Science & Technology HIGHLIGHTS

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Transportation user facility aids collaboration among research partners

The opening of the National Transportation Research Center, the home of many of ORNL's transportation programs, makes it easier for partners in industry and other research organizations to conduct R&D in cooperation with ORNL and access the unique resources of the national laboratory.

The NTRC is located in West Knox County, Tennessee, between Knoxville and Oak Ridge. Completed in the fall of 2000, it is the result of a joint effort involving ORNL, the University of Tennessee, DOE, NTRC, Inc. (a private foundation), UT-Battelle, and the Development Corporation of Knox County. The building contains about 83,000 ft^2 of space, about two-thirds of it dedicated to research laboratories and the rest to office space for staff from ORNL and UT.

DOE recently designated the entire NTRC a national user facility. DOE user facilities enable researchers from businesses, universities, and other institutions to have access to unique R&D equipment and resources at DOE's research laboratories that otherwise would not be readily available. They encourage collaboration between DOE researchers and those in the private sector. "The user facility designation greatly enhances our ability to interact with industry, universities and other laboratories," says Dick Ziegler, director of the NTRC User Facility. He adds, "This enables our researchers to work side-by-side with researchers from other organizations, jointly solving problems of mutual interest." ORNL's Office of Technology Transfer and Economic Development coordinates arrangements for use of ORNL's 18 user facilities (www.ornl.gov/tech_transfer/).

There are currently 11 laboratories and research centers at the NTRC:

Advanced Supply Chain Management Laboratory—investigates the use of radio-frequency identification tags to help track and control hazardous materials shipments.

Commercial Vehicle Operations Laboratory—analyzes equipment and technologies for making commercial vehicles safer and more efficient.

Composite Materials Laboratory—conducts controlled, programmable analysis of the deformation and failure response of composite automotive components in relation to impact velocity.

Fuels, Engines, and Emissions Research Center—analyzes power plant and vehicle performance and emissions reduction technologies.

Geographic Information Systems Laboratory—creates innovative ways to plan, manage, and track traffic by using geography-based decision support systems.

Infrastructure Materials Laboratory—tests and evaluates materials such as concrete and asphalt used in bridges, culverts, highways, roadbeds, and other parts of the transportation infrastructure.

Intelligent Transportation Systems Laboratory—provides an advanced, real-world environment for evaluating and applying ITS technologies to improve the efficiency, productivity, and safety of transportation, and to alleviate the impact of transportation on the environment.

Defense Transportation and Logistics Laboratory—provides the defense transportation community with innovative, practical tools and techniques for the analysis and management of transportation and logistics systems.

Analyzing engine performance in an NTRC lab.

Packaging Research Laboratory—helps clients develop safe, efficient, economical solutions for the shipment of hazardous and high-value materials.

Photonics and Fiber Optics Laboratory—conducts research on a wide range of applications, focusing primarily on remote sensing and weigh-in-motion, spectroscopy, full-spectrum solar energy, and sensors.

Power Electronics and Electric Machinery Research Center—develops and prototypes the next generation of cost-effective converters, adjustable-speed drives, electric utility and distributed-generation applications, motor controls, and efficient, compact electric machines.

For more information about the NTRC, see www.ntrc.gov.

ORNL FEMP helps federal sites implement cogeneration projects

The Federal Energy Management Program (FEMP) is charged with helping federal sites implement cooling, heating, and power (CHP) technologies. To expedite this mission, ORNL's FEMP team has launched "ADD CHP"—Accelerated Development and Deployment of CHP.

FEMP helps federal agencies move to CHP systems both by providing technical support and by directing sites to private financing programs such as DOE FEMP's super energy service performance contracts. CHP, also known as cogeneration, achieves extraordinary efficiencies by combining power generation with the recovery and use of thermal energy wasted by conventional power plants. FEMP emphasizes CHP systems for several reasons, among them:

- Large CHP systems are commercially available and use proven technology but are underused in the federal sector.
- CHP can provide federal facilities with significant reductions in overall utility costs and peak demand costs.
- CHP increases energy security by offering more reliable, supplementary electrical supplies.
- Although federal agencies have expressed interest in CHP, access to these technologies is not easy because of their initial cost.

Federal sites with central boiler/chiller plants or district heating/cooling systems in good condition are prime candidates for large CHP systems. So are individual buildings with thermal distribution systems for heating, ventilating, and air conditioning (HVAC) that are compatible with CHP technology, because "packaged" equipment designed to be inexpensively installed and easily adapted to work with conventional HVAC systems will soon be available on the market.

Over the past few months, ORNL's FEMP team conducted a national market assessment of the federal sector and ranked the CHP potential of federal sites in California, New York, and Texas that could cogenerate 1 MW of power or more. Approximately 350 MW of CHP potential was identified in facilities in the three states—230 MW in California alone. The study also estimated that nationally, federal facilities could provide more than 1000 MW. The team plans a similar assessment for the Southeast.

ORNL provides comprehensive technical support to agency sites that plan to develop CHP projects. Commercially available advanced CHP technology will be deployed; federal site facility managers will also be linked with manufacturers who are developing integrated CHP packages. Agencies needing private-sector financing will be partnered with energy services companies or utilities. The goal of ADD CHP is the deployment of 12 large CHP systems at federal sites.

ADD CHP is part of DOE's effort to expand the use of CHP in the United States. As FEMP works to make CHP accessible to federal facilities, DOE's Office of Power Technologies is making similar efforts in the private sector, as well as addressing policy, regulatory, and technical barriers. DOE's goal is to double CHP capacity in the United States by 2010. As part of this effort, ORNL's CHP Integration Laboratory focuses on the innovative integration of distributed generation, heat recovery, and thermally activated cooling and humidity control technologies into high-efficiency CHP systems.

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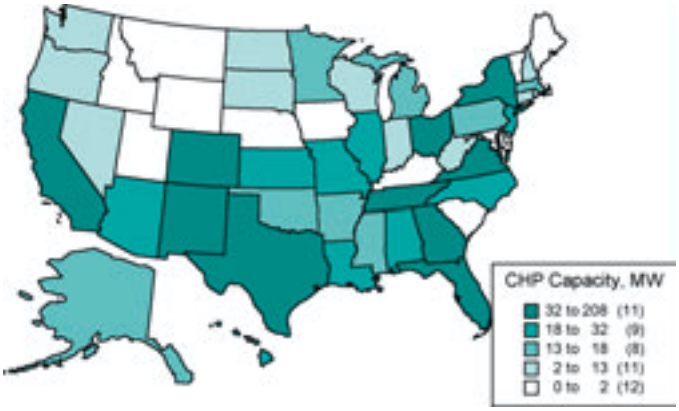

Potential for deployment of CHP in federal facilities. Facilities in ten states and the District of Columbia have the potential for significant energy and cost savings through implementation of cogeneration.

ORNL study confirms savings from ENERGY STAR clothes washers

A DOE-sponsored demonstration of an energy-efficient washer in a Boston suburb has produced such striking results that the Massachusetts legislature is using the research results to support a bill that would make ENERGY STAR appliances tax-exempt in that state.

In late 2000 John Tomlinson and his colleagues in ORNL's Buildings Technology Center (BTC) conducted a study with residents in a Reading, Massachusetts, apartment complex to determine savings in energy and water use with high-efficiency clothes washers. The study—a partnership between DOE, Maytag Appliances, and the residents of the apartment complex—was similar to a 1997 study in rural Bern, Kansas, also conducted by the BTC group. In both studies, energy and water use was monitored and calculated before and after installation of Maytag's Neptune washer. The earlier study found that the ENERGY STAR-labeled machines used 56% less energy and 38% less water, saving the town of Bern 640,000 gallons annually.

The study conducted in urban households found similar savings. In fact, the water savings in the Boston households were 10% greater than in Bern. In the Boston study, dryers used 13% less energy to dry clothes washed in the new washers, partially

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200th user of building envelope facility tests recycled concrete wall

A building's "envelope"—its walls, roof, and foundation—serves as the thermal barrier between the indoor and outdoor environment and is a key determinant of a building's energy requirements. The Building Envelope National User Facility, housed in ORNL's Buildings Technology Center (BTC), conducts research on improving building envelopes and the insulating materials they contain. To date, the facility has provided whole-wall performance evaluations of 67 different wall systems for industrial users.

Construction of the flyash test wall in the BTC. The AAC blocks, found to have good insulating properties, will be field-tested in a Habitat for Humanity house.

The facility recently tested a wall system for its 200th user, the Tennessee Valley Authority (TVA), in partnership with Babb International, Inc., the largest U.S. manufacturer of autoclaved aerated concrete (AAC) products. AAC is an extremely lightweight building material weighing as little as one-fifth as much as ordinary concrete. The two partners are interested in developing an AAC block made with 70 wt% flyash from TVA's coal-fired power plants—a building block that insulates well and recycles material that would otherwise have to be disposed of at some cost to the environment. BTC tests have shown a test wall using this AAC block to have a steady-state clear wall R-value of 7.2, higher than values for several other AAC block walls tested at the BTC. Analysis is under way to determine the equivalent whole wall performance accounting for its inherent thermal mass benefit.

TVA and Babb's interest in developing the flyash block dovetails with the interest of Habitat for Humanity International in applying AAC technologies to affordable housing. Because AAC block walls with high R-values may not require added insulation, they provide the potential for inexpensive, simple construction as well as energy efficiency. TVA plans to test the flyash blocks on both counts in the near future by building an energy-efficient Habitat house. BTC researchers will install instruments and monitor the energy efficiency and airtightness of the house for a year. The results will be compared with data obtained from the recently completed monitoring of two identical Habitat houses built in Lenoir City, Tennessee, in 2000.

This project will help DOE reach both of the broad goals underlying the most recent National Energy Plan—providing energy in an environmentally responsible manner and promoting energy conservation. It will also provide more data for the BTC's Whole-Wall Thermal Performance Calculator (http://www.ornl.gov/roofs+walls/whole_wall/wallsys.html) that enables Internet users to compare whole-wall R-values for more than 40 different wall systems, based on a uniform rating system.

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Sponsor: Tennessee Valley Authority

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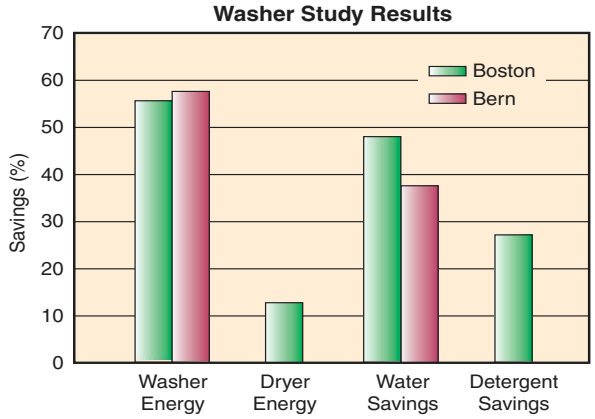
because the faster spin cycle removed more water. The new washing machines also used 27% less detergent. Such savings could have large ramifications: for instance, if every Boston household used energy-efficient washers, Boston could save 1.5 billion gallons of water annually and enough power to run 14,000 homes.



ORNL studies in Boston and Bern, Kansas, show that use of energy-efficient clothes washers produces significant savings.

Studies like these, which have been widely reported in the news media, are helping spur appliance manufacturers to offer super-efficient clothes washers and state legislatures to consider tax incentives for efficient appliances. Consumers, the environment, and the nation are the winners.

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GPLUS and Chemicals PLUS accelerate energy-related R&D in industries

The GPLUS and Chemicals PLUS programs are outgrowths of the DOE Office of Industrial Technologies' (OIT's) "Industries of the Future" (IOF) strategy, which creates partnerships between government, industry, national labs, and academia to accelerate energy-related R&D within nine energy-intensive industries.

The national laboratory coordinating contact for GPLUS is ORNL's Pete Angelini. The coordinator for Chemicals PLUS is ORNL's Sharon Robinson.

GPLUS (Glass Project Laboratory User Services) was initiated in FY 2000 by the Glass Manufacturing Industry Council (GMIC) in partnership with OIT. Recognizing that individual companies frequently face specific energy-related challenges, OIT allocated funds from its glass IOF budget to enable GMIC core member companies to propose relatively small-scale projects to be carried out in collaboration with any one of the DOE national laboratories. GMIC member companies, either on their own or in collaboration with another GMIC member, may request one $25,000 project per year.

Because of a simple application process, research can be carried out rapidly and results made available to the member within several months. Funding for GPLUS in FY 2002 will be approximately $300,000. In addition to three GPLUS projects discussed in the accompanying article, five other GPLUS studies are under way: windshield coatings, mechanical strength of tempered and annealed automotive glass, effectiveness of caustic soda in controlling boron emissions, use of encapsulated additives to reduce refractory corrosion, and high-temperature thermocouple degradation.

The *Chemicals PLUS program*, modeled on GPLUS, was developed by the Chemical Industry Vision 2020 Technology Partnership. Vision 2020 is an industry-led private/public partnership to accelerate innovation and technology development for the chemical industry.

OIT has allocated a budget of about $275,000 for up to three Chemicals PLUS projects in FY 2002. Two projects have been reviewed for FY 2002 funding: assessments to support an effort to deliver biomass energy to a combined heat and power plant, and a technical assessment supporting advanced chemical separations technology.

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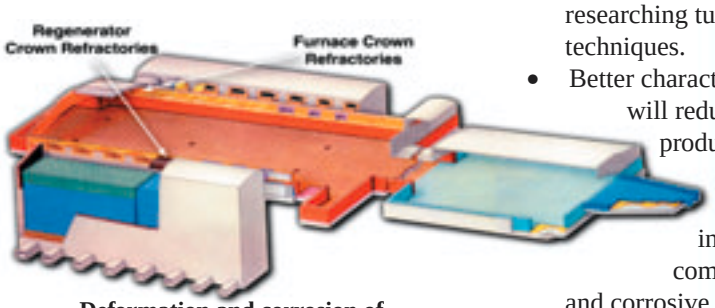
ORNL aids chemicals and glass industries in energy-saving research

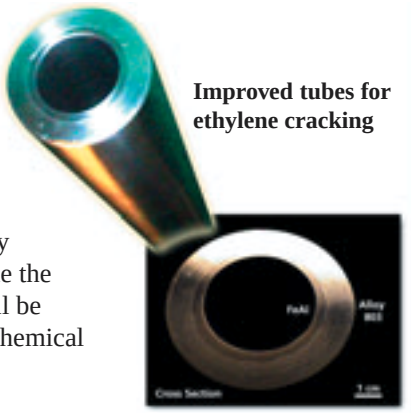
ORNL researchers are at work on several glass and chemical projects funded through DOE's Industries of the Future (IOF) program.

- Needles or whiskers form around glass extrusion orifices made of refractory metals, interfering with the flow of molten glass and hampering process efficiency. ORNL researchers will characterize the needles and use the data in thermodynamic models to address the causes of whisker formation.



Deformation and corrosion of refractories accelerate as furnaces are switched to more economical and efficient oxy-fuel firing.

- A castable refractory encases the precious metal bushings used in manufacturing glass fibers. ORNL will investigate materials, mix formulations, and drying/curing schedules to identify ways to improve the properties of the refractories.
- A GPLUS project seeks to develop improved refractions and determine critical thermo-mechanical and thermo-physical properties of refractories in various environments. The results will be used to enable oxy-fuel firing of large glass melting furnaces, a more energy-efficient process than air-firing.
- ORNL is working with ethylene producers to develop new materials for ethylene furnace tubes. Improved tube materials that resist coking and carburization would prolong tube life and increase furnace efficiency. ORNL is also researching tube fabrication methods and welding techniques.
- Better characterization of alloys under operating conditions will reduce energy use, improve process safety and productivity, and reduce the costs of using advanced alloys. ORNL is part of a project to develop a database to help the chemical industry predict the corrosion behavior of commercial alloys subjected to high temperatures and corrosive gases.
- ORNL is developing a predictive computer model to account for the hydraulics inside chemical distillation columns. The model will be used to improve distillation column operation and design higher-efficiency internal structures inside the columns. The result will be more energy-efficient chemical distillation processes.



Improved tubes for ethylene cracking

High Temperature Materials Lab adds equipment and capabilities

ORNL's High Temperature Materials Laboratory (HTML) is a national user facility sponsored principally by DOE's Office of Transportation Technologies. It assists American industries, universities, and governmental agencies in developing advanced materials by providing a skilled staff and numerous sophisticated, often one-of-a-kind, pieces of materials characterization equipment.

The HTML occupies a 64,500-ft^2 building at ORNL and houses six "user centers," which are clusters of specialized equipment used for specific types of properties measurements. Lots of new equipment and capabilities have been added to these centers recently.

- Researchers in the *Materials Analysis User Center* employ electron microscopy and surface chemical analysis to determine structure, surface chemistry, and microstructure to the atomic level. Since 1998, we have added a Hitachi FB2000 focused ion beam milling instrument and a Hitachi HD2000 scanning transmission electron microscope.
- Equipment in the *Mechanical Properties User Center* is used to study the fracture toughness, tensile strength, flexure strength, and tensile creep of advanced materials at temperatures of up to 1400°C. A recent addition is the Dilor raman microprobe, allowing measurements of stresses in materials at the micron resolution level.
- The *Residual Stress User Center* has X-ray diffractometers to measure residual stress and texture in and near the surface of ceramics and alloys, and neutron spectrometers to measure these characteristics deep inside specimens. Users can also access the National Synchrotron Light Source, located at Brookhaven National Laboratory, through this user center. Recent changes include the capability to handle various gaseous atmospheres surrounding the sample during examination.
- The *Diffraction User Center* has both room-temperature and furnace-equipped X-ray, synchrotron, and neutron diffractometers. A new Philips high-temperature X-ray diffractometer has been consigned to this center.
- Researchers in the *Thermophysical Properties User Center* study thermal stability, expansion, and thermal conductivity of materials at temperatures of up to 1400°C. The center also boasts a high-speed, high-sensitivity infrared camera for capturing thermal events digitally, allowing on-line or post-operation measurement of temperatures during rapid transient events. Since 1998, this center has added a quench dilatometer, allowing rapid determination of the stability of alloy phases.
- The *Machining and Inspection Research User Center* employs instrumented grinders to study grinding of ceramics and special alloys. Other capabilities include instruments for determining the ground component's shape, tolerance accuracy, and surface finish. Finally, the center provides equipment for measuring the friction and wear behavior of materials under various atmospheric and engine-simulated conditions. A new high-stiffness surface grinder was added to this center in 2001.

ORNL researcher Dorothy Coffey uses the focused ion beam milling instrument in the HTML.

The HTML User Program functions to help outside researchers solve materials problems using state-of-the-art characterization instrumentation. Either nonproprietary or proprietary research can be performed. Nonproprietary research is provided free of charge if the user publishes the information produced; proprietary research requires payment.

More information on working with the HTML is available at www.ms.ornl.gov/htmlhome.

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Unique instruments rev up research on engine efficiency and emissions

The Fuel, Engine, and Emissions Research Center (FEERC, formerly the Advanced Propulsion Technology Center), specializes in the detailed characterization of the efficiency and emissions of internal combustion engines. It is located in the National Transportation Research Center.

The comprehensive capabilities of the FEERC include benchtop engine exhaust simulators, a wide range of dynamometers, and full vehicles. The center boasts several special diagnostic and measurement tools—many of them rarely found at other facilities—that aid researchers in developing and evaluating engine and emission control technologies.

Research areas include an analytical lab, four engine labs with dynamometers, and a chassis dynamometer lab. The analytical lab houses a bench flow reactor, a direct sampling capillary mass spectrometer, a chemisorption unit, and an optical bench. Infrared spectroscopy and laser-phosphor thermography equipment are in adjacent labs.

The four engine dynamometer cells, three of them motored, range from 10 to 600 horsepower. They can be set up to provide highly controlled aftertreatment device performance. The chassis dynamometer has an absorption capacity of ~300 horsepower and can accommodate all the emissions instruments used in the center.

The FEERC staff includes specialists in emissions measurements, dynamometer cell operation, and engine controls and control theory.

Projects currently under way in the FEERC include

- Analysis of the effects of fuel sulfur on diesel emissions controls, diesel and gasoline engine particle emissions, advanced engine control strategies, and catalyst surface diagnostics
- Research on emissions control using NO_x absorber catalysts, selective catalytic reduction, exhaust gas recirculation (EGR), particle filters, and controls with virtual sensing
- Analysis of emissions from ethanol-diesel fuel blends
- Research on catalyst functions and EGR
- Development of innovative ignition concepts
- Study of the time response and sensitivity of NO_x sensors

Scott Sluder of the FEERC uses a chassis dynamometer to analyze engine efficiency and emissions.

Researchers from industry and academia can access the unique equipment at the FEERC by executing a User Agreement. This easily executed agreement defines the work to be completed and specifies the ownership of any resulting intellectual property.

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In industry/state partnership, ORNL analyzes residual stresses in steels

Cummins Engine, one of the largest makers of diesel engines, is using induction heating to make more-reliable and lower-cost engine components. Induction hardening, which treats a material by passing an electric current through it, eliminates lengthy, energy-intensive heat treatment in the manufacture of forged-steel components. The process, however, creates a transition zone in steel components where microstructural and stress gradients occur between the soft, large-grained iron-like core and the hard, fine-grained steel outer surface. These sharp gradients compromise fatigue strength and shorten component life.

As a first step in addressing this problem, ORNL, Cummins Engine, and the state of Indiana supported a project to analyze residual stresses in induction-hardened steels. ORNL researchers examined simple steel specimens provided by Cummins that were treated to produce a transition zone like that in a forged component. They performed metallographic characterizations of an identical companion and similar specimens. Residual stresses were then measured using X-ray and neutron diffraction techniques.

The neutron residual stress measurements clearly showed a sharp transition from the induction-hardened outer layer into the base material (see figure on p. 7). Cummins has used these residual stress data to optimize heat treatment of crankshafts in order to reduce warping and scrap.

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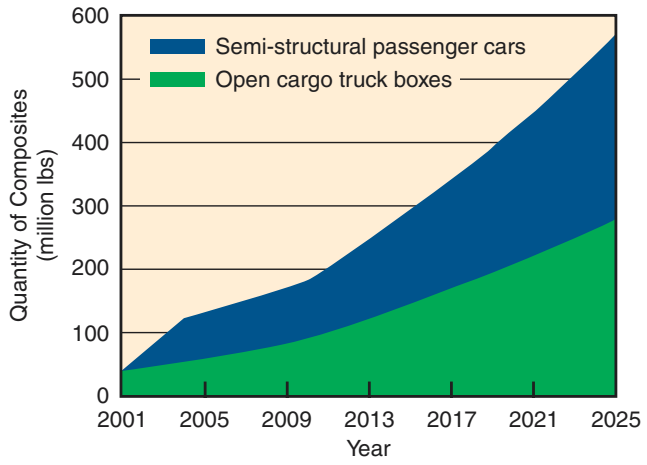
Cost-competitiveness is the driving issue for automotive composites

Polymer composites have been used in the automotive industry for several decades, especially in applications such as body panels. However, their major use is still in low- and mid-volume cars and trucks. They constitute only a very small percentage of the total material used in the American automobile: an average car contains only about 8% plastic and composites.



Market forecasts for the manufacturing of composite automotive structures, used to estimate benefits and costs.

The primary reason polymer composites are not widely used is their cost: in large production volumes, glass fiber– and carbon fiber–reinforced materials cost the manufacturer 62% and 76% more, respectively, than the conventional steel unibody. The high cost stems from the expense of producing the materials and the slow fabrication process.

For composites to be cost-effective, cycle times and materials use must be improved and the cost of carbon fiber must be reduced.

Greater use of such materials would be a boon to fuel economy because they would reduce vehicle weight substantially. Moreover, newer materials such as carbon fiber–reinforced polymer composites are half the weight of the conventional glass fiber–reinforced thermoset polymers used currently.

DOE would like to see an increase in polymer composites in vehicles and is exploring solutions through its Lightweight Materials Program. In a recent study, ORNL researchers examined the economic issues currently posed by automotive polymer composites and evaluated DOE's lightweight materials composites research in light of these issues to assess its effectiveness.

The ORNL study found that for composites to be cost-competitive in a part-by-part substitution, improvements are necessary in cycle times and material utilization, which currently contribute 60% and 21%, respectively, of the total cost of carbon fiber–reinforced thermoplastics. Moreover, there must be a 50% reduction in the cost of carbon fiber and smaller cost reductions in other thermoplastic materials.

An aggressive R&D program is needed to address these issues. In the cost area, it is appropriate to focus on materials, primarily carbon fiber. To improve the manufacturability of polymer composites, development of high-volume production manufacturing processes is also a priority.

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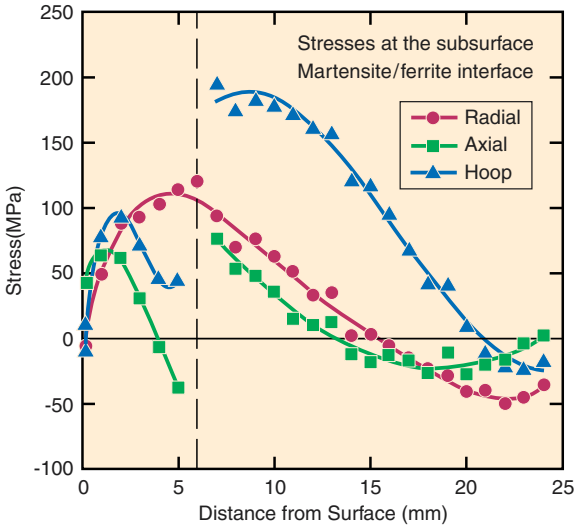

Residual stress is a function of depth through the induction-hardened outer layer into the base material.

Also as part of this project, the three partners hosted a conference in Indianapolis to share information about new technologies, recent advances in processing, and other topics of interest in the thermo-mechanical treatments of materials. A conference goal was to enhance R&D collaboration between industry, national laboratories, universities, and states. The meeting was so successful that the state of Indiana wants to make it an annual event.

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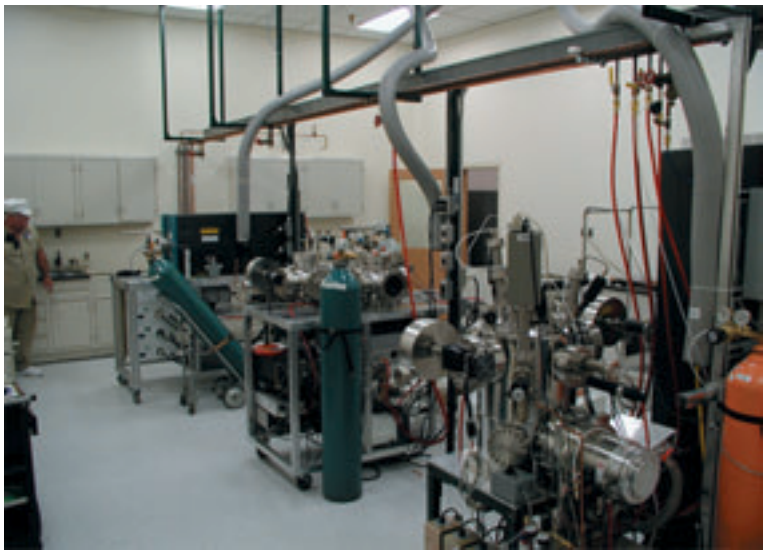
New laboratories accelerate high-temperature superconducting research

In April of 2001, ORNL opened a new high-temperature superconductor (HTS) research laboratory dedicated to the preparation and analysis of coated superconducting wires. The new lab is part of a joint effort between ORNL and Los Alamos National Laboratory to work with universities and industry to accelerate the development of power cables, motors, generators and transformers using new "second-generation" superconducting wire technology.

Superconductors are important to meeting the nation's energy needs in the future because they have virtually no resistance to electric current, offering the possibility of new electric power equipment with more energy efficiency and higher capacity than today's systems. Superconducting technology may help reduce the need for new electric power generation during the next three decades.

The new laboratory space accommodates new equipment required for superconducting wire research and integrates the successful coated conductor processes (for preparing superconducting tape) with reel-to-reel systems for depositing layers of material on tapes (textured metal templates). The new equipment includes



The new HTS laboratory includes reel-to-reel precursor deposition and buffer layer deposition systems, as well as large-area precursor conversion.

- a reel-to-reel X-ray diffractometer that is fully dedicated to the coated conductor program and thus represents a potential doubling of previous X-ray capacity
- a reel-to-reel Auger electron spectroscopy module for characterization of the surface composition of annealed tape
- a reel-to-reel, high-rate radio-frequency sputtering system used for buffer layer deposition, with a tape speed 20 times faster than that of its predecessor
- a batch reactor for yttrium-barium-copper oxide (YBCO) large-area precursor conversion that includes a rotating drum on which up to 6 m of 1-cm-wide precursor tape can be wound
- a low-pressure YBCO precursor conversion system equipped with energy-dispersive X-ray diffraction and mass spectrometry

Office space for two industrial partners and three postdoctoral research fellows was included in the laboratory design. In 2002, ORNL plans to further develop existing and new equipment for more rapid preparation and characterization of coated conductors.

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ORNL helps Iowa determine potential energy savings

ORNL recently completed a study to help Iowa determine its potential for energy efficiency. Like many other states, Iowa is grappling with how to fund its energy efficiency programs once its electric power industry is restructured. In establishing new programs, the state wants to use its funding in the most effective way. To do so, it needs to know the potential for energy efficiency or renewable power in the state and what can be accomplished with the funds available.

The ORNL study, jointly funded by the Iowa Energy Center, examined the residential, commercial, industrial, and power sectors of the economy, focusing on electric energy savings through improvements in equipment. The focus was on the potential impact of two key policies, (1) voluntary programs to reduce barriers to energy efficiency (e.g., financing and ENERGY STAR labeling) and (2) standards, to eliminate inefficient equipment (e.g., water heaters, air conditioners, heat pumps) from the market.

The results indicated that in the residential and commercial sectors, a total of 1455 GWh of electricity and 4.4 trillion Btu of gas could be saved, primarily from increased efficiency in space cooling and heating, water heating, and lighting (see table). In

Potential energy and cost savings in Iowa by 2020[a]

Sector	Electrical energy savings			Gas use savings			Total cost savings
	%	GWh	Cost	%	Trillion Btu	Cost	
Residential	5.3	850	$47M	2.4	2.1	$12M	$59M
Commercial	5.1	605	33M	3.7	2.3	$13M	46M
Industrial	14.0[b]	930	46M	—	—	—	46M
All sectors	**24.4**	**2385**	**$126M**	**6.1**	**4.4**	**$25M**	**$151M**

[a]Numbers represent only some potential savings and do not include measures such as more energy-efficient lighting in the residential sector, improved insulation, more efficient building standards, and use of distributed energy resources.

[b]Electrical savings only from improvements to motor drive systems, which represent 40% of electrical use in the industrial sector. Values do not reflect market barriers that limit market penetration.

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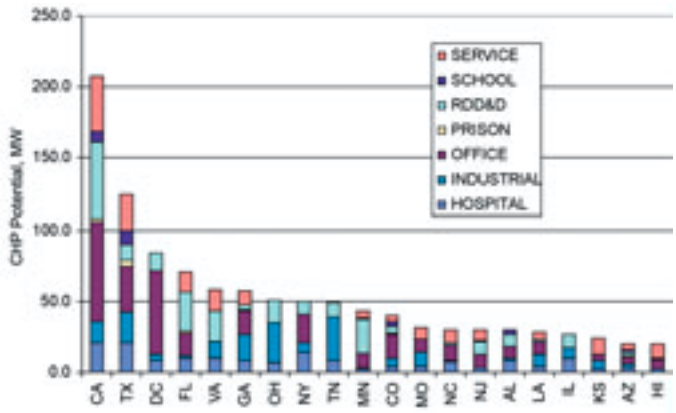
ORNL and seven industry teams to develop packaged CHP systems

ORNL's new Cooling, Heating, and Power (CHP) Integration Laboratory will be working with seven industry teams to develop and test first-generation "packaged" CHP systems for use in commercial and institutional buildings. Packaged systems include combinations of dissimilar subsystems designed to work in conjunction with each other at a higher efficiency and/or lower cost than they would operate individually. A packaged system might include, for example, a microturbine for power generation combined with a waste-heat-driven absorption chiller and a desiccant machine.

Researchers at the CHP Integration Lab examine a microturbine that provides power.



The potential energy savings from integrated cooling, heating, and power systems in various commercial and institutional settings.

The advantages of industrial CHP have long been recognized: such a system provides power and heating, allowing large facilities such as manufacturing plants to generate part or all of their own electricity. CHP for buildings is also cost- and energy-efficient because it recaptures and uses the thermal energy from waste heat and provides a reliable supply of electricity. Moreover, CHP systems can be used to provide supplementary power to existing utility grids.

The packaged CHP systems to be developed under the seven DOE contract awards will provide several benefits over today's custom-engineered CHP systems: they will be easy to install and will reduce first (capital plus installation) costs, improve performance (efficiency), increase system reliability, and reduce maintenance costs.

The projects to develop packaged CHP systems represent $18.5 million in contracts awarded by DOE to the seven industry teams on the basis of competitive proposals. The seven industrial teams and their projects are as follows:

- **Burns and McDonnell**, Kansas City, Missouri, in partnership with Solar Turbines, Inc., and Broad USA—design and construct a buildings CHP system that provides electricity from a Taurus 5200-kW turbine generator, up to 3000 refrigeration tons (RT) of free waste heat–driven absorption cooling, and up to 17,000 RT of additional supplemental gas-fired cooling.
- **Capstone Turbine Corporation**, Woodland Hills, California—design and test packaged CHP systems using waste heat from Capstone's 60-kW microturbine coupled with absorption chillers for air-conditioning and a desiccant system for humidity control.
- **Gas Technology Institute**, Des Plaines, Illinois, in partnership with Waukesha and Trane— combine Waukesha engine generators with Trane absorption chillers in engine sizes ranging from 290 kW to 770 kW to match a variety of building types and markets.
- **Honeywell Laboratories**, Minneapolis—develop and field-test (at Ft. Bragg, N.C.) a large CHP packaged system (2–5 MW) in which a turbine generator will be combined with a 500- to 2000-RT absorption chiller.
- **Ingersoll-Rand**, Portsmouth, New Hampshire—combine a new 70-kW microturbine with an ammonia-water absorption refrigeration system. The absorption system will cool the turbine's inlet air and also produce refrigeration for building space conditioning and refrigerator-freezer applications.
- **NiSource Energy Technologies**, Merrillville, Indiana, in partnership with a Hilton Hotel developer—demonstrate a modular packaged CHP system consisting of three microturbines, heat recovery heat exchangers, an absorption chiller, a desiccant unit, and an integrated control system that will be targeted for use by hotel and motel chains.
- **United Technologies Research Center**, East Hartford, Connecticut—develop an accelerated CHP system based on off-the-shelf components to make a packaged system as well as an additional optimized CHP system. These systems will use both recuperated and unrecuperated microturbine combinations. UTRC will also evaluate the use of waste heat–driven ammonia-water refrigeration systems, desiccant systems, and thermal storage.

The industry partners will contribute more than 43% of the total project costs. ORNL staff will provide technical guidance to the industry contractors and manage the contracts. ORNL's CHP Integration Laboratory will be used to support the development of the new systems.

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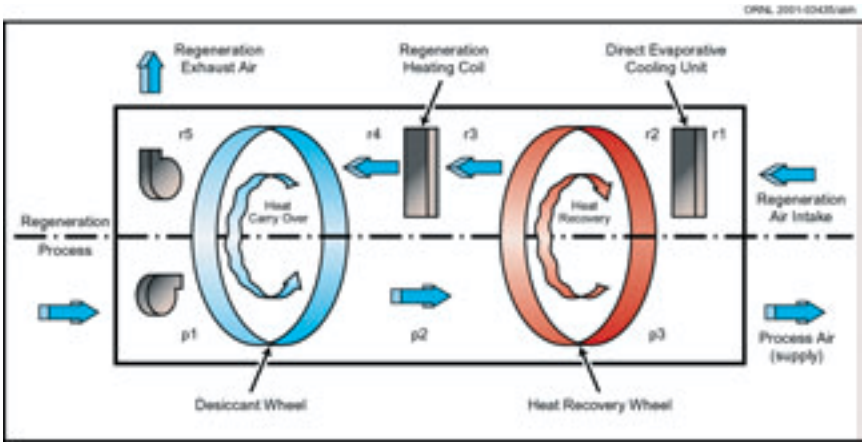
Desiccant technology keeps indoor air fresh, healthy, comfortable

Indoor air quality (IAQ) concerns are spurring interest in desiccant systems to maintain indoor air at comfortable and healthy humidity levels. ORNL is working with several research partners to develop and test improved desiccant equipment as a part of integrated building heating, ventilation, and air-conditioning (HVAC) systems.

Large amounts of fresh air are needed to ventilate modern buildings. Conventional HVAC equipment cannot control the humidity fluctuations that result from higher ventilation rates and set-point temperature control. Uncontrolled humidity results in outbreaks of "sick building syndrome" among occupants and causes mold and mildew that damage structures and furnishings.



Schematic of the operation of a desiccant dehumidification system

Desiccant systems use a moisture-absorbing material to dehumidify ventilation air. Typically, a system employs a lightweight honeycomb or corrugated matrix wheel whose surfaces are coated with a desiccant. The wheel rotates between a stream of incoming fresh air and a heated air stream that dries out the saturated desiccant. The dehumidified air is fed into the building's HVAC system; the moisture removed from the desiccant leaves the building in an exhaust stream.

Desiccant systems usually supplement conventional HVAC systems. Given dry air to cool or heat, cooling/heating equipment does not have to work as hard or use as much energy. Smaller, less expensive HVAC units can be installed, and utility operating costs are reduced.

ORNL staff are conducting R&D on desiccant-based equipment in several areas, including testing equipment both in the laboratory and in buildings, and working with industrial partners that are incorporating desiccant technology into HVAC systems.

ORNL is also working with Georgia Tech Research Institute, Georgia State University, and SEMCO, Inc., on a field study to verify the effects of humidity control and continuous ventilation on school IAQ and the health of schoolchildren. Building on a previous assessment (www.ornl.gov/ornl/btc/desiccant.html), the field study will be used to develop recommendations and HVAC design considerations for improving IAQ in large buildings.

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Microturbine demonstrations in the American heartland

The National Rural Electric Cooperative Association (NRECA), DOE, and the Electric Power Research Institute are sponsoring a nationwide field study of power-generating microturbines at nine rural electric cooperatives in the United States. DOE is funding ORNL to help analyze the field data.

The goal is to determine the operating performance of 30- to 75-kW microturbines in various rural cooperative settings (e.g., applications, climates, interconnection and local siting requirements, installation setups, and operating fuels). Maintenance and repair data also will be collected on the microturbines to assess their reliability.

Where possible, exhaust heat will be recovered from the microturbines to increase their overall efficiency. A microturbine with a recuperator and no additional waste heat recovery has a maximum efficiency of around 20 to 25%. Using the exhaust to fire a thermally activated technology such as a desiccant dehumidification unit or to heat water can boost overall efficiency to 70% or more. [ORNL's Cooling, Heating, and Power Integration Laboratory (*Highlights* issue 2, 2001) is researching how best to integrate thermal recovery and thermally activated equipment.]

Microturbine field tests at the nine rural cooperatives.

Cooperative	Location	Microturbine	Application	Thermal recovery
AVEC	Anchorage, AK	30-kW Capstone	Power at warehouse and office	Space heating
Arkansas Electric	Augusta, AR	75-kW Honeywell*	Power at electricity-generating facility	Freeze protection for plant boiler
Associated Electric	Kearney, MO	45-kW Elliott	Power for city water well pumps	TBD
Cass County Electric	Fargo, ND	30-kW Capstone	Power for domestic water heating at hotel and convention center	Pre-heat hot water for gas-fired boilers
Chugach	Anchorage, AK	30-kW Capstone	Power at warehouse and office	TBD
East Kentucky Electric	Winchester, KY	60-kW Capstone	Power at electricity-generating facility	TBD
Kotezebue Electric	Kotezebue, AK	45-kW Elliott or 60-kW Capstone	Power plant and later a commercial customer	TBD
Tennessee Valley Authority	Muscle Shoals, AL	30-kW Capstone	R&D office building	None
Tri-State G&T	Brighton, CO	70-kW Ingersoll-Rand	Industrial greenhouse	Preheat plant irrigation water

TBD = to be decided.

*Honeywell is closing its microturbine manufacturing facilties and will buy back purchased units, so this unit will be replaced with a microturbine from another manufacturer.

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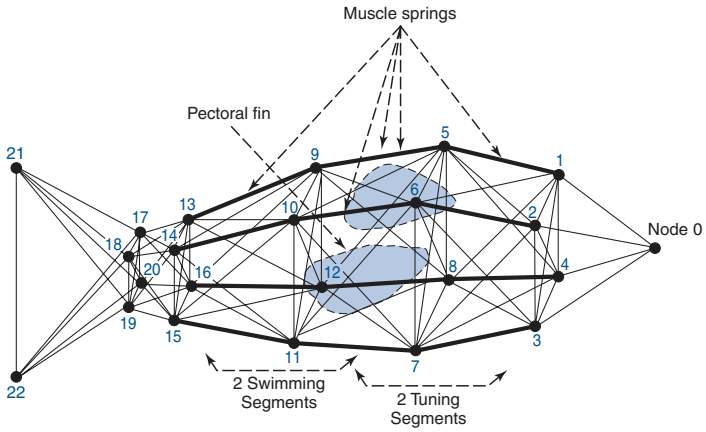
Digital fish helps make hydropower more "fish-friendly"

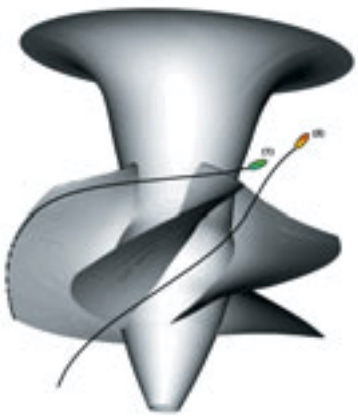
ORNL and its research partners are developing a "digital fish" and other computer models to study the environmental impacts of hydropower projects. These new modeling tools will ultimately help balance the competing needs of fish and power generation in the Pacific Northwest and other regions of the United States.

The digital fish is one of several ORNL projects to help hydropower systems generate electricity with less harm to salmon, sturgeon, and steelhead that pass through turbines. The DOE Advanced Hydropower Systems Program is sponsoring this research. ORNL is working with Georgia Tech and turbine maker Voith Siemens to build digital fish models that will take advantage of ORNL's teraflop (1 trillion calculations per second) supercomputers for simulation and data analysis. TVA is also supporting the research by collecting detailed measurements of the flow fields inside turbines.

The hydraulic environment inside a hydropower turbine is extremely complex and difficult to observe, so computational fluid dynamics models are used to simulate what happens to fish traveling through turbines. The models provide data to define a zone within which water pressure, shear forces, turbulence, and the likelihood of collision with turbine blades are reduced. The digital fish moves within the simulated flow field and measures physical stresses that would occur over different passage trajectories. The results of this work will be used to design turbines that are safer for fish.



A "digital fish" model being used to design turbines that are safer for fish.



Computed fish trajectories through a Kaplan turbine.

DOE's goal for the research is to reduce the mortality of fish passing through turbines to 2% from the current levels of 5 to 30%. Another goal is to develop aerating turbines to increase the level of dissolved oxygen in tail waters.

The digital fish moves within the simulated flow field and measures physical stresses that would occur over different passage trajectories. The results of this work will be used to design turbines that are safer for fish.

The ORNL team also is studying the viability of the white sturgeon in the Snake River. The white sturgeon, which can live more than 100 years, is the largest freshwater fish in North America. Fragmentation of rivers by dams threatens the sturgeon population by separating male and female spawning fish and by converting free-flowing rivers to reservoir habitats unsuitable for spawning. ORNL has developed a white sturgeon model that quantifies the effects of fragmentation, and a similar model to track individual Chinook salmon as adults migrate upstream to spawn.

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NRECA is purchasing the microturbines with funds from its Central Research Network and from EPRI. DOE and EPRI are funding the data collection and analysis.

Microturbines from several manufacturers will be tested. Five sites have microturbines installed and operating: Alaska Village Electric Cooperative Association (AVEC), Arkansas Electric, Cass County, Chugach, and the Tennessee Valley Authority. Four of those have 30-kW Capstone microturbines and one a 75-kW Honeywell microturbine. The AVEC unit is operating on No. 1 fuel oil and the Chugach unit on low-pressure natural gas. The Associated Electric microturbine will use high-pressure propane and the Kotezebue unit will use No. 2 fuel oil.

NRECA has developed a data collection protocol and identified monitoring technologies for the cooperatives. The cooperatives will collect the data, which will be made available to ORNL and EPRI for analysis.

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News Briefs

National energy group meets at ORNL

The State Energy Advisory Board convened in October 2001 at the National Transportation Research Center and at ORNL. The board, a national group of energy officials from various states, develops recommendations for DOE and the Congress regarding federal energy efficiency and renewable energy programs.

Board members heard presentations on the Lab's energy efficiency programs and toured the Buildings Technology Center; the Integrated Cooling, Heating and Power Lab; and the High Temperature Materials Laboratory.

ORNL EE/RE Program Manager Marilyn Brown related success stories from the State Partnerships Program, including an ORNL study of ways to protect buildings from moisture in Seattle's rainy climate; a vehicle exhaust emissions study in Minnesota; and a school energy benchmarking analysis in Iowa.

Remarked one participant, "The fascinating thing about these visits is there are so many things ORNL does. There's no way I could know about the capabilities here without coming here."

ORNL takes power R&D honors

ORNL was a partner in two of the four Research Partnership awards announced at the first-ever DOE Office of Power Technologies Research and Development Awards ceremony in December 2001. The awards in which ORNL participated were the superconductivity program for electric systems: 3M coated conductor development project; and ceramic stationary gas turbine development: nondestructive evaluation of stationary gas turbine ceramic components.

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the industrial sector, motor drive system improvements alone could cut industrial electrical use by 6%.

Overall, there is a good potential for saving at least 5% of the energy used in Iowa through a combination of market-based programs and standards, representing over $100 million per year. Active state and utility programs should be able to achieve well over this amount, especially if applied to broader savings measures than those studied in this project. The findings of the study helped to convince the Iowa Utilities Board to take a careful look at current energy efficiency programs and the potential to do more.

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