Science & Technology HIGHLIGHTS

Published by Oak Ridge National Laboratory's EERE and OE Programs

No. 1 2006

After the Storm Passes, They Check Out the Roofs

As anxious Atlantic and Gulf Coast dwellers scan the weather reports this hurricane season, ORNL roofing researcher André Desjarlais will be watching with them—but with a different concern in mind. Desjarlais, safe in the hills of East Tennessee, will be waiting to see if the hurricane damage assessment project he heads for ORNL will be called into action.

Ten years ago, ORNL and DOE entered into an agreement with the Roofing Industry Committee on Weather Issues, Inc. (RICOWI) to investigate and document the performance of roofing systems in the wake of major hurricanes. The criterion for action is a major hurricane (sustained wind speeds of 95 mph or more) striking land on the continental United States in a populated area. RICOWI's goal was to obtain unbiased, detailed damage assessments by credible parties from the roofing, insurance, and building research communities.

ORNL hosted training events for investigation team members, conducted by leading experts in examining wind-related roof damage, in 1996 and again in 2000. Meanwhile, the trainees waited for a big one to hit.

Not until Hurricanes Charley and Ivan struck the Gulf Coast in 2004 did a storm meet the criteria to set the program into motion. But then the teams were scrambling: RICOWI deployed seven teams in the Charley damage area around Punta Gorda, Florida, in August and five in the Pensacola area struck by Ivan in September to document the damage to roofs. Less than a year later, six teams combed the areas devastated by Hurricane Katrina in September 2005.

Desjarlais was a member of one of the Charley field teams and helped shepherd the preparation of the report. "Watching television reports on hurricanes does not even begin to prepare you to inspect the amount of damage created by these strong hurricanes," he said. "Entire neighborhoods are leveled and communities are destroyed."

Broken glass in doors (bottom) allowed winds from Hurricane Charley to enter and pressurize the interior of this Florida residence, blowing the plywood roof decking upward and destroying the roof (top).

Team members included structural and wind engineers, roofing material specialists, insurance analysts, and roofing consultants. Members were assigned to teams based on their areas of expertise, and teams were balanced by having two members representing manufacturers and two members from academia, the insurance industry, consulting firms, or other non-manufacturing fields.

More than 115 roof inspections were conducted on nearly every type of building and roof, including commercial, institutional, and residential, low-slope and steep-slope. The teams collected specific types of data on each building examined, including roof shape, roofing materials, edge conditions, installation details, and degree of deterioration. Damage to each roof was described in detail, and hundreds of photos captured visible details. Where possible, the teams identified the point where damage started and possible reasons for the initial failure.

A report published in May 2006 documented the damage from Charley and Ivan; Katrina damage will be covered in a report to be issued in late 2006 (The report is available at www.ricowi.com/html/reports).

The Charley/Ivan investigations provided valuable insights into the effectiveness of materials and methods of construction in resisting wind damage. A variety of factors were found to affect performance, including roof attachment, material selection, roof/structure design, deterioration, maintenance, and workmanship. The security of roof edgings and of the attachment of rooftop equipment proved to be major

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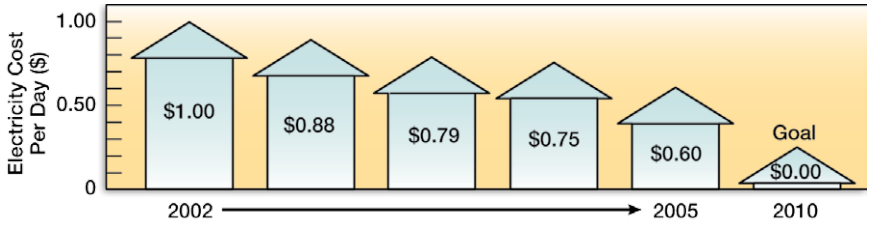
ORNL Works to Bring Zero-Energy Housing to the Masses

Wouldn't it be nice to check your electric meter on the hottest day of the summer, with the air-conditioner running full blast, and see the meter spinning backward instead of forward, earning instead of costing money? Residents of five homes in Lenoir City, TN, can do that—they live in houses that produce more energy than they use on sunny days.



Utility bills have decreased with each house built. The first of the five houses built (2002) averages about $1 per day, net, in electricity costs. The last house built (2005) is averaging about $0.60 per day.

The five near-zero-energy, all-electric homes were built by Habitat for Humanity in cooperation with ORNL, DOE, and the Tennessee Valley Authority. They are constructed to use a fraction of the electricity a similar conventional house uses. In addition, they are outfitted with solar photovoltaic (PV) panels that produce electricity and sell it to the utility grid. TVA credits the homeowners with $0.15 per kWh and sells the power through its "Green Power Switch" program that lets TVA customers choose power from renewable sources. The energy bills for the five dwellings average $25 per month, 50–70% less than those of neighboring houses.

The project is a win for everyone, says Jeff Christian, director of ORNL's Buildings Technology Center. The residents get low utility bills; TVA gets comparatively cheap green power to resell and about a 40% reduction in peak summer and winter demand, which also benefits its ratepayers; DOE uses data collected from the houses in its buildings research; manufacturers gain a testing ground for advanced energy-efficient products; and taxpayers benefit from technology advances that the collaboration fosters.

The long-term goal of the effort is to develop affordable zero-energy houses (ZEHs) that produce as much energy as they consume over a year. When DOE sought partners to develop a ZEH that the average home buyer could afford, TVA was the first electric utility to sign on. TVA, DOE, ORNL, and Habitat agreed to design, build, monitor, and analyze five research houses. The fifth house was occupied in January 2006.

Each of the 1000- to 2600-ft^2 houses has an airtight building envelope built of structural insulated panels (foam insulation between outer layers of oriented strand board). The panels provide superior insulation, airtightness, strength, and ease of use. The airtight envelope is critical to the low energy demand of the houses. High-performance windows under extended eaves minimize solar heat gain in summer, when the sun is high in the sky, and admit it during the winter. Reflective exterior paint and roofing materials further reduce heat gain. The heating/cooling systems are high-efficiency heat pumps (two are geothermal). Energy Star appliances and fluorescent lights cut the interior energy load. Each roof holds an array of 2-kW PV cells connected to the power grid operated by Lenoir City Utility Board, the local TVA distributor.

The fifth near zero-energy Habitat home was completed in late 2005.

Christian said energy efficiency has improved with each house built. ORNL's data show daily energy costs average $1 per day for the first house, $0.88 for the second, $0.79 for the third, and $0.75 for the fourth; preliminary data show $0.60 per day for the fifth. (The national average for a conventional house is $5 per day.) The first four houses were built for under $100,000 and the fifth for around $60/ft^2, including the market value of the energy-saving features and PV cells.

DOE, TVA, and ORNL are now working to move ZEHs into a wider market. According to Christian, several projects to do so are under way. A startup company is about to offer small, affordable ZEH kits on its web site. Lew Pratsch, Zero-Energy Homes project manager for DOE, predicts that ZEHs will be cash flow neutral (mortgage plus energy) compared with conventional houses a decade from now. For more information, see www.ornl.gov/sci/btc/news.shtm.

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Sponsor: DOE/EERE Building Technologies

ORNL Aids "Save Energy Now"

ORNL's BestPractices team enabled DOE's "Save Energy Now" program to meet a seemingly impossible deadline for staffing one of its industrial inspection programs. DOE asked the ORNL team to issue a solicitation and establish contracts for up to 30 steam and process heating specialists to conduct energy saving assessments in 2006. DOE wanted all the specialists under contract in a little more than two months to allow time to have them trained and in the field by early 2006.

Members of the BestPractices team, working with the ORNL contracts office, issued a solitication, chose contractors, and put contracts with them in place ahead of the DOE schedule.

During CY 2006, the specialists will conduct about 200 three-day energy savings assessments at some of the largest industrial plants in the United States. The plants are located in 23 different states.

The locations of the plants being assessed are at http://eereweb.ee.doe.gov/industry/sen/maps/plantmap.html.

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Sponsor: DOE/EERE Industrial Technologies Program

EERE/OE Recognized with Four R&D 100 Awards

Research conducted at ORNL recently won six R&D 100 Awards, presented each year by *R&D Magazine* in recognition of the year's most significant technological innovations. Four of the awards were for work funded in whole or in part by EERE or OE.

The 2006 awards push ORNL's total R&D 100 awards to 128, more than any other national lab and second only to GE overall. The following inventions related to EERE/OE were named as winners.

Hybrid solar lighting (HSL), developed by Jeff Muhs, David Beshears, Duncan Earl, and Curt Maxey of ORNL and Sunlight Direct of Oak Ridge. The HSL system uses a roof-mounted solar collector and small fiber optics to transfer sunlight to top-floor hybrid fixtures that also contain electric lamps. A control system dims the electric lights when the sunlight is bright and turns them up when it isn't.

The hybrid solar lighting technology was developed by this team of ORNL staff members.

One collector can power up to 12 fluorescent hybrid light fixtures or 30 to 40 incandescent accent lighting fixtures, which can illuminate about 1000 ft^2. The technology reduces energy usage for cooling as well as for lighting because it blocks ultraviolet and infrared heat. The savings can be substantial, especially in locations with abundant sunshine. ORNL's work was funded by DOE/EERE Solar Technologies.

Metal infusion surface treatment (MIST), developed by researchers from C3 International assisted by staff from ORNL.

This team from C3 International and ORNL developed the MIST metal coating process.

MIST can infuse up to 51 elements into the surfaces of metals and alloys and then secure the elements with a thin nanostructure coating. Metalworking tools and catalytic devices have been treated, resulting in increased lifetimes or higher performance. The MIST process can be performed on site.

In tests on cutting tools, MIST has yielded lifetimes 10 times better than those resulting from conventional coatings. Customers report the treatment also increases production rates and reduces manufacturing costs. MIST has potential applications in improved spark plug and catalytic filter function and in fuel cells. DOE/EERE Industrial Technologies and Freedom Car programs jointly sponsored the ORNL work.

TMA 6301 and TMA 4701 stainless steels, developed by Govindarajan Muralidharan, Vinod Sikka, Phil Maziasz, Neal Evans, Michael Santella, and Christopher Stevens of ORNL; Duraloy Technologies; and Nucor Sheet Mill Group. These two heat-resistant cast austenitic stainless steels with improved durability and lifetime at higher maximum operating temperatures were developed using computer-aided design. Use of the novel methodology reduced the time required to develop new alloys to about 3 years, compared with the 6 to 10 years typical for traditional trial-and-error methods.

These ORNL researchers used computer-aided design to develop TMA stainless steels.

The new alloys will be used in industrial equipment in the heat-treatment, steel, chemical, and petroleum industries. DOE/EERE Industrial Technologies funded ORNL's research.

Trane CDQ, developed by Jim Sand of ORNL in collaboration with the Trane Company. Trane CDQ is an air conditioning-dehumidification device that controls temperature and humidity inside buildings. The CDQ can control ambient air to a desired 45 to 60% relative humidity, which is important for libraries, schools, offices and, most important, hospitals. Because regulating humidity limits the spread of infection, medical institutions, including St. Vincent's Hospital in Alabama and Franklin Memorial Hospital in Maine, have installed the device.

This Trane CDQ unit was developed in partnership with ORNL.

Unlike other air-conditioning/dehumidifying units, the Trane CDQ effectively controls humidity without adding heat to the system. DOE/OE Distributed Energy funded Sand's participation.

Hybrid Solar Lighting Field Tests Go Nationwide

ORNL's hybrid solar lighting (HSL) team is working with companies across the United States to conduct a nationwide field trial program during 2006, called the "Sunlight Inside Initiative." Sunlight Direct, LLC, a start-up company in Oak Ridge, Tennessee (www.sunlight-direct.com), is purchasing and installing all components for each host-site location in the demonstration.

HSL vs Conventional Lighting	
Type of Lighting	Typical Energy Efficiency (~lumen/W)
Incandescent	15
Fluorescent	75
Hybrid Solar	200

To date, 12 sites have signed up and provided cost-share funds ($24,000) to participate in the field trials. ORNL will collect and publish performance data and user feedback from the trials to ensure successful future use of the technology.

HSL uses rooftop, 4-ft-wide mirrored dishes that track the sun with the help of a GPS receiver. The collector focuses the sunlight onto 127 optical fibers, which are connected to hybrid light fixtures with diffusion rods that spread the light in all directions. One collector powers enough hybrid light fixtures to illuminate about 1000 ft^2.

By 2011, HSL should be saving the nation over 50 million kWh/year and dramatically improving lighting quality in commercial buildings. More than 5000 HSL systems are expected to be installed by 2011 in regions of the United States where solar availability and electricity rates make them cost-effective. An initial system tailored to commercial buildings with mixed fluorescent and incandescent lighting (commonly found in retail stores) has been identified as the most likely first market. For that market, a system cost of $4000 (installed) has been identified as necessary to meet the energy savings goals by 2011.

HSL light pipes. Courtesy of *Discover Magazine*.

HSL has the potential to significantly reduce energy consumption while maintaining or exceeding lighting quality requirements. Implementing HSL across the country represents a significant energy savings and provides building managers with a near-term, energy-efficient, higher-quality, economically viable alternative to incandescent lamps.

HSL advantages include these:

- Infrared and ultraviolet energy in sunlight is separated from the visible light, rather than being transmitted into buildings. Heating, ventilation, and air-conditioning (HVAC) loads are thus reduced by 5 to 10%, compared with electric lighting systems.
- HSL systems are readily adaptable to commercial buildings with multiple floors, relatively low ceilings, and interior walls. A single system can distribute enough sunlight to illuminate several rooms in a typical office building.
- Plenum space—the area between the roof and drop ceiling—is not needed for lighting systems and is freed for other uses.
- HSL can be used for direct ambient lighting (as in skylights) and for indirect, task, and accent lighting.
- In retrofit markets, HSL is easily incorporated into existing building designs, and the optical fibers can be rerouted as lighting needs change. By intentionally misaligning the solar collector from the sun, occupants can even dim or curtail distributed sunlight.

Rooftop solar collector at Sacramento Municipal Utility District site.

During the field trial program, R&D will continue at ORNL to lower component costs, improve fiber longevity, and advance building integration. New solid state lighting (LED) hybrid luminaries are also being analyzed for increased energy efficiency. ORNL also will explore other uses for the HSL system, including water heating. See www.ornl.gov/solar for more information on ORNL's solar technologies program.

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Sponsors: DOE/EERE Solar Technologies, Tennessee Valley Authority

HTS Cable Operating at Urban Ohio Power Substation

Pulling the vacuum-jacketed flexible cryostat into the underground duct at the Bixby substation.

A team led by Southwire Company, which includes ORNL and several private partners, has installed an underground 200-m high-temperature superconducting (HTS) cable system at a power substation in Columbus, Ohio. The installation of an HTS cable in an operating power grid showcases a tri-axial cable design and advanced cryogenic cooling systems with the potential to offer economical, reliable HTS solutions for urban electrical transmission and distribution challenges.

Superconducting cables transmit electricity far more efficiently than conventional cables because superconducting materials conduct electrical current without resistance.

Two 100-m-long cryostat sections were inserted into the underground ductwork at the substation, and cable sections were then pulled into the cryostats using a small winch. Two 3-phase terminations developed and built at ORNL and a cryogenic cooling system supplied by Praxair were then installed. Off-line testing of the cable was completed in early summer, and the cable was integrated into the American Electric Power (AEP) grid in July.

The cable will be operated at least a year. It will supply power to the entire 13-kV distribution bus at the Bixby Road Substation of AEP in Columbus, providing power to residential, commercial, and light industrial customers.

The 3-kA, 5-m HTS cable is the highest-current-density cable in the world. The cable configuration uses about half as much superconducting wire as competing designs and has the lowest cryogenic heat load because of its compact geometry.

The tri-axial cable concept was jointly invented by ORNL and Ultera, which is a partnership between Southwire Company and nkt cables, and the cables were manufactured by Ultera.

In the cable, three concentric phase conductors are separated by electric insulating tape. The design phase current is 3000 Arms at 77 K, and phase-to-phase voltage is 15 kV. The phase conductors are silver-alloy tapes manufactured by American Superconductor; each electrical phase has two layers of these HTS tapes. The insulating material is made of layers of Cryoflex™ tapes immersed in liquid nitrogen. This insulation system is designed for a basic impulse level voltage of 110 kV (to simulate lightning), which is the requirement for this 15-kV class cable.

Comprehensive testing of the cables and terminations was completed in mid-2005. All high-current and high-voltage testing was successful, and the cable and terminations met rigorous IEEE standard performance criteria. For more information, see www.ornl.gov/sci/fed/applied/ornl_projects.shtml.

Pulling the HTS cable into the cryostat.

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Sponsor: DOE/OE Superconductivity Program

ORNL HTS Wins Nano 50 Award

ORNL's high-temperature superconducting (HTS) wire technology has received a Nano 50 Award recognizing it as one of the top 50 technologies, products, and innovations impacting the state of nanotechnology. The Nano 50 awards, presented by *Nanotech Briefs* magazine, a monthly digital publication, are considered to be among the most prestigious nanotechnology awards.

According to *Nanotech Briefs*, ORNL's winning technology (HTS wires enabled via 3D self-assembly of insulating nanodots) "demonstrates a route to sustain high supercurrents in wires in the presence of a large applied magnetic field, a step which could greatly expand practical applications of superconductors."

This is the first Nano 50 Award won by ORNL and is also the first awarded for a superconductor technology. The Nano 50 Awards will be presented at a special awards dinner during the NASA Tech Briefs National Nano Engineering Conference in Boston in November.

ORNL team members are A. Goyal (team leader), S. Kang, J. Li, K. J. Leonard, P. M. Martin, A. A. Gapud, F. A. List, E. D. Specht, L. Heatherly, M. Paranthaman, M. Varela, A. O. Ijaduola, J. R. Thompson, D. K. Christen, S. J. Pennycook and D. F. Lee, acting ORNL superconductivity program manager.

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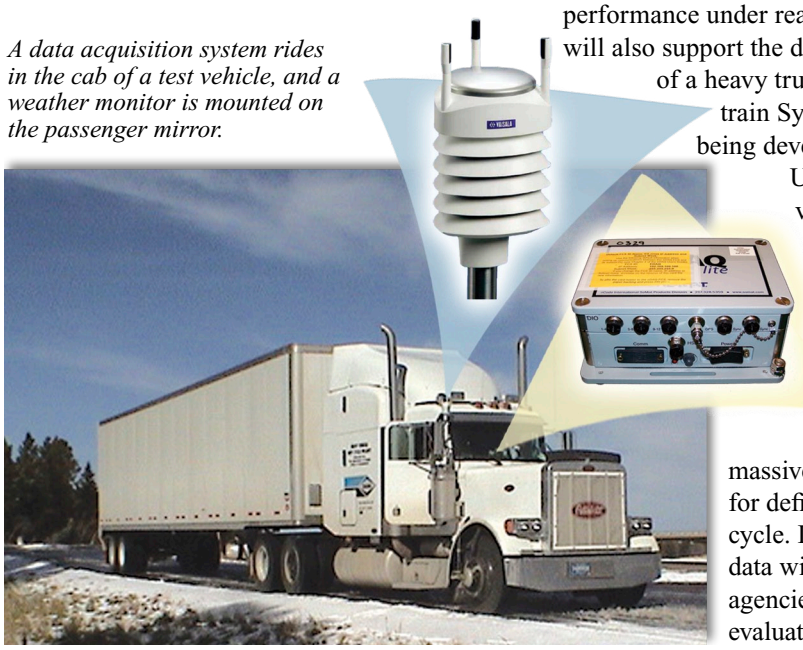
Sponsor: DOE/OE Superconductivity Program

Duty Cycle Program Tracks Real-world Truck Operation

The U.S. trucking industry is based in large part on small fleets of Class 8 trucks that operate on small profit margins and under considerable regulatory and economic pressures. Making heavy trucks more efficient would reduce fuel consumption and emissions and would contribute to larger profit margins. Lives could also be saved because efficient systems are typically safer. Currently, however, most assessments are based on information obtained from dynamometer testing, and knowledge of how trucks operate in the real world is limited.



A data acquisition system rides in the cab of a test vehicle, and a weather monitor is mounted on the passenger mirror.

The Heavy Vehicle Duty Cycle (HVDC) Program involves efforts to collect, analyze, and archive data related to heavy-truck operation in real-world highway environments. ORNL is leading the program in cooperation with two industry partners, Dana Corporation and Michelin Tire, and with Argonne National Laboratory (ANL). Participation by the U.S. Department of Transportation is being sought. The results will support technology evaluations and will provide a means of determining heavy truck performance under real-world conditions. They will also support the development and evaluation of a heavy truck module for the Powertrain System Analysis Toolkit model being developed at ANL.

Under the HVDC Program, a variety of sensors and instruments mounted on long-haul Class 8 tractor-trailers are being used to measure and record more than 90 different parameters, such as weather and road conditions. This massive effort will provide a basis for defining a heavy vehicle duty cycle. Information gleaned from the data will help DOE, other federal agencies, and the trucking industry evaluate technologies for improving the safety, efficiency, and management of the U.S. Class 8 truck fleet.

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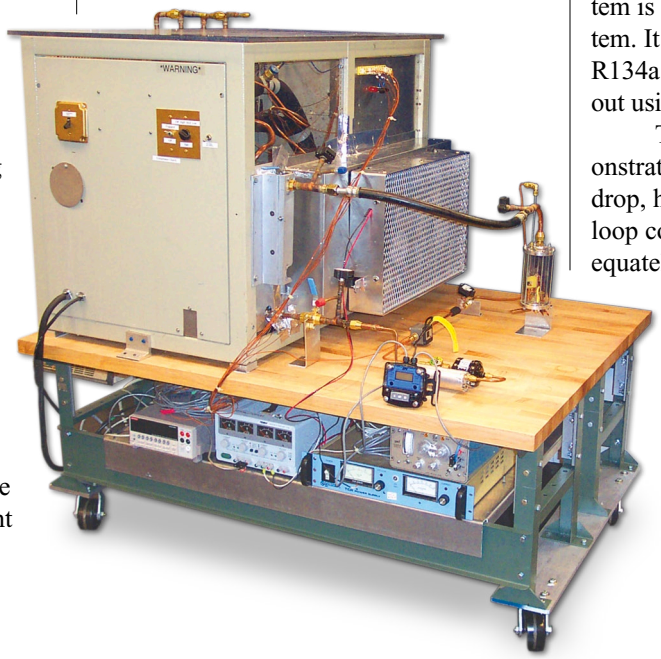
Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies

Floating Loop Helps Power Electronics Keep Their Cool

Removing heat generated by electrical losses in traction motors and their associated power electronics is essential for reliable operation of hybrid electric vehicles (HEVs). Motors and electronics run efficiently and reliably only if adequately cooled to reduce resistance losses. ORNL has developed a simple, compact cooling system that uses a vehicle's existing air-conditioning (AC) system to cool the motor and electronics with minimal input power.

HEVs currently use a dedicated cooling loop with a water/ethylene glycol mixture to cool power electronics to around 65°C. Automakers want to reduce system costs, eliminate this loop, and use the same cooling loop and 105°C coolant presently used in combustion engine automobiles.

The use of high-temperature coolant presents a challenge, as the silicon in power electronics devices begins losing reliability at 125°C and breaking down at 150°C.



Floating loop system attached to full-size sedan AC system (inside cabinet).

ORNL's "floating loop" cooling system is integrated into the existing AC system. It shares the use of the AC system's R134a coolant and is able to operate without using the AC compressor.

The concept was successfully demonstrated, proving that a low-pressure-drop, high-temperature, two-phase coolant loop could remove sufficient heat to adequately cool heat-producing electronics.

Tests were conducted with the loop attached to an automotive AC system, sharing its condenser, to prove the loop would not adversely affect AC system performance under steady state and

transient conditions. The loop successfully removed waste heat from the power electronics while the AC system cooled the passenger compartment.

To date, the loop prototype has successfully removed 2 kW of heat load in a 9-kW auto AC system with and without the AC running. The coefficient of performance for the floating-loop system has ranged from 40–45, compared with a typical AC system COP of about 2–4. The estimated required heat load for future hybrid applications is 5.5 kW, and the floating loop is easily scaleable for such a load.

The floating loop works well in compact heat exchangers and could be used to cool larger structures, such as motor housings. When electronic components operate at high efficiencies, fewer and smaller devices can be used. The floating loop is a first step toward shrinking the size of the traction drive and associated electronics while maintaining the net power output.

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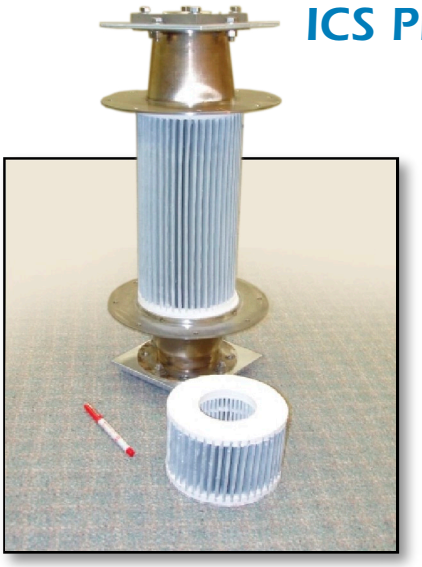
Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies

ICS Prepares to Market Ceramic Particulate Filter



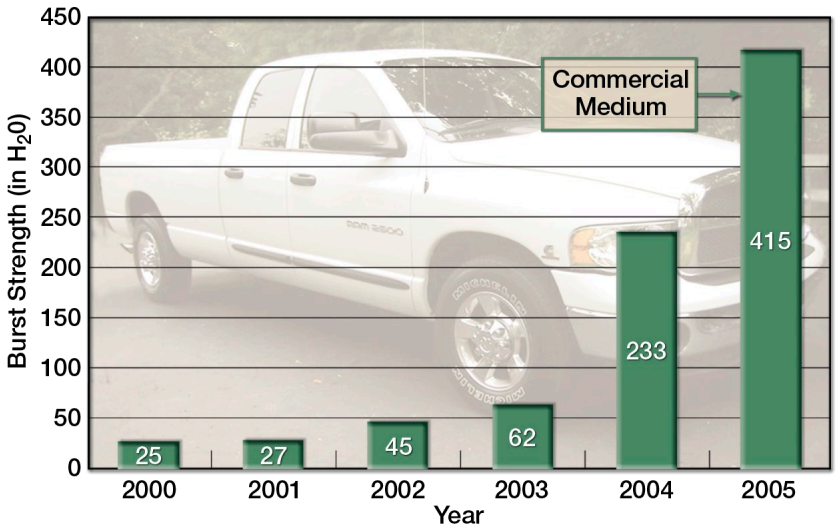
Prototype diesel particulate filters.

Every diesel engine in the world will need a particulate control device to meet more stringent emissions regulations to be phased in starting in 2007. Most diesel particulate filters (DPFs) are wall-flow extruded ceramic structures that are limited by high thermal mass, low soot-loading capacity, and an inability to conduct heat for regeneration. In addition, smaller diesel vehicles representing 90% of the market have exhaust temperatures too low to regenerate a DPF and thus may require auxiliary heating for their filters. Industrial Ceramic Solutions, LLC, (ICS) in Oak Ridge, Tennessee, is preparing to market a ceramic DPF cartridge that addresses these problems.

ICS developed a fabrication process that uses commercial papermaking equipment, SiC fibers, and ceramic binders to produce a pleated filter that can be heated by microwaves. An earlier prototype was too weak and could not be regenerated while exhaust was passing through it. ICS worked with ORNL's High Temperature Materials Laboratory to test and analyze the filter and, based on the results, produced an improved filter with increased burst strength and soot-loading capacity that can be regenerated while the engine is idling. The improved filter remained undamaged after 20 road tests on a 7.3-L Ford truck, during which the filter was loaded to more than 80 in. of water backpressure and then regenerated at 700°C.

The filter's thermal mass is 30% that of extruded ceramic filters. It achieves lower-energy soot combustion, adds less weight to the vehicle, and can handle about twice the soot loading of an equivalent extruded filter. Its open structure prevents destruction by temperature excursions when it is overloaded with soot. ICS has also demonstrated that the filter reduces exhaust backpressure on the engine and thus reduces its fuel penalty and improves engine performance.

ICS is working with a major filter maker to license the technology for introduction to the worldwide diesel market. For more information, see www.ornl.gov/sci/apm/documents/ALL.pdf.



ORNL's analysis work helped ICS increase the burst strength of the filter media from 233 in. of water in 2004 to 415 in. by 2005.

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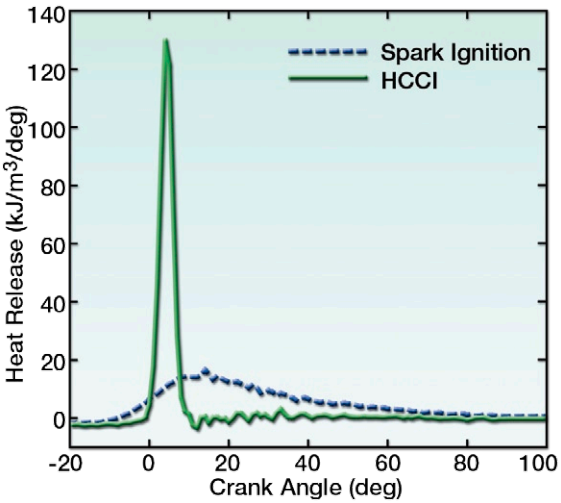
Sponsor: DOE/EERE FreedomCAR and Vehicle Technologies

Clean, Quiet Hydrogen Combustion Demonstrated with HCCI



Heat release rate data for HCCI (flameless) combustion mode vs. conventional spark-initiated flame propagation, showing more rapid heat release of the flameless combustion.

A team of ORNL researchers recently achieved homogeneous charge compression ignition (HCCI) in a hydrogen-burning internal combustion (IC) engine. Only a handful of research institutions worldwide have succeeded in running a hydrogen engine in HCCI mode.

To support the research, the team had to establish a hydrogen engine cell at ORNL's Fuels, Engines, and Emissions Research Center (FEERC). Jim Tassitano coordinated extensive equipment modifications to an existing engine cell at FEERC to enable the safe use of hydrogen fuel, which can be highly volatile in combination with oxygen.

While much attention has been focused on using hydrogen fuel cells for transportation, hydrogen is also a low-emission fuel in IC engines.

The engine shakedown experiments demonstrated ORNL's capability to achieve hydrogen-fueled conventional spark ignition (SI) and HCCI combustion in the laboratory. The effort prepares the way for future research in hydrogen IC engines and hydrogen HCCI at FEERC.

ORNL's project compared hydrogen combustion in conventional SI mode and HCCI mode. The tests demonstrated much lower nitrogen oxides emissions for HCCI—in the single ppm range—than for SI.

The experimental engine used was a modified 0.52-L single-cylinder Hatz diesel engine. The compression ratio was reduced to permit both SI and HCCI operation under similar conditions. Other modifications included an electric air pre-heater and a specialized hydrogen flow delivery and measurement system. The setup was instrumented to enable comparison of SI and HCCI modes. Measurements included standard regulated emissions, temperature and pressure of all inlet and outlet flows, and in-cylinder pressure with a 0.5 crank angle degree resolution.

The heat release rates for the two combustion modes at nearly identical power-output levels are shown in the chart. A characteristic of HCCI combustion is that reactions start and progress from many sites simultaneously throughout the combustion chamber, rather than in a thin, propogating flame. This overall rapid heat release is evident from the data in the chart.

In a previous task, similar data were acquired with diesel-fueled HCCI, and the comparative analysis is still under way.

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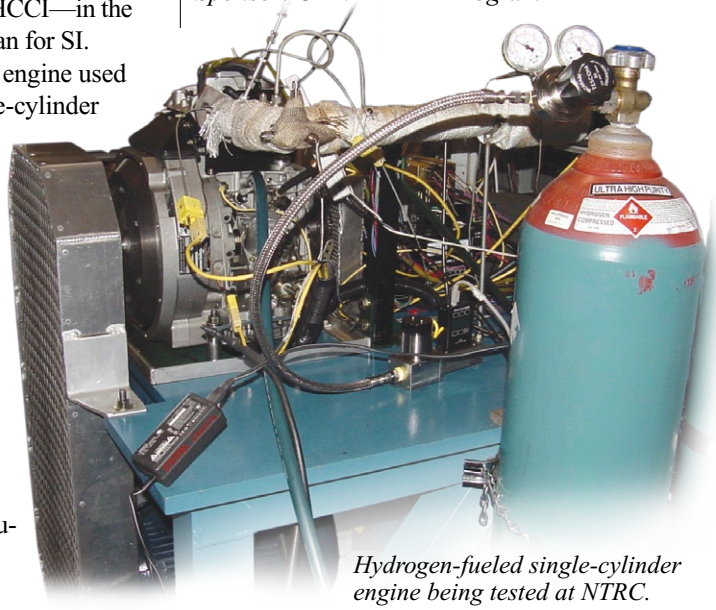
Sponsor: ORNL LDRD Program



Hydrogen-fueled single-cylinder engine being tested at NTRC.

ORNL Tech Transfer Expert Passes Away

Larry Dickens, a well-known leader nationally in the field of technology transfer, died suddenly May 8 at his home in Oak Ridge. A former commercialization manager at ORNL, he was serving as licensing executive at Oak Ridge's Y-12 National Security Complex.

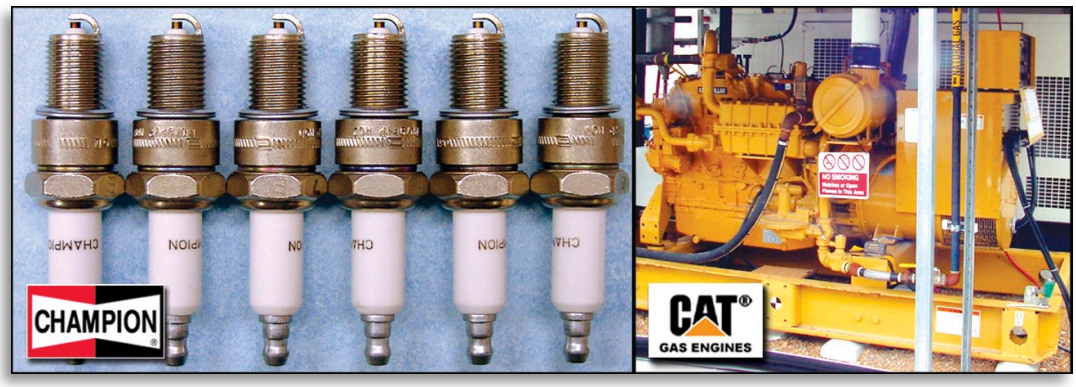
During his 15-year tenure at ORNL in the technology transfer organization, Dickens was instrumental in negotiating some of the largest cooperative research and development agreements in Laboratory history. He also was a leader in negotiating numerous licenses that had a significant impact on ORNL's technology transfer program.

Dickens received several national and regional awards in technology transfer and had served in a variety of leadership positions with the Federal Laboratory Consortium, including vice chairman.

He was also a dedicated local public servant. Dickens was serving on the Anderson County Commission at the time of his death and previously was a member of the Oak Ridge City Council.

Champion/ORNL Working on Longer-Lived Spark Plugs

ORNL is teaming with spark plug maker Federal Mogul (Champion) to develop new materials for electrode alloys to extend spark plug life. In 2005, Champion manufactured a set of 65 test plugs and sent them to ORNL for engine testing and microstructural analysis. Electrodes in the plugs included five ORNL developmental alloys and three Champion control alloys.



Spark plugs (left) being tested in a natural gas engine (right) include five ORNL alloys for electrodes.

The 65 plugs were run in a natural gas (NG) engine for 70 hours and then analyzed by scanning electron microscopy. ORNL researchers are comparing the results for the control and the developmental alloys. They will use the data to identify key mechanistic contributors to spark plug electrode wear in NG engines and develop alloys to extend electrode life.

Spark plug electrode wear has a major impact on the operating cost, performance, and emissions of industrial NG reciprocating engines. Currently, spark plugs last about 2–6 months in these engines. Engine performance declines as they deteriorate, and frequent shutdowns are necessary to replace them. A desirable plug lifetime for an NG engine is at least a year. As NG engines move closer to lean combustion to reduce emissions, plug reliability and performance are critical. Resolving these issues is a key to further advances in engine efficiency.

Earlier analysis of spark plugs from field-operated NG engines at ORNL identified electrode wear driven by oxidation and cracking of electrode materials during engine operation. This finding was unexpected, as electrode wear typically is associated with material loss during sparking. Subsequent studies of field- and engine-tested spark plugs at various stages of wear confirmed the importance of the oxidation/cracking during operation to electrode wear. The findings established a basis for developing new electrode alloys.

The plugs developed for the current analysis include electrode alloys selected for improved oxidation resistance and for thermophysical compatibility with platinum electrode insert tips. Several developmental high-melting-point, corrosion-resistant alloys also are being evaluated in place of platinum alloys for the electrode insert tip.

For more information about this and other distributed energy projects, see www.ornl.gov/sci/de_materials; click on "Accomplishments."

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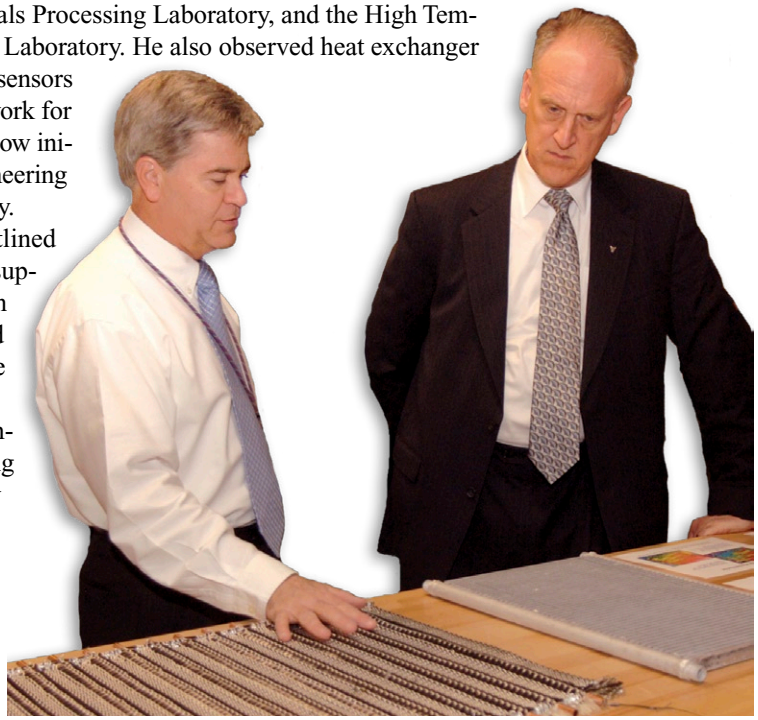
Sponsor: DOE/OE Distributed Energy

EERE's Doug Faulkner Tours ORNL

Doug Faulkner, DOE acting assistant secretary for EERE, visited ORNL in the spring of 2006, touring EERE-related research projects.

His tour included alternative fuel and power electronics research at the National Transportation Research Center, the Spallation Neutron Source, the Buildings Technology Center, the Materials Processing Laboratory, and the High Temperature Materials Laboratory. He also observed heat exchanger research, wireless sensors for industry, and work for the Save Energy Now initiative in the Engineering Technology Facility.

Faulkner outlined energy programs supported by the Bush administration and said EERE and the Office of Science are working together toward achieving energy technology goals.



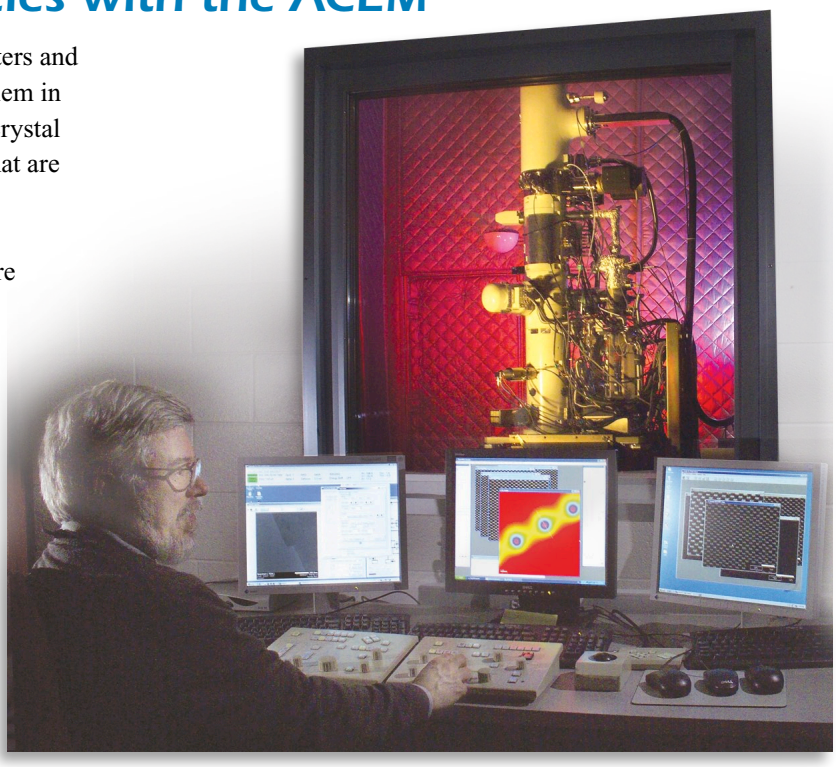
Ed Vineyard explains heat exchanger research to Faulkner.

Imaging Au-Pd Nanoparticles with the ACEM

Understanding how matter organizes first into clusters and then into particles with thousands of atoms is a key problem in catalysis and nanotechnology. Little is known about the crystal structures of the bimetallic nanoparticles (0.5 to 2 nm) that are critical in most catalytic systems.

ORNL researchers, along with colleagues at Texas Materials Institute and the University of Texas–Austin, are using ORNL's aberration-corrected electron microscope (ACEM) to study catalytic processes at the atomic level by analyzing nanoparticles of gold (Au), palladium (Pd), and their alloys. Gold-based catalysts are of particular interest to researchers because of their effectiveness in controlling many types of catalytic reactions. The most prominent uses are in the area of chemical separations, but automotive researchers are interested in their potential for improving exhaust treatment systems for diesel vehicles. Studies of the Au-Pd bimetallic alloy particle system help researchers advance the art of imaging nanoclusters and nanoparticles of other catalyst systems at sub-Ångstrom resolution.

The ACEM was used for high-angle annular dark-field (HA-ADF) imaging of Au-Pd nanoparticles ranging from pure elements to mixtures varying from Au1Pd5 to Au5Pd1. Recent experiments indicate that nanoparticles composed of a noble metal (one resistant to oxidation) and a transition metal typically take an icosahedral shape. Images of these nanoparticles were compared with calculations of model particles in which an icosahedral was used as the initial particle. The models were subjected to a simulated heating and cooling cycle comparable to the conditions in which working catalysts operate, and the resulting structure was compared with that of the experimental samples.



Larry Allard at the controls of the ACEM.

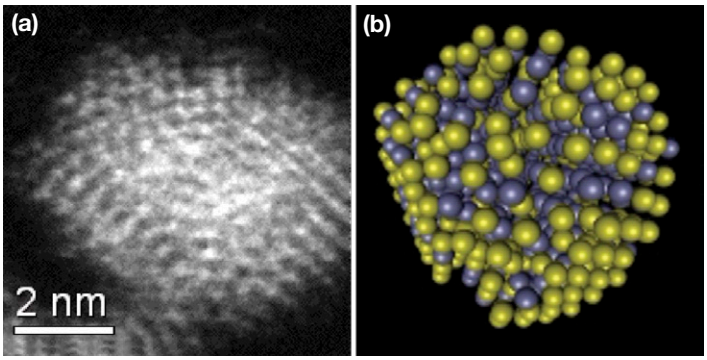


Fig. 1. HA-ADF image of Au-Pd particle (a) and particle model, heated and then cooled to room temperature. The observed particle and the model are reasonably good matches.

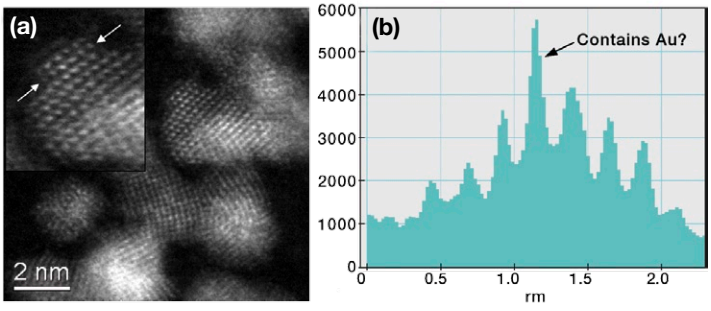


Fig. 2. HA-ADF image of Au1Pd5 nanoparticles (a). Intensity profile (b) of the atom row indicated in the inset in (a). The height of the central atom column suggests Au atoms are present in the row.

Figure 1 shows an ACEM image of an Au-Pd nanoparticle along with a model of a similar particle that shows comparable surface roughness. (Both particle and model were obtained during rapid cooling from high temperature.) The surface defects are likely sites for promotion of catalytic reactions. Figure 2a shows nanoparticles in an Au1-Pd5 system; clearly, some atomic columns are brighter than adjacent columns. An intensity profile of a row of presumed Pd atoms in a particle indicates Au atoms also are present in the row. Full image calculations of a model particle that includes Au and Pd concentrations matching those in the ACEM images should clarify the structure.

Only microscopes with sub-Ångström annular dark-field imaging capabilities like the ACEM can generate images that can be analyzed with such precision. These studies are contributing fundamental knowledge about atomic-level catalytic processes.

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Sponsor: DOE FreedomCAR and Vehicle Technologies

ORNL Material May Cut Cost of Hydrogen Production

ORNL has developed a proton transport membrane with the potential to cut the cost of hydrogen purification by 25%. The new membrane is an oxide that enables separation of hydrogen from syngas and other mixed gases.

No other membrane separation technology has been able to simultaneously achieve high hydrogen throughput, tolerate contaminants, operate at low system temperatures (200°C), and withstand harsh operating conditions at a cost low enough to compete with conventional hydrogen purification systems. The new material developed by ORNL operates between 200 and 500°C with hydrogen fluxes comparable to those achieved in state-of-the-art oxides such as barium cerate ($BaCeO_3$) at 900°C. Early results indicate this new material is insensitive to carbon monoxide, carbon dioxide, and hydrogen sulfide—common contaminants in mixed gas streams.

Although the development is in the early stages, the material is a promising step toward the development of low-temperature inorganic membranes for hydrogen separation. The results of ORNL's research have the potential to be used in the development of natural gas reforming technologies to produce hydrogen at a cost competitive with the pump price of gasoline.

Using currently available technology, the estimated cost for hydrogen generated through natural gas reforming at refueling stations is $3–5 per kilogram. (The typical car is being designed to hold 4 kg of H_2, which translates into 300 miles between refills.) That price is not competitive. DOE has set a 2010 target cost of $1.50 per kilogram of hydrogen.

GM fuel cell vehicle concept.

While DOE is researching a range of hydrogen production options, reforming of natural gas is the closest to commercial deployment. However, major technology advances are required to lower equipment and operating costs. A recent DOE analysis indicated capital costs must come down by 53%, operating and maintenance costs must drop by 39%, and system efficiency must improve by 10% to realize the 2010 target. ORNL's separation technology is a promising option for simultaneously lowering capital equipment and operating costs and improving overall system efficiency.

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Sponsor: DOE/EERE Hydrogen, Fuel Cells, and Infrastructure Technologies

Brown Heads for Georgia Tech

Marilyn Brown, former director of ORNL's Energy Efficiency and Renewable Energy program office, will join the Georgia Institute of Technology in August 2006 as Chair of Energy Policy in the School of Public Policy. In addition to teaching, conducting research, and expanding the various energy initiatives at Georgia Tech, she will be a visiting faculty scientist at ORNL where her mission will be to strengthen energy R&D collaborations between the two institutions.

Brown has held leadership positions at ORNL in the Engineering Science and Technology Division and in the EERE program. She is an internationally recognized expert on alternative energy futures and on the role that energy efficiency can play in meeting expanding energy needs. Her research has also focused on issues surrounding the commercialization of new technologies and the performance of energy programs and policies. She has authored more than 140 publications and is currently co-editing *Energy and American Society: Fourteen Myths*, which will be published in late 2006 or early 2007. She has been an expert witness in committee hearings in the U.S. House of Representatives and the Senate. She serves on the boards of directors of the American Council for an Energy-Efficient Economy and the Alliance to Save Energy and on the editorial boards of several journals and is a member of the National Commission on Energy Policy.

S&T Highlights is a communication of Oak Ridge National Laboratory's *Energy Efficiency and Renewable Energy (EERE), and Electricity Delivery and Energy Reliability (OE) Programs*

Websites: **www.ornl.gov/eere** and **www.ornl.gov/etd**
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Oak Ridge National Laboratory is operated by UT-Battelle for the U.S. Department of Energy under contract DE-AC05-00OR22725.

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News Briefs

Daw, Finny Take FLC Awards

Stuart Daw and Charles Finny of ORNL were among the winners of awards for excellence in technology transfer from the Southeast Region of the Federal Laboratory Consortium. Their Flame Doctor® technology monitors burners in coal-fired power plants to signal when burners need to be adjusted to reduce emissions and increase energy efficiency. The technology could save utilities tens of millions of dollars annually in maintenance and downtime costs and prevent up to 50% of the fuel loss and 30% of the NOx emissions resulting from incomplete combustion.

Babcock and Wilcox has a worldwide license to market Flame Doctor. The system has been demonstrated for coal-fired boilers; it should be easily adaptable to oil- and gas-fired burners.

Bob Shelton Retires

Robert B. Shelton retired from ORNL in March after 25 years of service. While at ORNL he held various positions, including interim director of the Energy Efficiency and Renewable Energy program office.

John Hsu Elected IEE Fellow

John Hsu has been elected a fellow of the Institute of Electrical Engineers. The IEE is the largest professional engineering society in Europe and has a worldwide membership of 120,000. Fellowship in IEE is the most senior category of membership and is awarded to members who have demonstrated significant individual responsibility, sustained achievement, and exceptional professionalism during their careers.

Hsu is a researcher in ORNL's Power Electronics and Electric Machines Research Center. Before coming to ORNL, he conducted research for Newman Industry in England, Emerson Electric, Westinghouse, and the University of Texas. He holds 18 patents and is the author of more than 100 technical papers and reports. He is a senior member of the Institute of Electronic and Electrical Engineers and a member of the IEEE Motor Drive and Induction Motor committees and the IEEE Standard 112 working group.

After the Storm continued from p.1

issues, and the report recommended more rigorous codes and enforcement in both areas. Typically, the teams found, roofing installed according to the latest codes resisted wind damage well.

RICOWI officials hope product manufacturers, roofing system designers, contractors, and building officials will use the knowledge gained from the field investigations to improve the resistance of roofing systems to wind damage. If more durable roofing systems reduce insured losses in coastal areas, consumers all over the country could benefit from lower insurance rates.

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Sponsor: DOE/EERE Building Technologies

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P.O. Box 2008
Oak Ridge, TN 37831-6186