Science & Technology HIGHLIGHTS

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Small Business Partnerships Offer Energy Innovation

DOE's Office of Energy Efficiency and Renewable Energy has a vision of clean, abundant, reliable, and affordable energy for the nation. In pursuit of this vision, DOE/EERE is seeking high-potential energy innovations from all sources. Fresh, innovative ideas spawned in small businesses offer particular promise.

ORNL's EERE Program partners with small businesses through many contractual mechanisms. These can generally be divided into two categories: procurement and technology development. This article focuses on partnerships using six technology development mechanisms. Key considerations in the selection of a mechanism include intellectual property rights and funding sources.

Cooperative research and development agreements (CRADAs) allow partners to collaborate on mutually beneficial research projects. This mechanism allows the industry partner to truly team with ORNL staff and use ORNL facilities in pursuit of a mutually desirable technology objective. The ultimate goal of a CRADA is a product the commercial partner can take to the marketplace. In the case of EERE CRADAs, this can also be considered deployment of an energy-efficient technology. ORNL has executed more than 100 CRADAs with small businesses.

Small businesses can gain access to ORNL-developed technologies and inventions for specific uses through **license agreements**. The business is required to pay for the use of these technologies during the term of the license.

ORNL provides **technical assistance** to small businesses on a funds-available basis and when the assistance to be provided does not place ORNL in competition with the commercial sector. An important condition of the technical assistance project is that it cannot transfer or generate intellectual property. However, technical assistance agreements may be used for special analyses that use unique ORNL capabilities, such as materials characterizations available from the High Temperature Materials Laboratory. Technical assistance is provided to more than 20 small businesses each year.

User facility agreements provide access to ORNL's 19 designated user facilities, stipulating terms and conditions under which qualified users from universities, industry, or other institutions can conduct research. Six ORNL user facilities are hosted by ORNL/EERE (www.ornl.gov/ORNL/Energy_Eff/EE_partnerships.htm):

- Buildings Technology Center
- Cooling, Heating, and Power Integration Laboratory
- High Temperature Materials Laboratory
- Materials Processing Laboratory User Center
- National Transportation Research Center
- Bioprocessing Research Facility

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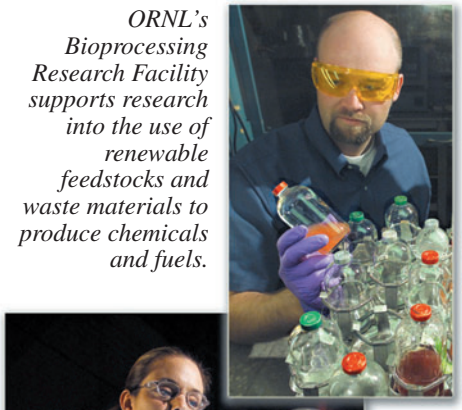

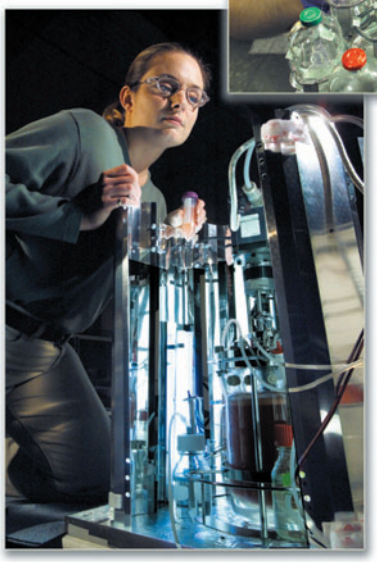

ORNL's Bioprocessing Research Facility supports research into the use of renewable feedstocks and waste materials to produce chemicals and fuels.

ORNL's EERE Program has a strong history of partnering with small businesses, and many successes have resulted from these collaborations.

Small businesses have been a powerful force of innovation and economic growth. By partnering with small businesses, ORNL has helped DOE/EERE capitalize on that small business entrepreneurship and innovation; these partnerships have helped to develop and drive a next generation of energy technologies into the marketplace.

In this article, Terry Payne (director of ORNL's Government Partnerships Program) describes the different mechanisms available for small businesses and ORNL to work together in support of DOE/EERE. Illustrative projects involving small businesses are spotlighted throughout this newsletter.

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AMCL Will Provide "Quiet" Environment for Electron Microscopes

Compelled by the lack of appropriate space for existing ultra-sensitive electron-optical instruments and the scheduled arrival of the aberration-corrected electron microscope (ACEM) in the fall of 2003, ORNL is building a new facility tentatively called the Advanced Materials Characterization Laboratory (AMCL).

Artist's rendering of the Advanced Materials Characterization Lab.

The AMCL will house the ACEM, the most critical of the new microscopes to be added in support of work at ORNL's High Temperature Materials Laboratory (HTML) (see www.ms.ornl.gov/htmlhome/). Construction began in early 2003 and is to be completed early in 2004. The first of a new generation of electron microscopes, ACEM has a corrector for aberrations that will allow a resolution of better than a single atomic diameter. It requires a site with ambient magnetic fields below 0.1m Gauss at 60 cycles and has specifications for floor vibrations, microphonics, temperature, and air pressure stability that are at critically low levels. No existing laboratory at ORNL comes close to supporting the "quiet" environmental factors it requires.

The ACEM will have sub-angstrom resolution for both imaging and chemical species determination. It is expected to prove especially useful for the study of nanomaterials (materials whose critical dimensions are in the range of 1–100 nanometers).

In addition to the ACEM, the AMCL will house initially two scanning transmission electron microscopes that have been upgraded by the addition of aberration correction elements and a fourth instrument associated with the Shared Research Equipment (ShaRE) Program, another of ORNL's user programs.

The AMCL will be a freestanding laboratory facility located adjacent to the HTML.

Another new facility to be constructed soon at ORNL is the Center for Nanophase Materials Sciences (CNMS). The CNMS will operate as a user facility, and its users will be able to take advantage of the ACEM, as well as other instruments at ORNL.

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Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies and DOE/ Office of Science

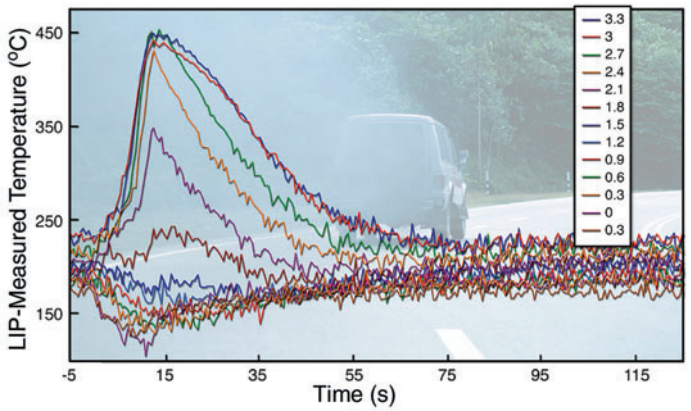
The aberration-corrected electron microscope.

ORNL's Instrument Measures Temperature Distributions in Catalysts

ORNL is providing diesel engine makers with unique measurement tools essential to improving control strategies for diesel emissions. Researchers at ORNL's Fuels, Engines, and Emissions Research Center have developed a tool based on phosphor thermography that can resolve temperature distributions within an operating catalyst. The data it provides will be used to improve the performance of catalysts for treating exhaust emissions.

Catalysts (materials that trap and convert compounds such as nitrogen oxides, sulfur, or particulates) are coated onto honeycomb-like filters with channels that are millimeters wide and several inches long. As exhaust emissions travel along the channels, constant subtle changes occur in their temperature and chemistry. To clarify what happens inside an operating catalyst, it is necessary to measure these spatial and temporal variations quickly and accurately.

The phosphor thermography instrument (PTI) is based on the temperature-dependent phosphorescence lifetime of ceramic phosphors. A 337-nm laser injected into one leg of a fiber coupler ex-



Spatiotemporal temperature distributions through a 3-in.- long catalyst. Catalysis lightoff occurs only in the back third, indicating that the front 2/3 of the catalyst is not active.

cites a phosphor deposited on the tip of a gold-coated optical fiber. (The gold coating enables use at temperatures up to 750°C.) The coated fiber captures some of the phosphorescence and directs it to the detection leg of the fiber coupler, where the laser light is filtered out and the remaining light detected by a photomultiplier tube. The phosphorescence signal decays at a known rate proportional to temperature. The tube's signature is continuously monitored and analyzed to determine rate of decay, and a calibration curve converts the decay rate to a temperature. The current instrument allows for temperature measurements at up to about 2 Hz.

The new instrument has been used to quantify spatiotemporal temperature distributions throughout an operating EmeraChem NOx adsorber catalyst during regeneration.

The PTI has the rapid response and minimally invasive nature required for accurate, high-speed emissions analysis. It is

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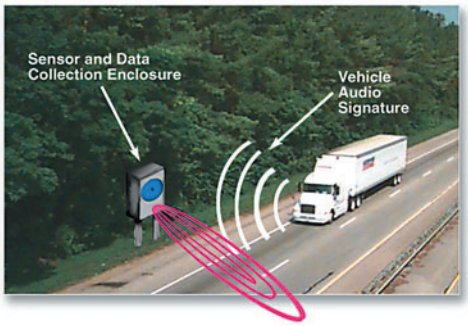
ORNL and UT Turn Section of I-40 Into Environmental Lab

Without even slowing down, the 25,000 big rigs rumbling through Knoxville daily will help researchers from ORNL and the University of Tennessee (UT) understand real-world vehicle emissions and their effects on the environment.



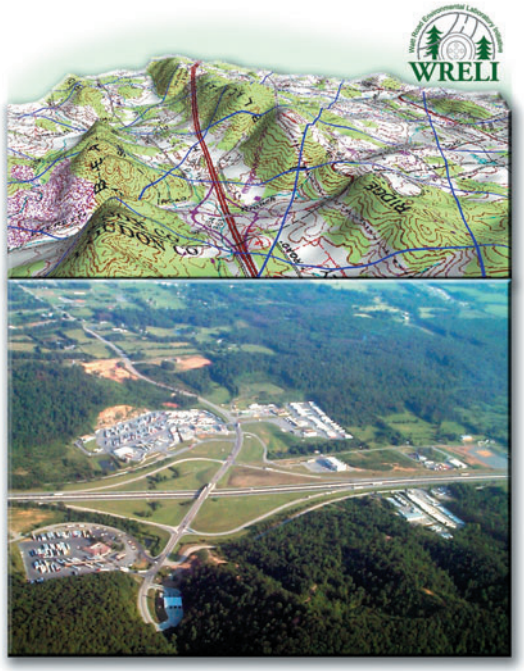
Roadside panels will use sound signature analysis to determine operating conditions of passing trucks.

Instrumentation being installed near the Watt Road and Interstate 40 interchange west of Knoxville will create a world-class field laboratory devoted to analyzing emissions data from on-road heavy vehicles. Two meteorological towers are operational already, and equipment will be installed to measure nitrogen oxide (NOx) and particulate matter (PM) emissions as trucks pass. Researchers envision using stepped FM-AM LIDAR (light detection and ranging) to measure PM and ultraviolet absorption to measure NOx emissions. Both of these techniques are currently under development at ORNL.

"We'd like to determine, for example, whether the stricter emission regulations for trucks are achieving actual benefits to the environment," said Ralph McGill of ORNL. "In the immediate future, though, we're hoping to learn more about truck emissions during different operating conditions, all remotely so we won't interfere with traffic flow."

Large trucks contribute about 40% of NOx and 60% of PM from mobile sources. Emissions vary according to a truck's load, speed, and acceleration, yet few studies exist that quantify differences in emissions among modes of operation.

The field lab will extend 2.5 miles eastward along the valley from the Watt Road/I-40 interchange to a weigh station at the top of a ridge. This stretch of road is one of the most heavily traveled in the country because it is where three interstate highways converge for 20 miles.



Top: Topographical map of the area around the I-40/Watt Road interchange. Bottom: Aerial view of the interchange showing the trucking-related facilities.

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Analyzing the Mischief Caused by Idle Trucks

Pass a truck stop or rest stop and you'll see hundreds of 18-wheelers sitting and smoking. Long-haul trucks idle for hours to operate lights and climate control systems for the cabs while their drivers rest. There are few data regarding how millions of trucks idling daily impact air pollution or fuel consumption.

ORNL's National Transportation Research Center (NTRC), the U.S. Environmental Protection Agency, and the state of New Jersey are cooperating to measure and characterize emissions and fuel use during idling. They also are studying the effects of using auxiliary power units (APUs) and diesel-fired heaters in parked trucks. The APU uses a small, efficient diesel engine to drive an alternator that charges the batteries and powers a heating or cooling system for the cab. The diesel heater keeps the cab and engine warm in cold weather.

Instrumented tractor rig in the environmental chamber at the Aberdeen Test Center.

For the tests, five Class 8 tractors from different manufacturers were operated in an environmental chamber at the Aberdeen Test Center in Maryland that simulates a range of summer and winter weather conditions. The trucks represented model years ranging from 1992 to 2001; all had turbochargers, direct injection, and electronic controls. Emissions were measured at ambient temperatures of 0, 65, and 90°F and at idle speeds of 600 and 1200 rpm while the cabs were maintained at a constant temperature.

Researchers from the Fuels, Engines, and Emissions Research Center at NTRC provided technical expertise and instruments to measure particulate matter and other emissions.

In most cases, fuel use and emissions were substantially higher at a 1200-rpm idle than at 600 rpm. Both the APU and the heater cut fuel use and exhaust emissions compared with engine idling, However, at current fuel prices, it would take two years or more for the fuel savings to offset the cost of the units. The data gathered will be used to develop models of emissions and fuel use for state energy and air quality planning and to support technologies to mitigate emissions and reduce fuel waste.

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Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies and ORNL's State Partnerships Program

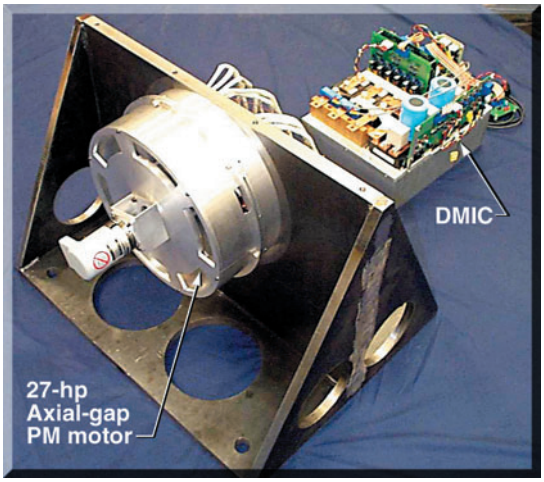
Overcoming Barriers to More Efficient Hybrid Electric Vehicles

Auto makers would like to use permanent magnet (PM) motors to propel hybrid electric vehicles (HEVs) because they are smaller and more efficient than the induction motors now used. However, several barriers must be overcome first, including two that relate directly to vehicle safety:

- With a PM motor, it is difficult to deliver constant power at high speeds so that the HEV accelerates like a conventional vehicle.
- If an electrical failure interrupts the current to a PM motor, it will begin regeneration, causing the vehicle to decelerate. This can be dangerous in traffic.

Researchers at ORNL's Power Electronics and Electric Machinery Research Center have invented a device that promises to resolve the issues with PM motors—a voltage controller called a dual-mode inverter controller (DMIC) that regulates the current passing between the inverter and the motor.

The constant power/speed ratio refers to the ratio between the maximum speed at which rated power is produced and the maximum speed at which rated torque is produced. What is needed is high torque at low speed, to get a vehicle going, and then constant power with diminishing torque as speed increases, to keep a vehicle at a consistent, controllable pace.



The dual mode inverter controller with a permanent magnet motor. The DMIC has the potential to resolve problems with the use of these light, efficient motors in HEVs.

The DMIC controls torque to be high from rest up to base speed and then decrease as speed increases so that power delivery is constant over an extended speed range. In addition, it ensures that if current is interrupted, the vehicle loses power and coasts instead of suddenly braking. The new controller has other advantages:

- Matching the motor and inverter for operation at rated current and rated power at base speed eliminates the need for overdesign and reduces the cost of the traction drive system.
- It is compatible with HEV electrical requirements.
- It allows the use of bridge transistors rated for low current and voltage levels by protecting them from back-electromotive force.
- At high speeds, it can deliver up to 150% of rated power with a negligible increase in current, a feature beneficial to HEVs for passing and climbing hills or whenever increased power is demanded.

Testing is under way at ORNL to explore the limits of the DMIC. A major U.S. auto maker is interested in using the system with a PM motor as the drive system in its HEVs.

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Sponsor: FreedomCAR and Vehicle Technologies

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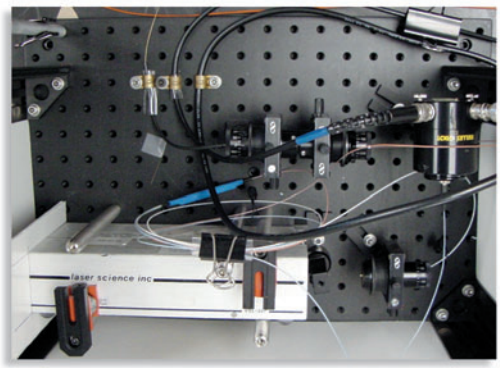
portable and can be transported to industrial labs to evaluate emission control systems. It is a companion to ORNL's SpaciMS instrument that maps changes in the chemistry of emissions as they travel through a catalyst (www.ornl.gov/ORNL/Energy_Eff/stnews.htm). These two tools will provide invaluable data on temperature and species distributions to enable the detailed understanding and modeling of catalyst processes.



The phosphor thermography instrument can resolve temperature distributions in an operating catalyst.

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Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies

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The area is also home to three large truck stops, a trucking company terminal, and other trucking-related facilities.

In addition to measuring concentrations of emissions, roadside mounted panels will perform acoustic and magnetic probing and sensing. The resulting data will enable calculation of emissions for individual trucks on a gram-per-mile basis through the use of sound signature analysis to determine each truck's operating condition, including engine speed, turbine speed, and number of cylinders.

Faster, inexpensive instruments eventually will allow researchers to set up arrays capable of measuring an entire exhaust plume rather than just one slice, as will be necessary in the beginning. Later, with a suite of detectors and instruments available, the site will attract researchers from across the country and make a major contribution to understanding truck emissions.

Sponsors: ORNL's State Partnerships Program, Laboratory Directed R&D program

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Partnerships in Superconductivity Yield Electrifying Results

An international horse race is heating up among major competitors to be first to market electric power applications with high-temperature superconductors (HTSs). ORNL and its industrial partners are leading the way. Two major steps forward occurred this fall: one in the development of superconducting wires and the second in applications for transmission cables that can carry many times the power of conventional cables in ducts of the same size under city streets.

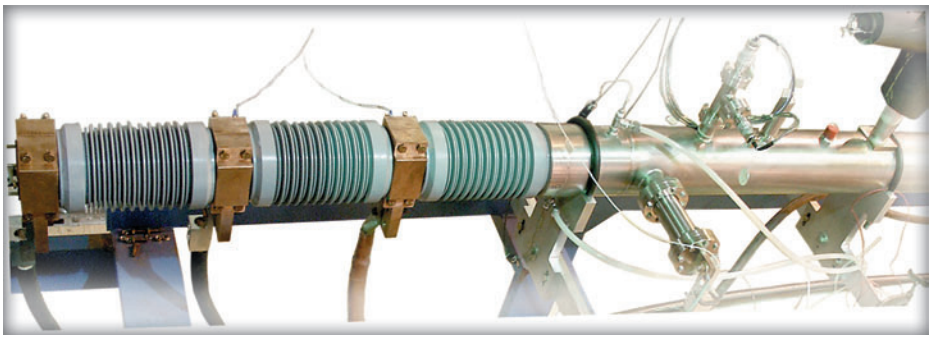
In October, ORNL's cooperative research and development agreement (CRADA) small business partner American Superconductor Corporation (AMSC) announced it had achieved reproducible results in electrical performance over 10-meter lengths of its second-generation, coated conductor composite, HTS wires that are significantly ahead of the goals set by DOE. AMSC has demonstrated its ability to manufacture multiple 10-meter lengths of second-generation wires, each with >100-ampere critical current in liquid nitrogen, a performance level more than twice the 50-amp DOE milestone. This exceptional wire performance was verified by ORNL.

As part of the CRADA agreement, ORNL and AMSC have developed several key technologies for the manufacture of second-generation wires. One of these is the buffered template for the wire, called "RABiTS," which AMSC has licensed. AMSC has incorporated certain aspects of this technology into its proprietary manufacturing process. The resulting manufactured wires are the longest coated conductors reported in the United States.

Concurrently, ORNL began initial testing of the world's most compact HTS cable. Encouraged by the positive test results for a 1.5-m long prototype "tri-axial" cable, a team of scientists and engineers from ORNL and Southwire Company conceived, designed, and built a 5-m tri-axial cable with first-of-a-kind 3-phase terminations. The three concentric superconducting phases are made of first-generation BSCCO-2223 HTS tapes separated by layers of cold-dielectric tape. The completed tri-axial cable is enclosed in a flexible cryostat. Cooling of the cable and terminations is achieved by liquid nitrogen flowing through the annulus between the cable and the cryostat. The resulting 3-phase cold dielectric cable and termination design is nearly as compact as the single-phase co-axial design developed previously by Southwire and ORNL (a system that was dedicated in February 2000 and is still running strong).

ORNL verifies the performance of AMSC's superconducting wire.

This design represents the highest cable current density achievable in an electric ac power cable. Testing for dc operation of the 5-m cable, completed in November 2002, included measurement of voltage-current curves for each of the concentric HTS phases, cable heat loads at varying dc currents, liquid nitrogen flow-pressure measurements, and over-current tests. Testing for ac operation included ac loss measurement, measurement of induced current in the copper shield, and operation at the line voltage test. The ac losses were low, indicating a good potential for commercialization. The team plans a much longer cable installation in the year 2004 at a substation owned by American Electric Power in Ohio.



HTS cable being tested in the joint ORNL/Southwire Cable Research Laboratory.

For more information about superconductivity research at ORNL, see www.ornl.gov/HTSC/htsc.html.

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Sponsor: DOE/EERE Distributed Energy and Electric Reliability Program

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

New Partnership Pursues Distributed Energy Solutions

Created as a partnership to increase the use of distributed energy across business and government**,** the National Accounts Energy Alliance (NAEA) unites DOE, ORNL, the American Gas Foundation, the American Gas Association, natural gas utilities, the Gas Technology Institute, and national commercial chains in pursuit of energy benefits. The partnership is the first of its kind to assist energy managers who offer their facilities as test sites for distributed energy applications.

Emphasizing energy-intensive industries with nationwide operations, NAEA coordinates tests and assessments of energy-related equipment in varied operational settings. The work is carried out under a subcontract with ORNL. NAEA offers its members a cost-effective way to develop projects to install, test, and assess energy-efficient technologies. The goal is to provide interested parties with information on integration of technologies to the grid and to building loads and knowledge about integrated energy systems applications.

The work holds great promise because of the involvement of well-known national retail, restaurant, grocery, hospitality, and health care chains with the potential to propel technology solutions into broad markets. Reports from field assessments of representative facilities will provide information for thorough case studies and national conferences and exhibitions. The web will be a major communication vehicle. Information will be generated through 2005.

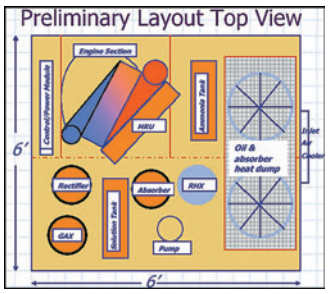
The current NAEA projects include the following.

Russell Development, Portland, Oregon
Utility: NorthWest Natural
Application: General office building
Uniqueness: First-of-kind installation in the United States of a microturbine/hot-water-activated absorption chiller applied to air-conditioning an office building.
Technologies: Capstone, 27-kW microturbine, Unifin heat-recovery heat exchanger, and 10-RT Yazaki hot-water-activated absorption chiller.
Status: Initial data collection is complete–parasitic power is about 10% of total output; average net efficiency is about 20–22%. See www.bpa.gov/Energy/N/projects/200market/.

H-E-B, San Antonio
Utility: City Public Service of San Antonio
Application: Onsite power. Cooling, heating, and power (CHP) and liquid refrigerant subcooling will be tested and verified.
Uniqueness: Cutting-edge CHP/refrigeration research. May also combine critical black-start capability for the first time.
Technologies: Bowman/Elliott 80-kW microturbine and 50-RT broad absorption chiller in a first-generation system.
Status: Site agreement, initial design completed.

McDonalds, Tampa, Florida
Utility: Tampa Electric
Application: Involves critical latent load removal, onsite power, and demand-reducing food service equipment.
Uniqueness: First-of-kind dehumidification system potentially able to reduce peak load and match building latent load. New engine technology with potential to reduce cost.
Technologies: Desiccant dehumidifier developed by DOE and ORNL in partnership with SEMCO and a new GENERAC 50-kW auto-derivative gas engine.
Status: Scheduled for second quarter of 2003.

A&P, Long Island, New York
Utility: Long Island Power Authority
Application: Onsite power generation with recovered thermal energy to regenerate desiccant dehumidifier, reducing operating costs of dehumidifier and winter heating.
Uniqueness: Dehumidification of refrigerated case aisles coupled with onsite power energy recovery. First-of-kind CHP dehumidification/heating system applied to a supermarket.
Technologies: Capstone 60-kW microturbine, Unifin heat-recovery heat exchanger, and Munters desiccant dehumidifier.
Status: Data analysis under way. Negotiations progressing on interconnection agreement.



Albertsons/Cinemark, Dallas
Utility: Texxon Utilities
Application: Two special Munters condenser-regenerated desiccant rooftop units, a microturbine, and absorption chiller for refrigeration sub-cooling.
Uniqueness: System offers complete power/thermal integration with no cooling tower and with the capability to cool below freezing.
Technologies: Ingersoll Rand 70-kW microturbine with integrated ammonia/water absorption chiller.
Status: Construction delayed by economic downturn. A possible alternative application at a Cinemark theater involves a Hess-Microgen generator and several desiccant units.

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Sponsor: DOE/EERE Distributed Energy and Electric Reliability Program

Improving Energy Performance in Commercial Buildings

Researchers in the Commercial Buildings Group (CBG) at ORNL have been studying the energy performance of commercial buildings for many years. Residential and commercial buildings account for about 35% of the nation's total energy use, and commercial buildings are not improving in energy efficiency as rapidly as their residential counterparts. While residential building energy use has consistently accounted for 20% of national energy use in the years 1960 through 2000, commercial building energy use has grown from 10% of national energy use in 1960 to 18% in 2000.

Examination of the energy systems as well as the energy performance of the whole building provides clues to major causes of inefficiency. Large, inflexible heating and cooling systems are a major contributor to efficiency loss in buildings and provide poor quality of service. National surveys of office buildings indicate that 90% of the occupants in larger buildings complain of heating and cooling problems. Similar problems often occur in smaller buildings as well when highly centralized heating and cooling systems are used.

Inefficient system design or operation often counteracts the installation of more efficient equipment. Accelerated research is needed on decentralized heating and cooling systems, size reduction and simplification of system components, and modifications to system configuration. Currently, international innovation in heating and cooling is focused on splitting the ventilation services from the overall system. Many large corporate building owners and developers are trying different approaches to accomplishing this split in an attempt to increase the quality of the space, the indoor air quality, and the thermal control. The United States lags behind both Europe and Asia in some areas of commercial heating and cooling innovation.

Research by ORNL staff and others on geothermal heat pumps has shown that this technology has important cost-saving and energy-saving potential. These systems typically are based on small, distributed heating and cooling units, which demonstrate more efficient performance. Buildings with geothermal systems benefit from the higher efficiency derived from both geothermal energy production and small, distributed units. Additional R&D on best applications for geothermal systems and small, distributed heating and cooling systems is needed.

An example of research conducted on small, distributed systems is the Buildings Technology Center (BTC) office building at ORNL. The first building at any DOE national laboratory to receive the Energy Star award for energy-efficient buildings, the BTC achieved an efficiency rating of 91 out of a possible100 points. It has small, distributed heating and cooling systems that are controlled by an energy management system (EMS). Most occupants have individual control of heating and cooling in their offices. The EMS sets back comfort settings during unoccupied hours. CBG staff help ensure that building efficiency is maintained.

ORNL is currently the primary provider of technical rating scales used by the national Energy Star program for assessing the energy performance of commercial buildings. These scales, developed through national survey data on energy use in commercial buildings, are used to identify factors that can be used to normalize the performance of different buildings. In addition to developing these scales, further research is needed on

- Determining technology, design, and construction combinations that lead to high-performance buildings
- Developing data and methods for rating the performance of new designs
- Developing benchmarks for acceptable performance of new buildings
- Designing more general (sectoral) benchmarking methods
- Enabling design/build performance guarantees with real consequences

For further information on issues related to energy systems design, standards, and ratings systems see http://eber.ed.ornl.gov/commercialproducts/design.htm

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Sponsors: DOE/EERE and the Environmental Protection Agency

The valve wheel on the right is missing, meaning the system cannot be adjusted. Disrepair and neglect of equipment in large systems is a prime cause of inefficiency.

An extreme example of neglected maintenance of chilled water pipes.

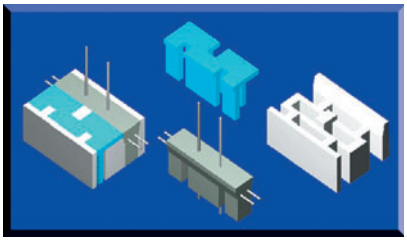
Calculation Tools Help Assess Usefulness of Building Products

A wall assembly being tested at ORNL. Data from such research are used in the energy efficiency calculators.

Consumers are deluged by energy-saving performance claims for building products, some of which are misleading. They need a credible source of unbiased, reliable information. To help homeowners and commercial building operators assess building products, ORNL has developed a suite of web-based energy-efficiency calculators.

The Roof Radiation Control Calculator estimates the annual cost savings from installing a radiation-control coating on a low-slope roof. ORNL's Roof Research Center has tested a wide range of reflective coating materials over a 3-year period. Their long-term performance is reflected in this calculator, which calculates both the summer cooling load reduction from the coating and the additional heating that will be required in the winter. The calculations are based on an extensive database of weather variables, because savings are a function of the traditional cooling and heating degree days, as well as local insolation.

The ZIP-Code Calculator provides advice to homeowners adding insulation to existing houses or building new houses. It uses the homeowner's postal zip code to assign appropriate weather variables and cost factors, which are then used to determine the amount of insulation that will result in the optimum life-cycle cost. Official DOE insulation R-value recommendations cited by many manufacturers and conservation organizations are based on zip codes.



Steel wall configurations designed to reduce "short circuit" heat transfer through steel-stud walls.

The Whole-Wall Calculator, founded on both extensive experimental data and detailed analytical models, provides design guidance for steel- or wood-stud, masonry, and concrete walls. Before this tool became available, homeowners often thought that a wall containing R-11 batts would perform as an R-11 wall. However, heat conducted through the framing, windows, and doors leads to an overall wall performance that is much less than that of the insulation placed in the wall cavity. The calculator allows for these variables and enables users to determine the thermal resistance of various types of wall structures accurately by selecting the specific components that make them up.

The calculators, along with other tools, are available at http://www.ornl.gov/roofs+walls/calculators/

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Sponsor: DOE/EERE Building Technologies Program

MHEA Aids Weatherization of Mobile Homes

ORNL has added another computer-based tool to a suite of programs that help DOE's state-based Weatherization Assistance Program agencies determine the most cost-effective energy-efficiency measures to install in homes. The new Manufactured Home Energy Audit (MHEA) supports retrofit decisions for manufactured (mobile) homes. The MHEA and a companion program, the National Energy Audit (NEAT), which supports retrofit decisions for site-built homes, are now packaged together as the "Weatherization Assistant."

The latest version of MHEA is expected to reach about 800 agencies and interested private and utility companies. MHEA and NEAT will assist in the weatherization of more than 70,000 units in 2003. Many measures formerly available only in NEAT have been incorporated into MHEA, including a database of more than 14,000 refrigerators for evaluating refrigerator replacement and a similar database of water heaters. The program accepts data on the efficiency of the delivery of conditioned air through the existing duct work, as well as the savings from sealing those ducts.

A weatherization crew making energy-efficiency improvements to a mobile home as a result of MHEA Program screening.

MHEA also evaluates standard insulation measures, as well as air-sealing the home, painting the roof with white elastomeric paint, window shading, lighting replacements, and a variety of equipment (furnace/air-conditioning) measures. The recommendations produced by MHEA may be adjusted to reflect the home's past energy use as determined from utility bills.

Future efforts will focus on expanding the capabilities of the tools to better address small multi-family housing, such as garden apartments; increasing the use of libraries; allowing users to record actual work performed and costs as opposed to the tools' recommendations; and implementing the tools on palm or tablet computers, using character recognition to allow written input. Efforts have also been initiated to make the software generally available over the Internet.

The new MHEA was adapted from an earlier DOS version developed by the National Renewable Energy Laboratory. It has the same Windows user interface as NEAT.

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Sponsor: Weatherization and Intergovernmental Program

Sensors & Controls: Essential Enablers for Efficiency Technologies

Ever more rapid, precise, and "smart" sensors are essential to achieving greater energy efficiency and waste minimization in U.S. industry. ORNL is a leader in the effort to harness advances in sensing transduction, computing technology, signal processing, and miniaturization to enable continuous improvement in sensing instruments.

Numerous DOE and industry R&D road maps have identified advances in sensors and controls as a necessity for progress in several technology areas, including

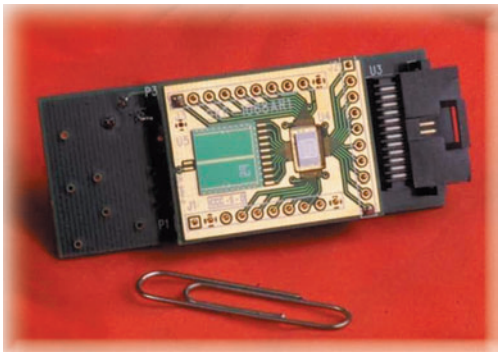
- energy efficiency
- increased industrial productivity
- reduced product losses
- emissions minimization
- safety
- total cost reduction

To achieve those goals, processes must be measured, controlled, and monitored to ensure optimized performance and regulatory compliance.

A 1-mm ion trap mass spectrometer for analyzing gases.

ORNL is improving industrial systems through R&D, advanced engineering, and integration of sensor and control systems. More than 200 multidisciplinary ORNL researchers are involved in all aspects of sensor and control systems research: transduction development, low-power electronics, photonics, electro-optics, wireless sensors and networks, image processing and machine vision, material synthesis, signal processing, and advanced distributed and supervisory controls.

Ten businesses have already been started using sensor and controls technologies developed at ORNL, including IPIX, a company that provides 360° Internet imaging technology.



A micro-sensor array (10 different measurements with very-low-power electronics).

ORNL has long relationships with Industrial Technologies' Industries of the Future, the Sensors and Controls Crosscut Program, Building Technologies, and FreedomCAR. Work has been initiated in the research areas of Hydrogen and Fuel Cells, Best Practices, and Distributed Energy and Electric Reliability.

In the Industrial Technologies Program, the steel industry has been aided by ORNL's development of non-contact temperature measurement, non-contact tube thickness measurement, wireless networks, and controls for overall plant supervision and plant optimization. Efforts in the forest products industry include determining the dryness of wood in kilns by using microwaves to measure moisture content. On-line inspection systems developed for several industries use sensing technologies to detect manufacturing defects in real time. These systems improve yield, increase throughput, and reduce energy costs by spotting manufacturing problems before defective materials proceed through the supply chain. Systems have been developed for textiles, ceramic processing, paper and pulp processes, and semiconductor manufacturing.

For the transportation industry, ORNL has a rich history of developing sensors and controls to improve engine performance and reduce emissions. High-temperature NOx, O_2, and ammonia sensors are under development. Several methods to characterize exhaust particles have been developed, as well as first-of-a-kind fast-response mass spectrometry. Engine diagnostics and controls have been implemented to extend exhaust gas recirculation tolerance. Many of these sensor concepts may also be applied to fuel cell applications. When a method of measuring total exhaust gas flow was needed to employ new exhaust constituent sampling techniques, ORNL worked with an industrial supplier to develop a low-pressure-drop, high-accuracy vortex shedding flowmeter to do the job.

To achieve net-zero energy buildings, monitoring of building conditions for comfort, health, and energy efficiency is essential. In addition, communications and advanced controls needed for improved ventilation, system integration, and energy usage optimization will require low-cost, low-power sensor systems. ORNL is working to bring together microsensor arrays, very-low-power electronics, signal processing, and wireless networks to provide integrated sensing, control, and monitoring for zero-energy buildings.

As a result of fast-paced advances in this high-tech field, vast opportunities exist to provide improved energy efficiency, emissions reduction, and process optimization through novel sensor and control approaches.

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This on-line defect sensor inspects fabric for flaws as it is woven, saving time and avoiding waste.

Helping U.S. Industry Identify and Use Best Practices

The Industrial Technologies Program is helping U.S. industries develop, demonstrate, and deploy technologies in their facilities that could enable them to save more than a quadrillion Btu per year. IT's Best Practices program delivers a variety of energy-saving products, services, and technologies to energy-intensive industries, helping them deploy emerging technologies; verify and validate the performance of new technologies that are installed; and implement more energy-efficient plant utilities such as compressed air, steam, and pump systems.

ORNL supports Best Practices in the areas of tool development, training, and assessments, and in the verification and validation of emerging technologies.

The Best Practices Program helps industrial facilities optimize the energy efficiency of plant utility equipment such as this.

Tool Development

A single facility may have thousands of possible opportunities to save energy. Computer software tools help identify the best opportunities, and reports and guides assist in the selection of energy-efficient equipment. For example, it is not uncommon for a large industrial plant to have 5000 pump systems. Examining each one to assess its energy efficiency would be prohibitive. However, using the Pump System Assessment Tool (PSAT), plant personnel can identify a handful of systems that offer the greatest savings. A Fiberglass manufacturer with 6000 pump systems used PSAT to identify 20 systems that offered 90% of the potential savings, in descending order of potential savings, in less than a day.

Personnel from a participating industrial plant can attend a 1-day workshop where they are introduced to Best Practices software tools and/or methods for identifying energy efficiency opportunities. The workshop describes tools and general optimization principles for a specific utility system—pumps, steam, compressed air, and process heating. Almost 1000 people attended the training sessions during FY 2002. In some instances, ORNL can augment the training by sending a Best Practices staff member to the plant to help apply the software in a targeted assessment. In the process, plant personnel learn how to obtain data for the software, calculate data, input the data, and interpret the results. When the process is finished, the company has completed an assessment of some of its systems and has developed its own experts who can conduct futher assessments.

For each system, the scoping tool identifies the system's actual efficiency, the potential efficiency with an optimal system, and the potential annual savings. Narrowing the field to a few systems that promise significant savings makes it more likely that improvements will be pursued. How to actually capture savings is left up to the company, working with its suppliers and consultants.

In addition to PSAT, Best Practices offers a Process Heating Assessment and Survey and a Steam System Assessment Tool. Work is under way to develop a fan system assessment tool, which should be available in late 2003. All of the Best Practices software tools can be downloaded from www.doe.gov/bestpractices or obtained on CD from the Clearinghouse at 1-800-862-2086.

ORNL researchers have also produced the *Steam System Survey Guide*, which provides a methodology for assessing efficiency opportunities in steam systems, and the *Guide to Low-Emission Boiler and Combustion Equipment Selection* (www.oit.doe.gov/cfm/fullarticle.cfm/id=653).

Training

Some plant personnel need more in-depth training than is provided in the 1-day introductory workshops on software tools. More detailed instruction is available in 2-day qualified specialist training sessions, which provide hands-on experience in using the software tools and interpreting the results. More than 50 people attained qualified specialist status in FY 2002.

Plantwide Assessments

Participants in DOE's Industries of the Future Program have identified a need for technical assistance in using energy more efficiently, reducing waste, and increasing productivity. Cost-shared plant-wide assessments sponsored by Best Practices help these industries identify ways to improve the energy efficiency of

Small Business Participation

Small businesses are actively involved in the tool development and training aspects of the Best Practices program. Their role so far is mostly in developing the software tools and training plant personnel to use and optimize them. The small company E3M, Inc., developed the Process Heating Assessment and Survey Tool (PSAT) scheduled for release soon. (E3M was selected as the ORNL small business contractor of the year for 2002.) Diagnostic Solutions, LLC, conducts qualified specialist training for the PSAT. Small companies also conduct training for plant personnel on compressed air projects, and more small businesses are getting involved as suppliers, trainers, and consultants. Alcoa has developed its own plantwide assessment program using some of the same companies that Best Practices uses as vendors.

specific plant utilities and processes. About 25 assessments had been completed by the end of FY 2002. About ten more are ongoing, and DOE is soliciting participants for the next round.

The combined potential annual cost savings identified at the 25 facilities exceeds $138 million. Potential electric savings are estimated at 273 million kWh and thermal energy savings at 3 million MMBtu annually.The average projected investment payback period is less than 2 years, and in many cases less than a year. Implementing the recommended projects would also result in significant benefits from increased productivity, reduced environmental impacts, and reduced maintenance requirements.

ORNL recently completed a follow-up review of the impact of implemented projects at five plants that completed plantwide assessments in FY 2000. The review focused on energy efficiency, cost savings, and environmental benefits, comparing the actual savings realized over 18 months with the benefits projected in the assessment. On average, actual savings were 88% higher than the savings estimated in the assessment study. The difference was due mainly to two factors: (1) savings estimates in the assessments tend to be conservative and (2) once implementation starts, companies are spurred to identify and carry out other improvements.

ORNL also tracks the replication effects of assessments—that is, whether companies adopt the assessment as part of their energy management program and perform assessments at their other plants. During FY 2002, four companies integrated the plantwide assessment into their energy management strategies and 10 replications occurred. The replications identified potential savings of $46 million in costs, 2 million kWh in electricity, and 1.96 million Btu of gas annually.

Daryl Cox of ORNL checks a flow meter at a plant participating in the Best Practices program.

Validation and Verification

ORNL also conducts independent, unbiased verification and validation of the benefits of new and emerging technologies. Thus potential users have access to verified information and do not have to rely solely on the claims vendors make for their technologies. Technologies are tested in industrial plants under real-use conditions, and the performance results are published in reports. The objective is to mitigate the hurdle of initial acceptance for yet-to-be-proved technologies and promote broad use for those that prove worthwhile.

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Sponsor: DOE/EERE Industrial Technologies Program

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Small businesses can use these facilities and take advantage of the unique equipment available in each. Recently, for example, a small business used the Buildings Technology Center to collect data on the insulating capability of a new material for tents.

Entrepreneurs for Energy Efficiency, Inc. (E-3), A group of 20 successful small-business owners who commercialized technology funded by grants from DOE's Inventions and Innovations Program (formerly the Energy-Related Inventions Program or ERIP) have formed a not-for-profit organization to promote entrepreneurialism in energy efficiency and to assist new grantees who are trying to commercialize energy-efficient technologies. ORNL has provided technical assistance to the I&I and ERIP programs since 1978 and was the inspiration for the development of E-3. ORNL continues to facilitate activities of this group, including building membership to 100 by the end of FY 2004, and oversees the conduct of mentoring as a core activity of this organization. E-3 held its annual meeting in Washington, D.C., on May 8, 2003.

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Work for Others is a contracting mechanism that permits U.S. businesses, including small businesses, to have work performed by a DOE laboratory. This mechanism generally requires the industrial partner to provide funding for the ORNL work on a 100% cost recovery basis.

Finally, small businesses can participate in **personnel exchange projects** with ORNL. ORNL employees can do work at the small business facility, or small business staff members can work at ORNL to enhance technical skills.

More details on partnering with ORNL can be found at www.ornl.gov/tted/.

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Phil Childs of ORNL's Buildings Technology Center monitors the energy efficiency of a wall system and window.

News Briefs

ORNL Revitalization Team Recognized

An ORNL team that helped bring about three privately financed new buildings on the east campus with energy-efficient and sustainable design features has received a Certificate of Appreciation in the 2002 Federal Energy and Water Management Awards Program. The Federal Energy and Water Management Awards are designed to recognize "federal leadership by example."

Mei Elected ASME Fellow

Vince Mei of ORNL's Engineering Science and Technology Division has been elected a fellow of the American Society of Mechanical Engineers. Mei's research focuses on energy-efficient heat pumps, air-conditioning, refrigeration, heat transfer, and fluid flow. He has published more than 90 technical papers and co-edited 8 heat pump symposium volumes and has 9 patents and several patents pending.

Lin Is American Ceramic Society Fellow

Hua-Tay Lin of ORNL's Metals and Ceramics Division was made a Fellow of the American Ceramic Society in April. Lin joined ORNL in 1989 and has worked on projects involving mechanical property testing of advanced ceramics, testing of composite materials, and properties verification of silicon nitride microturbines and components.

Lara-Curzio Receives Award

Edgar Lara-Curzio received the 2003 Richard Fulrath Jr. Award from the American Ceramic Society "for outstanding contributions to ceramic science and engineering."

NTTRC Dedicated

The National Transmission Technology Research Center (NTTRC) was dedicated at ORNL in March. Participants included James Glotfelty, director of the Office of Electric Transmission and Distribution; Glenn McCullough, chairman of the Tennessee Valley Authority board; and Congressman Zach Wamp.

The NTTRC conducts accelerated tests of advanced transmission conductors. Controlled testing is critical for utilities to gain the confidence to entrust system reliability to these new technologies. ORNL researchers are working with counterparts from the Tennessee Valley Authority and 3M to test a replacement conductor for power lines that addresses the problem of power outages caused when lines sag under the heat of high current loads.

NASA calls on ORNL Insulation Expertise

ORNL's Ken Wilkes participated in a NASA technical forum to review findings related to the role that foam insulation falling from an external tank may have played in damaging the thermal protection system of the Columbia space shuttle and the subsequent loss of the spacecraft. Wilkes and the ORNL research team are nationally recognized experts in the field of material science and foam insulation properties.

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