organic waste is burned to generate steam and power and the chemicals are recovered for recycling. This process has several shortcomings: the energy recovery is not efficient; the boilers are highly expensive; gaseous emissions are produced; and failure of the high-pressure tubes forming the boiler walls can cause violent explosions.

Black liquor gasification, a more energy-efficient process, is being developed as an alternative to recovery boilers. A gasification process developed by a Swedish company is being used at a Weyerhauser mill in New Bern, North Carolina. The gasifier operates at 950–1000°C and uses a refractory-lined vessel. Successful implementation of the new technology depends on the resolution of several materials issues, the most serious of which is the limited lifetime of the refractory lining in the harsh conditions of the gasifier.

To address refractory performance, ORNL has developed test facilities in which refractory samples are exposed to molten salts and then analyzed to determine the nature and extent of the reaction. A fusion-cast magnesia-alumina spinel has been identified as especially promising. Two magnesia-alumina bricks were included in a refractory lining installed at the North Carolina mill early in 2003. Examination of the test bricks after 6½ months of exposure showed significantly better resistance to degradation than the standard lining.

A full lining of the magnesia-alumina refractory was installed in the gasifier for testing during the September 2004 shutdown, at a cost to the paper company of about $750,000. If the refractory lives up to expectations, it will suffer significantly less degradation and will have a lifetime of well over one year, thus resolving one of the major problems with the gasification technology.

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Sponsor: DOE/EERE Industrial Technologies Program

Cross section of a plug removed from a test brick exposed as part of the refractory lining.

Tech Fair Showcases ORNL Technologies

The Energy-Efficiency Technology and Business Fair in January in Asheville, NC, showcased nearly 350 energy-efficient technologies from ORNL and other labs and universities. The program linked more than 60 entrepreneurs, inventors, and businesses with individuals and organizations to help commercialize those resources.

The Fair was hosted by the Western North Carolina Center for Technology Commercialization (www.wncctc.org), created in 2004 as a result of DOE/EERE funding awarded competitively through ORNL. Partners who supported the development of the Center are Western North Carolina's Education and Research Services, The Institute at Biltmore and Asheville-Buncombe Technical Community College; and South Carolina's Spiro Center for Entrepreneurial Leadership at Clemson University.

ORNL offered 11 energy-efficient technologies for potential commercialization (research staff contacts are indicated):

- Acoustic fiber-optic detector for leak detection, diagnostics, and security protection (Roger Kisner)
- Thermally enhanced cellulose insulation (Jan Kosny)
- CF8C-Plus stainless steel for high-temperature uses (Phil Maziasz)
- Water-heating dehumidifier (Evelyn Baskin)
- Frostless heat pump (Vince Mei)
- Graphite foam for heat exchange (James Klett)
- High-strength undiffused brushless machine (John Hsu)
- Simplified hybrid secondary uncluttered induction machine (John Hsu)
- Nickel aluminide for high-temperature manufacturing (Vinod Sikka)
- Nitrided stainless steels for electrochemical devices (Michael Brady)
- Steel-skinned sandwich wall panel (Jan Kosny)

For more information on these technologies, see www.ornl.gov/sci/eere/state_partnerships/index.htm

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Sponsor: State Partnerships Program

"Reckoning" More with Less

This hotel uses a CHP system, including gas microturbines, for energy savings and energy security. The Reckoner evaluates the economics of such applications.

Responsible funding stewardship includes stretching research dollars to obtain the most results for the least cost. An example is the further development of an economic screening tool for combined heat and power (CHP) applications called the Cogen Ready Reckoner.

The Reckoner is a stand-alone Windows software that evaluates the financial viability of on-site electrical generation compared with purchasing electricity from the utility grid. By using waste heat from electricity generation to power heating and cooling equipment, distributed generation saves the fuel usually required for those purposes. While always beneficial from a resource conservation standpoint, however, distributed generation is not always financially advantageous. The Reckoner uses calculations based primarily on the difference between unit prices of grid power and of primary fuel (e.g., natural gas) to evaluate the economics of a potential application.

ORNL discovered the Reckoner in a survey to determine what tools are available for economic evaluation of CHP. Developed under the sponsorship of the Australian government, the software is publicly available free of charge and captures the technical and economic nuances of CHP systems well. But there was a problem for U.S. applications: it worked only in SI units and Australian dollars. In the United States, most thermal analysis is still based on English units (e.g., the btu). To broaden its applicability, ORNL proposed to the Australian developer that the Reckoner be enhanced with the options to use English units and U.S. currency. The software was so modified, with the understanding that the tool would remain publicly available.

The Reckoner is now being used in the United States to quickly evaluate the payoff for potential CHP projects. It prompts users with pop-up screens, provides default values for many inputs, and produces detailed tabular results for both the CHP and the baseline utility system scenario. It can be downloaded at www.eere.energy.gov/der/chp/chp-eval2.html.

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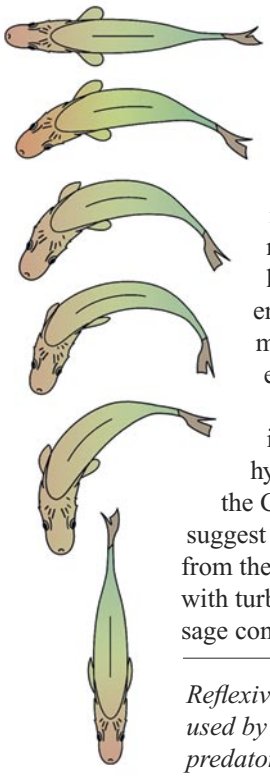
Sponsor: DOE/EERE Distributed Energy Program

Solving the Mystery of the Dying Salmon



DOE's Office of Wind and Hydropower Technologies is conducting R&D that will improve the environmental performance of hydropower projects, to enable both new development and continued generation at existing sites.

Recent studies of dead salmon at hydropower projects in the Columbia River basin suggest that disorientation from the turbulence associated with turbine or spillway passage contributes to their demise.

Reflexive, C-shape behavior used by startled fish to escape predators.

This confusion makes them more susceptible to predation by other fish or birds. In response to this behavior, ORNL scientists evaluated a new technique for assessing fish mortality, based on their innate behavioral response to a startling stimulus. The behavioral response is a rapid movement commonly referred to as a C-shape, named after the characteristic body position assumed by the fish. When viewed from above, a startled fish rapidly bends into a C-shape, then springs back and swims away in a direction different from its original orientation. C-shape behavior is reflexive, very rapid (completed in a small fraction of a second), common among many fish species, and an important mechanism by which fish escape predators. Laboratory tests confirm that C-shape behavior can be compromised by turbulence, brief exposure to a fish anesthetic, or passage through a small-scale turbine. These reductions in escape behavior make the fish more susceptible to largemouth bass predators.

Hydroelectric dams in the Pacific Northwest are interested in applying this new technique to assess losses of downstream-migrating salmon. If this rapid, inexpensive test proves to be a suitable indicator of fish mortality, it can be used to modify the operations of hydropower projects to produce more electricity with less adverse impact to migrating fish.

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Sponsor: DOE/EERE Wind and Hydropower Technologies Program

ORNL's EERE National User Facilities:

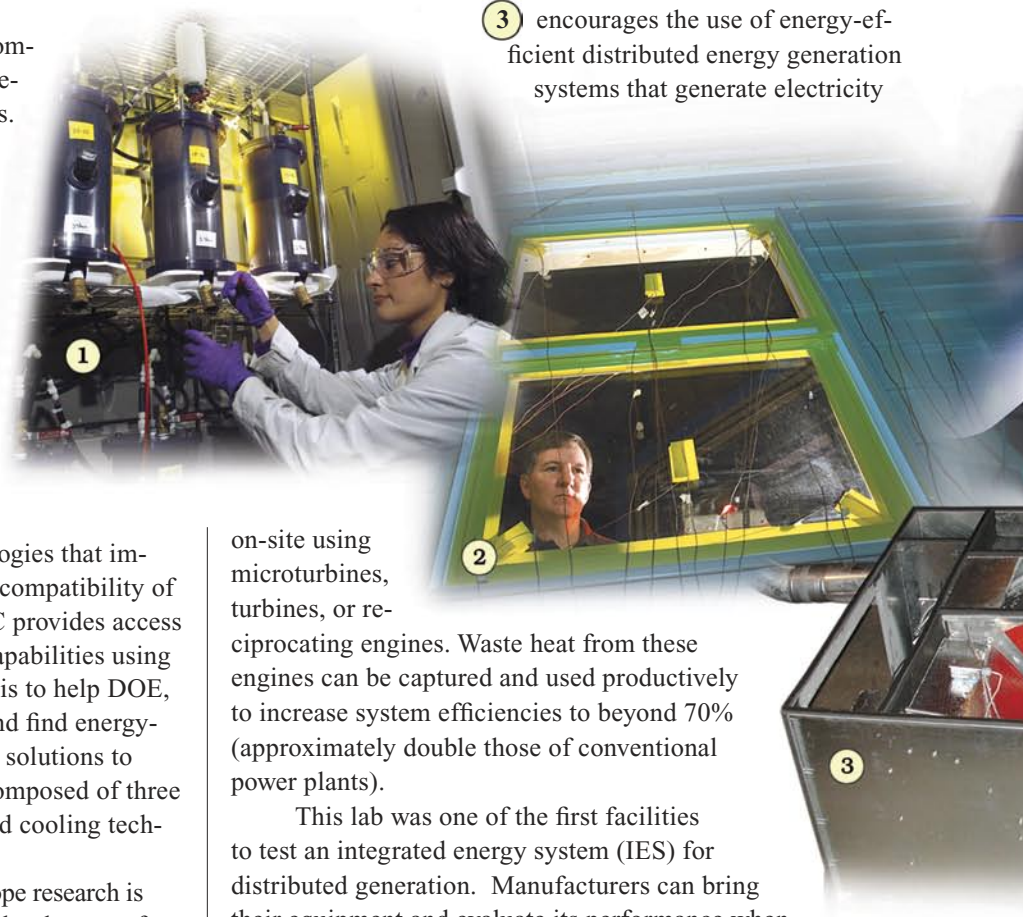
State-of-the-art research equipment and tools that no industrial company or university can afford are available to researchers nationwide at DOE's national user facilities at ORNL. These facilities serve as catalysts for partnerships and collaborations between ORNL and research partners. Six of them receive funding from DOE/EERE and are described further at www.ornl.gov/sci/eere/partnerships.htm. They are truly national resources for energy researchers.

The **BIOPROCESSING R&D CENTER** (1) houses equipment for investigating advanced bioprocessing concepts, including stirred-tank and columnar bioreactors and a fermentation plant for large-scale batch and columnar experiments. The range of equipment sizes accommodates both bench-scale experiments and large-scale demonstrations or process scale-up studies. Researchers have produced small, uniform, immobilized biocatalysts in demonstrating a scaled-up fluidized bed for producing ethanol from corn. The center has also collaborated with others to develop a bioreactor-based method of converting corn into succinic acid, demonstrating that renewable farm crops can be a cost-effective, environmentally friendly substitute for petroleum in making chemicals.

The **BUILDINGS TECHNOLOGY CENTER (BTC)** (2) is the premiere U.S. research facility devoted to developing technologies that improve the energy efficiency and environmental compatibility of residential and commercial buildings. The BTC provides access to a unique collection of testing and analysis capabilities using advanced experimental equipment. Its mission is to help DOE, industry, and other customers identify issues and find energy-efficient, environmentally sound, cost-effective solutions to problems in building systems. The facility is composed of three centers: building envelope research, heating and cooling technology, and existing buildings research.

The centerpiece facility for building envelope research is the ***large-scale climate simulator***, which sandwiches large roof sections between two environmental chambers. The upper climate chamber can simulate almost any outdoor weather condition; the lower one typically models interior conditions. The ***rotatable guarded hot box*** is used to test full-size wall, window, roof, and floor systems; data from these tests have been entered into a whole-wall rating database. The ***roof thermal research apparatus*** has tested 24 different reflective roof coatings for low-slope roofs, providing durability data to establish the long-term thermal performance of the coatings. The ***envelope systems research apparatus*** is used to study energy and moisture flow through building envelopes. The complete apparatus tested simultaneously and defined the thermal performance of 40 different roof systems, accounting for changes in rooftop surface reflectivity over time. An indoor-outdoor ***environmental chamber*** simulates temperatures and humidity conditions for the development of cutting-edge air-conditioning, refrigeration, and heat pump technologies. A heat exchanger test facility helps researchers design, develop, and test the performance of novel air-to-refrigerant heat exchangers without lubricant additives.

The **DISTRIBUTED GENERATION AND COOLING, HEATING, AND POWER INTEGRATION LABORATORY** (3) encourages the use of energy-efficient distributed energy generation systems that generate electricity on-site using microturbines, turbines, or reciprocating engines. Waste heat from these engines can be captured and used productively to increase system efficiencies to beyond 70% (approximately double those of conventional power plants).



This lab was one of the first facilities to test an integrated energy system (IES) for distributed generation. Manufacturers can bring their equipment and evaluate its performance when coupled with any of the engines, heat exchangers, absorption chillers, or desiccant systems in the laboratory. They can also use ORNL-developed software to optimize the design and performance of advanced IES technologies. New capabilities are being added to address the need for more-efficient heat exchangers and chillers, as well as the challenge of generating and controlling reactive power from distributed generation. Reactive power is important because it can be used to increase system efficiency, regulate voltage, improve power quality, and help stabilize the grid.

Research Tools for The Nation

The **HIGH TEMPERATURE MATERIALS LABORATORY (HTML)** (4) houses a staff of materials experts and unique materials characterization equipment, including scanning transmission electron microscopes that can be operated remotely. HTML staff work with industrial researchers to solve materials problems that limit the efficiency and reliability of advanced energy conversion systems, such as gas-fired microturbines and reciprocating engines.

HTML's six user centers are devoted to materials analysis, mechanical characterization and analysis, diffraction, thermophysical properties, residual stress, and machining, inspection, and tribology. HTML staff have access to a new aberration-corrected electron microscope in ORNL's new advanced microscopy lab, enabling characterization of materials at the subatomic level.

Researchers at HTML are designing components for thermal management systems that will enable the efficient operation of fuel-cell–powered cars and many other devices where heat transfer is critical. These components are built by weaving graphite fibers with high thermal conductivity. The resulting structures possess thermal properties comparable to those of ORNL's revolutionary graphite foam, but they possess much higher damage tolerance and mechanical strength.

The **METALS PROCESSING LABORATORY USERS FACILITY** (5) helps researchers in key U.S. industries, universities, and federal laboratories improve energy efficiency and enhance the global competitiveness of the U.S. metals and materials industry. MPLUS provides access to the specialized technical expertise and equipment needed to solve metals processing issues that limit the development and implementation of emerging metals processing technologies. Here's an example:

Logan Aluminum, which re-melts ingots of recycled aluminum-magnesium (Al-Mg) alloy, came to MPLUS for help. The company had found that a significant fraction of the alloy is high in dross content, an aluminum oxide solid waste that is either sent to landfills or further processed to make Al-Mg alloy. Aluminum is produced from aluminum oxide using electricity, so dross formation represents a waste of energy for the aluminum industry. Logan wanted to know why ingots contain so much dross and how it is formed.

ORNL researchers analyzed samples from the centers of the ingots. When they heated the material to temperatures 200°C higher than the alloy's melting temperature, they found it did not melt but instead formed dross. Using a scanning electron microscope, they observed that a thin oxide layer surrounded aluminum grains, like an eggshell enveloping an egg.

When the molten material slowly cools to form an ingot, air is pulled into the ingot's semi-solid center, leading to the formation of aluminum oxide on the surfaces of aluminum grains. When the ingot is re-melted, the oxide layer does not melt. Instead, high-quality molten aluminum grains are entrapped in the oxide shell and turned into dross. MPLUS suggested a different way of cooling to minimize dross formation. Logan put the method to use, reducing energy use by an estimated 0.34 trillion Btu/year.

The **NATIONAL TRANSPORTATION RESEARCH CENTER (NTRC)** (6) assists industry in using unique hardware and computing technologies to address problems of national and international significance, such as inefficient use of energy, dependence on foreign oil supplies, poor air quality, traffic congestion, and highway safety. The center has an array of unique testing equipment, including dynamometers to test diesel and other engines, and the Test Machine for Automotive Crashworthiness (TMAC), which measures the energy absorption properties of composites and metals when crushed in simulated collisions between vehicles. NTRC houses centers and laboratories for the study of composite materials; fuels, engines, and emissions; photonics and remote sensing; and power electronics and electric machinery.

—Adapted from ORNL REVIEW*, Vol. 38, No. 1, 2005*

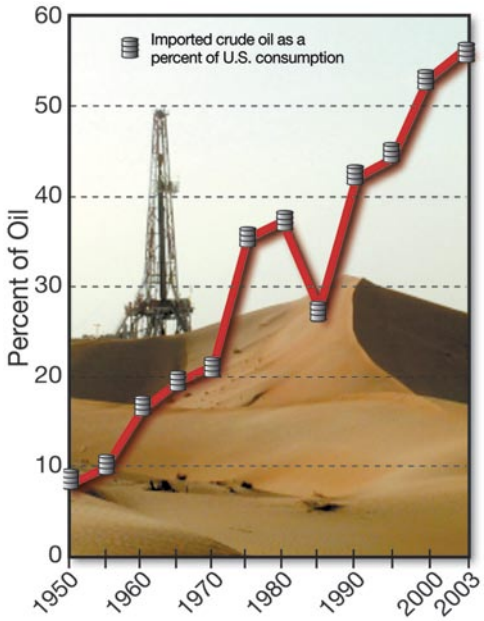
Time to Plan the Inevitable Transition from Conventional Oil

The world has a finite supply of petroleum, which is being consumed at a steadily increasing rate. Yet questions about when the supply of easily recoverable oil will begin to run out, and what will be done then, receive little serious public attention. An ORNL study makes the point that the time has come to begin considering and planning the transition from conventional oil to other fuel sources.

The study, *Running out of and into Oil: Analyzing Global Oil Depletion and Transition Through 2050*, attempts to combine the best available knowledge about the extent of world oil reserves with scenarios of world energy use to foresee when production of conventional oil is likely to peak and the transition to unconventional oil sources is likely to ramp up.

The report defines "unconventional oil" as heavy or viscous oils (e.g., oil sands) and shale oil (sedimentary rock containing organic matter that can be converted to synthetic petroleum under high heat). "Conventional oil" refers to light and medium liquid oils and natural gas liquids in permeable reservoirs.

Over the next 30 years, oil consumption worldwide is expected to grow by 60%. The debate over when demand will begin to overrun the conventional oil supply is important for two main reasons: (1) the world's economies need to know when and how rapidly the transition from conventional oil will occur so they can plan for a smooth rather than a disruptive transition; and (2) to protect the global environment and break free of dependence on oil, nations may want to plan for transitions to alternative energy sources.



The ORNL study creates an integrated model of the depletion of conventional oil and the transition to unconventional oil resources. The model permits a risk analysis by assuming probability distributions for several key parameters, including the quantity of conventional resources, advances in oil exploration and production technologies, Middle East oil production, and other economic assumptions. It can be run using various scenarios of world oil demand. A detailed description of the model is available at www-cta.ornl.gov/cta/publications/pdf/ornl_tm_2003_259.pdf.

The results of the study indicate that conventional oil production outside the Middle East is likely to peak and begin to decline before 2025. The model also predicts that conventional oil output worldwide will peak around 2020, decline slightly, recover briefly, and then peak for good near 2050.

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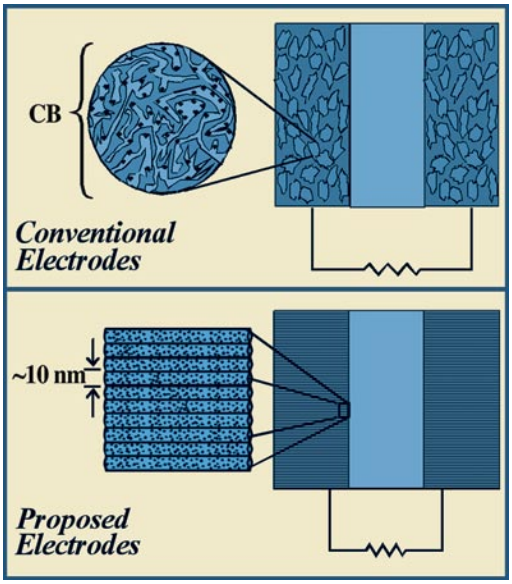
Sponsor: DOE/EERE Planning, Budget and Analysis

Nanochannels Clear the Way through Fuel Cell Membranes



An MEA being developed at ORNL provides a straight path to the platinum catalyst for H_2 and O_2.

Proton exchange membrane (PEM) fuel cells show great potential as a source of clean, efficient energy. However, a key hurdle to making PEM fuel cells cost-effective is the cost of the platinum (Pt) catalyst needed to spur the electrochemical reaction that produces power. The current cost of the required Pt is prohibitive, and no cost-effective alternative has emerged.

ORNL researchers are working on an alternative membrane electrode assembly (MEA) for PEMs that could significantly reduce the amount of Pt catalyst needed for power requirements, thus dramatically reducing the cost of a PEM fuel cell stack. The new assembly minimizes the path along which H_2 and O_2 must diffuse through the MEA. Conventional MEAs disperse Pt particles in nanoporous carbon black (CB), and the gas molecules must follow long, winding paths through the MEA to reach the Pt at the various sites. This route underutilizes much of the Pt.

The structure devised at ORNL is made of carbon nanochannels that allow the gas molecules a linear path through the MEA to the Pt particles. The inexpensive nanochannels are easily formed in the pores of an aluminum oxide template, which is available commercially. Once the alumina is removed, the nanochannels form an MEA that is essentially made of carbon tubes with a wall thickness of 4–5 nm and an outside diameter

continued on p.12

"Clean Cities" Coalition Helps Clear the Air in East Tennessee

The East Tennessee Clean Fuels Coalition (ETCFC), a partnership among more than 40 municipalities and counties, utilities, and public and private organizations, has been recognized as a member of DOE's "Clean Cities" program. The official designation took place at a ceremony at the headquarters of the Great Smoky Mountains National Park.

ORNL is a founding member of ETCFC. The Clean City designation will allow ETCFC to access Clean Cities Program technical and financial resources to support local decisions that enhance public health and quality of life by reducing air pollution while reducing dependence on foreign oil.

The Clean Cities Program seeks to advance U.S. economic, environmental, and energy security by supporting local decisions to adopt practices that reduce petroleum consumption. It develops public/private partnerships to promote alternative fuels and vehicles, fuel blends, fuel economy, hybrid vehicles, and technologies to reduce vehicle idling.

Smoky Mountains National Park bus.

ETCFC has several efforts under way:

- A "Biodiesel Brigade" of local drivers and fleets are using a biodiesel blend.
- Big South Fork national park is using biodiesel in its entire diesel equipment fleet.
- The ETCFC quarterly newsletter features information about use of alternative fuels and hybrids in East Tennessee (see http://eerc.ra.utk.edu/etcfc/index.html).
- Knoxville Area Transit's emissions reduction efforts resulted in its designation as a National Clean Bus Leader by EESI.org.

The East Tennessee coalition includes the towns of Knoxville, Sevierville, Maryville, Gatlinburg, Alcoa, Athens, Pigeon Forge, and Chattanooga and Anderson, Blount, Knox, Sevier, and Washington counties. Other members include the Great Smoky Mountains, Big South Fork, and Fall Creek Falls parks, ORNL, the Tennessee Valley Authority, the University of Tennessee, and several East Tennessee utilities, fuel providers, mass transit fleets, state agencies, and community organizations.

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Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies

E-Beam Curing of Polymer Composite Benefits Auto Maker

ORNL and its industry partners have demonstrated that electron beam (e-beam) curing can be used to manufacture composite automobile panels more energy-efficiently and more quickly than the thermal curing technique currently used. The research also identified technical challenges that must be resolved to make the process attractive to the auto industry.

Polymer matrix composites (PMCs) are strong, lightweight materials that can be used to reduce the weight of vehicles by replacing heavier metal components. Although PMCs are used routinely in aircraft bodies, the demands of high-volume auto manufacturing, with cycle times measured in seconds or minutes, have been a barrier to their use in automobile structures. The conventional process for curing PMCs includes heating for up to several hours in an autoclave. E-beam curing uses high-energy radiation instead of heat to cure the polymer resins in PMCs. It works more rapidly than thermal curing and in many cases uses less energy.

GM is using a carbon-fiber-reinforced polymer (CFRP) hood for its 2004 Corvette Z06 commemorative edition—the first time a North American automaker has used a painted CFRP exterior vehicle panel. The hood is 10.6 pounds lighter than the standard fiberglass hood. GM's supplier for the CFRP hood is using an improved, faster thermal curing process. ORNL tested the e-beam curing process on a prototype of the Corvette hood. The results indicate that e-beam curing could be scaled up to produce the component faster and at a higher volume than the process GM is using, and an approximate cost analysis suggests that the cost of e-beam curing would be lower. However, to fully exploit the advantages of e-beam curing, other technological advances are needed, including rapid upstream manufacturing processes and techniques for achieving a Class A finish.

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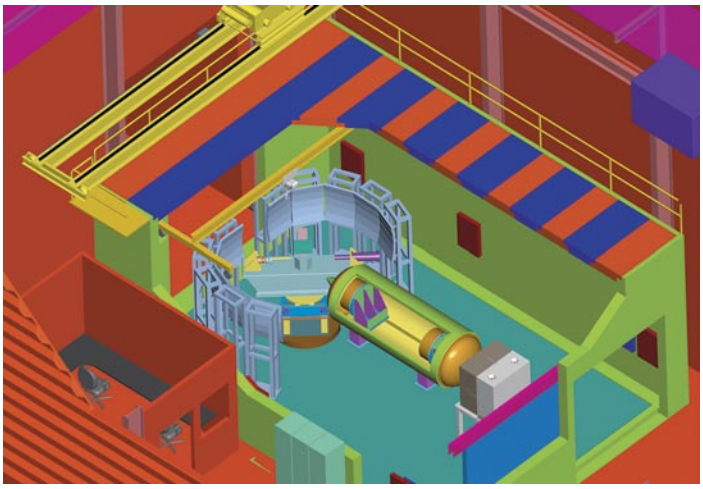
Sponsor: State Partnerships Program

PMC outer hood ready for e-beam curing (top). Finished PMC outer hood (bottom).

HTML's ANSWER for Materials Science Collaboration



ANSWER is working to make the proposed VULCAN neutron-scattering facility at ORNL's Spallation Neutron Source a reality.

ORNL's High Temperature Materials Laboratory has joined with the University of Tennessee (UT) and the Spallation Neutron Source (SNS) to establish ANSWER—Advanced Neutron Scattering netWork for Education and Research. The organization was chosen by the National Science Foundation as one of three International Materials Institutes in the United States and received a $3.6 million grant from the Foundation to establish an organizational framework, expand membership, and bring a new dimension to neutron science education. UT committed another $1.13 million to support ANSWER, bringing its funding to $4.73 million over 5 years.

Neutron scattering is one of the most powerful means available for characterizing materials, and a number of facilities for neutron science have been established in the United States, including the $1.4 billion SNS under construction at ORNL. Despite the investment in facilities, however, materials scientists were concerned that there was no concerted effort in the United States to advance the science of neutron scattering in materials research, especially research into the mechanical behavior of advanced materials. The National Science Foundation established the International Materials Institutes to address that need.

The overall mission of ANSWER is to develop an international neutron scattering network for innovative multi-disciplinary materials research and education. This effort is expected to significantly expand the use of neutron stress measurement in the United States, particularly HTML's new facility at ORNL's High Flux Isotope Reactor and the VULCAN instrument at SNS.

Another goal of the Institutes and ANSWER is to train young scientists at the undergraduate, graduate, and postgraduate levels to develop global leadership in neutron science. Other participants in ANSWER include the California and Illinois Institutes of Technology, Northwestern, the University of Missouri at Columbia, the University of Pennsylvania, and several corporations.

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Sponsor: National Science Foundation

New Microscopy Capabilities at HTML—Imaging of Atoms

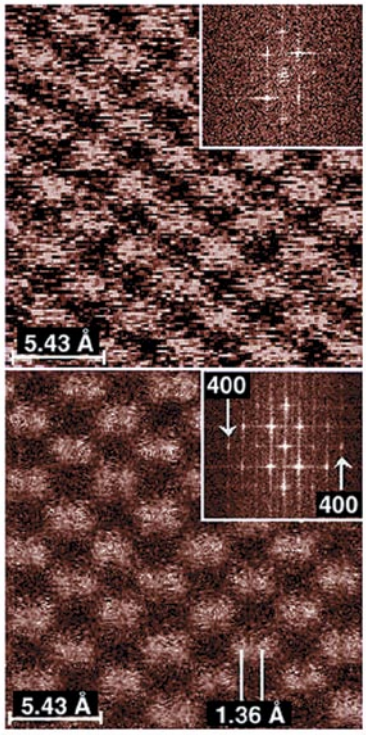
ORNL's newest world-class electron microscope is demonstrating an outstanding capability to image ultra-fine clusters of atoms and even single atoms of heavy metals used, for example, in catalytic materials. The instrument is one of the first of a new generation of microscopes equipped with an aberration corrector to improve resolution significantly over previous-generation machines. The aberration-corrected electron microscope (ACEM) can resolve detail in the sub-Ångstrom range (a million Å cover the diameter of a human hair), and single atoms are easily resolved using special imaging techniques.

The unprecedented resolution enables researchers to actually examine materials atom-by-atom. Because they can see the arrangement of atoms in a sample, they can confirm or revise theories, setting the stage for the development of improved materials.

The newest addition to the High Temperature Materials Laboratory's microscope collection is so sensitive it has to be housed in a special building—the Advanced Microscopy Laboratory— that minimizes electromagnetic interference and provides very strict control of building temperature, air turbulence, vibration, noise, humidity, and pressure changes. The building will eventually house four of ORNL's ultra-sensitive electron microscopes.

The JEOL 2200FS-AC, ORNL's new aberration-corrected electron microscope.

The ACEM was built by JEOL at its factory in Japan. It will be used primarily to support research and development of improved catalysts for reducing vehicle emissions. Because microconstituents of catalysts are often dispersed to the atomic level (platinum atoms on alumina particles, for example), extraordinarily fine resolution is necessary to fully characterize catalyst structure.



These images show a sample before aberration correction (top) and after (bottom).

Aberration correction compensates for an intrinsic imperfection in the lenses used in electron microscopes, called "spherical aberration." This imperfection prevents the lens from achieving a precise focus. ACEM uses a series of lenses and computer control to correct for the aberration and enable the microscope to achieve a focus that allows scientists to see individual atoms.

Other microscopes capable of aberration correction and sub-angstrom resolution exist, but are either privately owned or are research instruments not built for ease of use. Much of the ACEM's operation is computer-controlled with automatic aberration correction, making it relatively simple to use. ACEM will be available to researchers from industry and academia through the HTML National User Program. For more information, see http://html.ornl.gov/mauc/ACEM/ACEM.htm.

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Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies

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OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Southeast Army Energy Security Planning Effort Is a Success

ORNL's Federal Energy Management Program (FEMP) team has completed efforts to support 16 U.S. Army installations in the Southeast in developing energy security plans required by Army headquarters. Responding to a March 2004 Southeast Regional Army office request for assistance, DOE FEMP sponsored ORNL in this effort. A quick turnaround was necessary to meet the Army deadline of September 30, 2004, to complete plans for each installation. The FEMP group teamed with ORNL's Homeland Security group, SensorNet, and EERE Distributed Energy and worked in collaboration with DOE's southeastern Regional Office.

An integrated energy system with turbine generator and absorption chiller provides cooling, heating, and reliable power to barracks at Ft. Bragg.

ORNL first worked with Ft. Bragg to develop its energy security plan, which was a model for the other 15 installations. Five on-site kickoff meetings were held with multiple bases, including one at Ft. Bragg. ORNL also developed tools for all the installations to use in developing their plans. The tools included an energy security checklist, an energy security plan template, and a guide to using the template. The checklist and template were customized to ensure that plans would meet the detailed requirements of the Army Defense Energy Program Policy Memorandum 92-1. The plans include an energy vulnerability assessment, an energy emergency preparedness and operations plan, and a remedial action plan that details steps to mitigate energy security vulnerabilities.

The Army's attention to energy security seemed more than timely when one kickoff meeting was darkened by an emergency power outage and work on another plan was postponed because base operations shut down as the result of a hurricane and subsequent outage.

The installations served were Anniston Army Depot (AL), Bluegrass Army Depot (KY), Fort Benning (GA), Fort Bragg (NC), Fort Buchanan (Puerto Rico), Fort Campbell (KY/TN), Fort Gordon (GA), Fort Jackson (SC), Fort Knox (KY), Fort McPherson (GA), Fort Gillem (GA), Redstone Arsenal (AL), Fort Rucker (AL), Fort Stewart (GA), Hunter Army Air Field (GA), and Sunny Point Military Ocean Terminal (NC).

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Sponsor:DOE/EERE Federal Energy Management Program

News Briefs

Energy and Water Management Award

ORNL has received a 2004 DOE Federal Energy and Water Management Award for achievements in energy and water management in its East Campus modernization project. The building project of over 300,000 ft^2 achieves savings of $0.5 million in energy costs each year and has received certification by the U.S. Green Buildings Council as a LEED Version 2 project. Important changes in established practices were introduced at ORNL that now allow all new building projects to proceed using sustainable, integrated design practices that will benefit the site through its multi-year modernization program.

Goyal Named AAAS Fellow

Amit Goyal of ORNL's Metals and Ceramics Division has been elected a fellow of the American Association for the Advancement of Science. He is honored for his contributions to the field of high-temperature superconductivity and for the invention and development of the rolling-assisted-biaxially-textured substrates (RABiTS) process to fabricate high-performance superconductors. Goyal has been issued 42 U.S. and three international patents. He has earned numerous awards and co-authored about 270 publications.

Parans Is Institute of Physics Fellow

Parans Paranthaman of ORNL has been elected a fellow of the Institute of Physics in London. Parans is noted for his work with superconducting technology. He is a member of ORNL's Chemical Sciences Division.

Turning Goals into Reality

ORNL, members of the Distributed Energy Program, Argonne National Lab and the Midwest Regional Office have received NASA's prestigious Turning Goals into Reality (TGIR) Award. The TGIR Award acknowledges outstanding contributions and exceptional progress toward achieving program goals and objectives of the Office of Aeronautics. The Distributed Energy Program team contributed to a collective effort to develop coated ceramic matrix composite components for gas turbine applications.

Fuel Economy Guide On-Line

The 2005 *Fuel Economy Guide* published by DOE and the Environmental Protection Agency is now available on-line at www.fueleconomy.gov. In addition to a link to the latest edition of the *Fuel Economy Guide*, the site offers other detailed information on vehicle fuel economy. Fuel economy information goes back to 1978, making it helpful for evaluating used cars. It also includes emissions information, safety data for model year 2005 vehicles, and fuel economy tips for drivers. Printed copies of the *Fuel Economy Guide* are available at car dealerships, public libraries, and credit unions.

Nanochannels continued from p.8

of 20–200 nm. Because the gases can easily reach all the Pt particles, the catalyst is used more efficiently and less Pt is needed to produce the same amount of power. Laboratory results in a research-grade PEM fuel cell demonstrated a 6× improvement in the power generated per gram of Pt for the new support compared with the conventional Pt/carbon black.

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Sponsor: ORNL Laboratory-Directed Research and Development

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