Science & Technology HIGHLIGHTS

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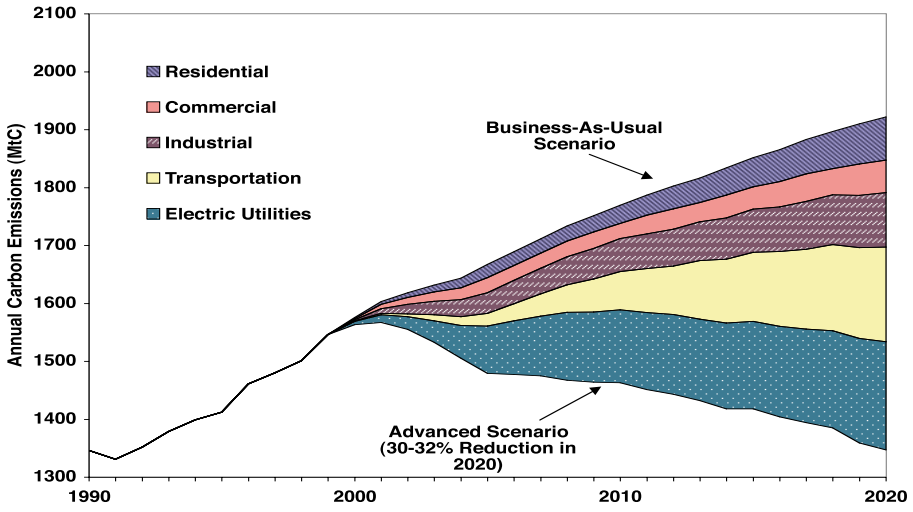
Landmark study charts pathways to a clean energy future

ORNL's EE/RE Program participated in a recent landmark study of the potential of clean, efficient energy technologies to meet energy-related challenges of the United States as it enters the 21st century. The study concludes that accelerating the development and deployment of advanced energy technologies could significantly reduce energy waste, air pollution, greenhouse gas emissions, and oil dependence at no net cost to the U.S. economy. The policies examined include increased R&D; voluntary agreements to promote energy efficiency in vehicles, buildings, and industrial processes; programs promoting cogeneration; electric sector restructuring; and a domestic carbon cap and trade system with a permit price of $50 per metric ton of carbon, implemented in 2005.

The study, *Scenarios for a Clean Energy Future*, was conducted by researchers from five DOE national laboratories and was led by Marilyn Brown of ORNL, Mark Levine of Lawrence Berkeley National Laboratory, and Walter Short of the National Renewable Energy Laboratory. It was commissioned by DOE's Office of Energy Efficiency and Renewable Energy and was co-funded by the Environmental Protection Agency.

The report couches its analysis in the form of scenarios that illustrate how the future might unfold under three different sets of policies: business-as-usual (BAU); a moderate level of effort toward a cleaner, more efficient energy system; and a more aggressive set of policies.

The BAU scenario forecasts U.S. energy consumption will rise from around 97 quadrillion Btu (quads) in 2000 to 119 quads in 2020, and CO_2 emissions will grow at approximately the same rate. Under the advanced scenario, the United States in 2020 could consume 23% less energy than in the BAU forecast, and carbon emissions could be cut to 1990 levels (see figure).



Carbon emissions reductions by sector in the advanced scenario. Without determined action, U.S. carbon emissions are projected to rise by about 30% by 2020.

Other advanced scenario findings:

- Clean energy technologies and policies could cut the U.S. energy bill by $122 billion by 2020—far more than policy and technology implementation costs.
- Voluntary agreements to make automobiles more fuel-efficient, along with other measures, could cut U.S. oil use by 5 million barrels per day. The transfer of U.S. wealth to foreign oil exporters could drop by an estimated $23 billion by 2020.
- Efficiency gains in buildings and industry could trim electricity demand by 22% compared with the BAU forecast—at a negative net cost.

In testimony before the U.S. Senate Environment and Public Works Committee regarding the study, Marilyn Brown noted that "Virtually any future based on continuing present trends would include large increases in carbon emissions. . . . Absent major shifts in policy and the economy, the United States will be ever further from stabilizing its emissions." The report and appendices can be downloaded in pdf formats at www.ornl.gov/ORNL/Energy_Eff/CEF.htm. Printed copies can also be provided while supplies last (contact brownma@ornl.gov).

Summaries of the study findings for the buildings, industry, power, and transportation sectors are presented in this issue—look for the blue boxes.

SPEED meters will help evaluate weatherization measures

ORNL is implementing a new remote monitoring system to collect data on electricity loads in low-income homes served by DOE's Weatherization Assistance Program.

The Weatherization Program now offers electric-efficiency measures (such as compact fluorescents and more efficient refrigerators) to its clients, along with its traditional building shell retrofits. Because electricity use accounts for more than two-thirds of an average residential energy bill, new evaluation methods were needed to understand the potential for weatherization measures to affect electric loads.

ORNL's study employs single-point end-use energy disaggregation (SPEED) meters and the Nonintrusive Appliance Load Monitoring System (NIALMS) software. SPEED/NIALMS is a whole-house monitoring system that allows collection of electric load data by end use without entering houses or installing meters on specific appliances. Field testing has shown the system to be 90–95% accurate for most end uses.

A SPEED meter can be installed behind an existing electric utility meter in about 20 minutes. The SPEED recorder collects data and transmits them over existing telephone lines. It samples incoming current and voltage 2000 times per second and looks for edge transitions to determine when an appliance turns on and off. It calculates and stores the date and time of each transition along with the voltage, current, and real and reactive power.

NIALMS receives the stored data from the SPEED meter when the recorder initiates a telephone call. The software then matches load characteristics to a library of appliance signatures. It produces graphs and charts of electricity consumption by end use. After a study is completed, the SPEED meter can be moved to another location.

ORNL's computing equipment can receive data remotely from up to 300 SPEED meters and process them into end-use-specific descriptions of electric loads in each house monitored.

A SPEED meter ready for installation behind an electricity meter. Installation takes only about 20 minutes.

The research effort will collect baseline electric load profiles by end-use in monitored homes, compare profiles for a pre-and post-weatherization year to identify savings by end use, and compare savings predicted by energy audits with measured savings.

Contact: Linda Berry, 865-574-5949, berrylg@ornl.gov
Sponsor: Office of Building Technology Assistance

NEAT 7.0 upgrades the weatherization toolbox

Thanks to DOE and ORNL, state agencies and utilities have an updated, expanded tool for determining the most cost-effective retrofit measures for single-family homes, aimed at increasing energy efficiency and comfort levels.

NEAT, the National Energy Audit, was developed by ORNL for DOE and first released in 1993. More than 600 agencies in 30 states use NEAT to make decisions about retrofitting low-income homes. During 1995 alone, NEAT was used on more than 80,000 homes, and helped save some $70 million in energy costs over the lifetime of that year's retrofits.

In April 2001, ORNL and DOE released NEAT Version 7.0. New features make the package more user-friendly and expand its functionality.

- NEAT now features a Windows graphical user interface. Users of Windows and Microsoft Access will be comfortable with the look and feel of NEAT.

Attic insulation is one of 34 measures that NEAT might recommend to save energy and improve comfort.

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Coming soon ...

ORNL gets into hot water in a whole new way

ORNL's two R&D 100 awards this year included one for a "drop-in" residential heat pump water heater (HPWH), developed by ORNL's Buildings Technology Center (BTC) in partnership with industry, that is three times as efficient as the best conventional electric water heater.

The key to this impressive performance is a small heat pump located on the top of the water tank that extracts heat from the air surrounding the water heater. As a side benefit, the HPWH can also provide cool, dehumidified air in the space where it is installed.

A heat pump water heater developed by ORNL Buildings Technology Center researchers (from left) Randy Linkous, Van Baxter, Rick Murphy, and John Tomlinson. The high-efficiency appliance will soon be available to consumers.

The HPWH can replace a conventional 50- or 80-gallon electrical unit. "Drop in" means it can be installed by a plumber without specific training for HPWH installation. The units are expected to be available for purchase by homeowners by the end of 2001.

The installed cost is about $500 more than for a conventional water heater, but the energy savings will typically pay the difference in less than three years. The HPWH saves 5 to 10 kWh of electricity daily, depending on hot water consumption. At average electricity rates, that's the equivalent of $200 to $300 each year. Homeowners with electricity rates or hot water usage higher than the national norm will recoup their investment in less than 2 years.

The HPWH has proved durable for more than 5000 compressor cycles in laboratory tests so far—equivalent to about

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Clean Energy Future—Buildings

More than a third of the energy consumed in the United States is used to heat and cool buildings, provide services for occupants, and power appliances. The cost of those energy services (e.g., heat, lights, warm or cold food, hot water, and home entertainment) is about $240 billion per year.

The policies that drive energy savings envisioned for buildings in the *Clean Energy Future* study include standards to improve equipment and appliance efficiency, expanded voluntary programs, and stricter building codes to increase the market penetration of efficient building technologies. The advanced scenario also includes increased R&D funding and a domestic carbon trading system. These policies address the well-documented fact that technology can vastly decrease energy use while delivering the building services that occupants demand and saving consumers money.

Technological advances that improve the energy efficiency of buildings in the CEF scenarios include

- Switch-mode power supplies to reduce standby losses
- Variable speed drives for pumps and fans
- Improved building and equipment controls
- Advanced heat pump water heaters
- Small metal-halide lamps
- Thermally activated heat pumps
- Multifunction electric heat pumps that use waste heat to heat water
- Advanced glazing for windows

The moderate scenario modeled for buildings sees a 9% increase in primary energy consumption by 2010 and an 11% increase by 2020 over 1997 levels, compared with forecasted ("business-as-usual") increases of 13% and 22%, respectively. In the advanced scenario, energy use barely increases by 2010 and declines slightly from that level by 2020. In the moderate scenario, carbon dioxide emissions increase steadily over the two decades, although at a lower rate than in the business-as-usual forecast; in the advanced scenario, emissions decline steadily, falling to below 1990 levels by 2020.

Contacts: Jon Koomey, 510-486-5974, jgkoomey@lbl.gov
Andrew Nicholls, 202-646-5238, ak.nicholls@pnl.gov

ORNL's New Cooling, Heating, and Power Integration Laboratory

ORNL is testing the performance of a commercial microturbine—along with various configurations to recover and use waste heat from it—in a new Cooling, Heating, and Power (CHP) Integration Laboratory. The laboratory and the research are part of a DOE effort to encourage the use of distributed generation (DG) systems.

About two-thirds of the fuel energy used to generate electricity in power plants is wasted as discarded heat and through losses incurred in power transmission and distribution; by the time the power gets to its point of use, total efficiency can go as low as 30%. By productively using waste heat to provide heating, cooling, and humidity control in commercial and institutional buildings, DG/CHP systems can improve total (resource) efficiency levels to 70% or greater.

Four phases of testing are planned initially for the microturbine system:

- Phase 1 examined startup and shutdown capabilities and limitations of the microturbine and its load following performance. Baseline performance testing determined the variability of the microturbine's operating performance variables, such as power output, voltage, current, and heat output. Nominally, the microturbine's maximum power output and efficiency without waste heat recovery are 28.5 kW and 23%, respectively. In addition, exhaust gas backpressure tests were conducted to determine how the expected backpressure of the thermal recovery technologies will impact the performance of the microturbine.
- Phase 2 testing will include a heat exchanger for waste heat recovery. Ducting has been installed to route exhaust gas from the microturbine to the heat exchanger, as have water pipes. Water heated by the exhaust gas is piped to an indirectly fired desiccant dehumidification system to test regeneration of the desiccant wheel.
- Phase 3 will include a directly fired desiccant dehumidification system fed directly from the microturbine exhaust gas, instead of through the heat exchanger/hot water setup. In addition, the directly fired desiccant unit could be tested in series with the heat exchanger/hot water setup.
- Phase 4 will include an indirectly fired absorption chiller. Water heated by the heat exchanger will be fed to a 10-ton absorption chiller. The capacity for providing space cooling will be measured, and the effect of providing inlet air cooling from the chiller to the microturbine will be tested.

Abdi Zaltash checks equipment inside ORNL's new CHP Integration Laboratory.

These initial laboratory evaluations will focus on effective integration of current CHP thermal recovery and thermally activated cooling and humidity technologies.

Contact: Phil Fairchild, 865-574-2020, fairchildpd@ornl.gov
Sponsor: Office of Distributed Energy Resources

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7 years of use in a home. Testing to the equivalent of 10 years of real-world use (7000 cycles) continues. The HPWH is also undergoing a national field demonstration study that began this spring.

A more recent water heating invention from the BTC—the "Hot Rod"—offers the prospect of an even faster investment payback. The Hot Rod allows easy conversion of a standard electric water heater into an HPWH. It is a small packaged system containing a bayonet condenser (the hot rod) that can be inserted through the threaded fitting at the top of a conventional water tank. The Hot Rod, heated by a small, efficient heat pump, heats the water in the tank. The resistance elements are retained for backup heating in the case of heavy hot water draws. Research, development, and testing of designs for the Hot Rod concept are under way, and a design suitable for commercialization is expected to be ready by 2004.

Contact: John J. Tomlinson, 865-574-0291, tomlinsonjj@ornl.gov
Sponsor: Office of Building Research and Standards

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Marilyn Brown, Director; Mike Karnitz, Deputy Director

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Managing editors: Marilyn A. Brown and Kathi H. Vaughan
Technical editor/writer: Deborah M. Counce

Your comments are invited and should be addressed to
Penny Humphreys
Oak Ridge National Laboratory
humphreyspm@ornl.gov
865-241-4292; fax 865-576-7572

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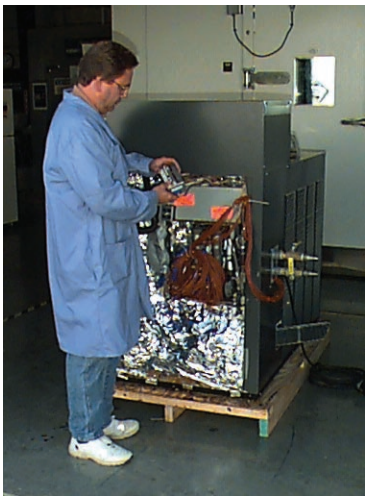
Hi-Cool promises breakthrough in natural gas heating and cooling

An advanced natural gas heat pump that uses at least a third less energy than a conventional electric unit could be available to consumers within two years. ORNL and its research partners have worked for several years to develop the technology.

The advanced heat pump uses an absorption cycle (conventional units use a compression cycle) and uses an ammonia-water mixture instead of ozone-depleting refrigerants. In tests conducted at ORNL, a prototype proved to be 33% more efficient for heating than the best existing gas furnace. That prototype used an off-the-shelf chiller fan coil. A complete absorption unit should be even more efficient.



ORNL technician Jerry Atchley works with a lab prototype of a natural gas heat pump.

The advanced ammonia-water absorption technology was developed largely at ORNL under DOE sponsorship. The Ammonia-Water Absorption Venture, a partnership of U.S. gas companies (Mississippi Energies, Southern California, Williams/Texas, Southwest, and Southern Natural) is now working with researchers and equipment manufacturers to bring the advanced heat pump to the market in large volumes. The Venture hopes to introduce high-efficiency, competitively priced units to the consumer market over the next two years.

The cooling efficiency of the advanced absorption heat pump is about the same as for a conventional electric heat pump. A more efficient cooling technology will be needed to expand the market for absorption heat pumps into warm climates. ORNL is leading a research effort to develop next-generation heat pump products (Hi-Cool absorption cycles) having at least 30% more cooling efficiency than current technologies (with a potential for even higher heating efficiency, also). The Hi-Cool cycles are also expected to work well in rooftop commercial units, where annual cooling loads are greater than for residences.

Laboratory test model of a Hi-Cool natural gas cooling system.

Hi-Cool cost-shared contracts are in place with two research companies to build prototype units using higher-efficiency cooling technologies. Testing of the prototypes is expected to begin this year; it is hoped the Hi-Cool technology can be introduced to the market in 2004–2005.

Contact: Abdi Zaltash, 865-574-4571, zaltasha@ornl.gov
Sponsor: Office of Distributed Energy Resources

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- Users can see and enter data in either “form” view (data displayed on fillable forms) or “datasheet” view (as in a spreadsheet).
- All input and output data are stored in a relational database, enabling interaction with other management or financial database tools.
- Additional base load measures can be evaluated: refrigerator and water heater replacement, water heater pipe insulation and tank wrap, and low-flow showerheads.
- Refrigerator and water heater descriptions use an extensive database of manufacturers’ models, eliminating input of detailed equipment descriptions by users.
- ASHRAE Draft Standard 152P algorithms for estimating savings from duct sealing are incorporated. NEAT accommodates three alternatives for measuring and recording duct leakage: whole house blower-door, blower-door subtraction, and duct-blower measurements.
- Individual windows can be evaluated separately for any window retrofit measure. Users can categorize the leakiness of each window to better estimate retrofit energy savings attributable to conduction and infiltration.

As part of DOE’s Weatherization Assistance Program, NEAT is free to state agencies; but other companies and individuals must pay for the software. NEAT can be obtained from the Energy Science and Technology Software Center of the Office of Scientific and Technical Information, 865 576-2606 or estsc@adonis.osti.gov. A demonstration version of the software may be downloaded from http://eber.ed.ornl.gov/pub as wa711d.zip. Unzip the file into a temporary directory and then execute setup.exe for installation. A copy of the user’s manual is included as a pdf file.

Contact: Michael B. Gettings, gettingsmb@ornl.gov
Sponsor: Office of Building Technology Assistance

Secretary Abraham stresses energy security during ORNL tour

The importance of energy security to national well-being was the message of the day for Energy Secretary Spencer Abraham's visit to ORNL in June. The Secretary toured the Buildings Technology Center and the Cooling, Heating, and Power (CHP) Integration Laboratory and received a briefing on the latest research.

Jeff Christian of ORNL's BTC discusses ORNL's research on heat pump water heaters with Dave Garman, DOE Assistant Secretary for Energy Efficiency and Renewable Energy (center), and Energy Secretary Spencer Abraham.

ORNL was the first national laboratory visited by Abraham following the release of the administration's energy policy, and he used the occasion to stress the importance of increasing energy supplies. "We must not lose sight of the link between energy security and our national and economic security," he said. "Our ability for economic growth is affected by the energy supply, as is national security."

Alluding to the research on advanced energy-efficient technologies that he observed at ORNL, Abraham stressed that although conservation is an important part of the new energy plan, energy supplies must be increased to meet increasing demand. "The problems in California are not coming East, and they won't if we carry out the President's energy plan," he said.

At the CHP Integration Laboratory, Abraham operated an advanced microturbine generator that uses the heat from exhaust gases to operate heating, dehumidification, and air-conditioning equipment.

Secretary Abraham also noted the historic and ongoing roles of the three DOE facilities at Oak Ridge. "Oak Ridge continues to set the pace of the very best science and technology," Abraham said.

Clean Energy Future—Power

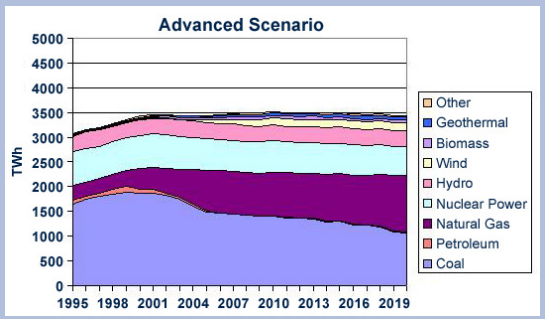
The generation, transmission, and distribution of electricity consume about 36% of the energy used in the United States. Approximately two-thirds of this electricity is produced by burning fossil fuels. About 38% of the CO_2 emissions produced yearly in the United States results from electricity production.

The policies that underlie the energy savings in this sector in the *Clean Energy Future* study include programs to increase the use of wind energy, tax credits for non-hydro renewable energy sources, increased federal support for R&D, national restructuring of the electricity industry with renewable energy portfolio standards, and net metering allowing sales of surplus power to the utility grid. The advanced scenario includes a domestic carbon trading system with a permit price of $50 per metric ton of carbon. This system will encourage generators to retire old fossil-fueled power plants and replace them with cleaner, more efficient modern plants.

Advances that drive down CO_2 emissions in the CEF scenarios include

- Combined heat and power systems
- Improved natural gas turbines
- Utility-scale fuel cells
- Longer-lived nuclear plants
- Advanced wind energy
- Biomass cofiring in coal power plants
- Geothermal energy
- Improved photovoltaic cells

The moderate scenario for electricity generation shows a 5% decline in fuel consumption by 2010 and a 20% decline by 2020 compared with the business-as-usual forecast. Total carbon emissions decline 6% and 12%, respectively, compared with business-as-usual. In the advanced scenario, fuel consumption drops by 11% in 2010 and 24% in 2020 compared with business-as-usual, and carbon emissions decline by 29% and 46%, respectively.



Projected changes in power sources in the advanced scenario.

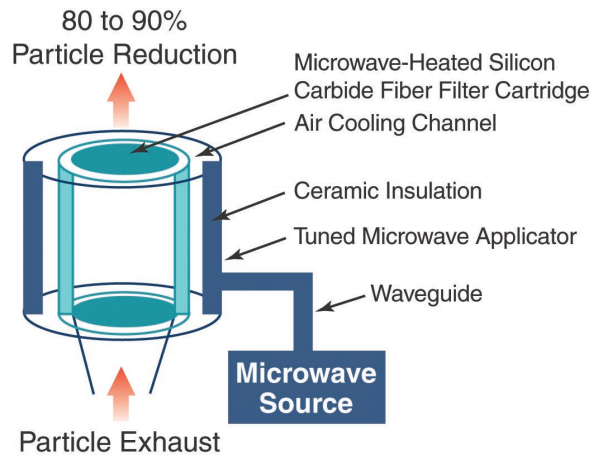
Contacts: Stan Hadley, 865-574-8018, hadleysw@ornl.gov
Walter Short, 303-384-7368, wshort@tcplink.nrel.gov

Microwave-regenerated filter destroys diesel particulates

Beginning in 2007, new diesel vehicles must meet stringent regulations for particulate emissions. (Particulates are potential carcinogens that get trapped in people's lungs.) Manufacturers are scrambling to develop exhaust treatment technologies to meet the deadline. A ceramic filter (at right) developed with the help of ORNL may provide an answer to the problem.

The large market potential—20 million vehicles a year worldwide—spurred Industrial Ceramic Solutions (ICS) in Oak Ridge, Tennessee, to develop a microwave-cleaned ceramic particulate filter system. It incorporates a patented technology that can remove and destroy the fine particulates in diesel exhaust. The filter is cleaned by using microwave power to heat a special fiber to a high enough temperature—about 600ºC—to oxidize the particles trapped on the filter. Tests demonstrate that the filter cartridge can be heated in seconds to the required temperature using less than a kilowatt of microwave power and can be regenerated while the vehicle is operating.

The microwave regeneration system is much more energy-efficient than other regeneration devices; it causes only a 0.5% fuel efficiency penalty, compared with 5% for other systems.



Three tests of an improved filter cartridge mounted on diesel engines demonstrated 90–95% removal of diesel particulates. In the tests, microwave regeneration of the filter cartridge during

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Laundered lignin produces low-cost carbon fiber

The advantages of using carbon fiber materials in automotive applications are well established, but cost and availability issues have limited their use. As a result, carbon fibers have been used mostly in high-performance products such as airplanes and sporting goods..

DOE's Automotive Lightweight Materials Program is developing new methods of producing low-cost carbon fibers from renewable and recycled materials. The ultimate goal is to cut the cost of industrial-grade carbon fiber by half and increase production capacity tenfold.

As part of that effort, ORNL is developing processes for making carbon fiber feedstock from renewable polymers and recycled plastics. Research is under way at ORNL to evaluate the feasibility of lignin, a byproduct of paper production, as a fiber source. A washing process has been developed to remove inorganic salts, which weaken the spun fiber, from lignin. In addition, coatings and additives have been incorporated to minimize the hydration of spun fibers and thus improve storage life for subsequent processing. Fibers in the desired diameter and length have been melt-spun from lignin (see illustration). Evaluation of several other promising renewable carbon fiber feedstocks is planned.

Spools of graphitized carbon fiber produced primarily from kraft-pulping lignin.

Using renewable and recycled materials as feedstocks has several advantages:

- They are available in the high volumes and low prices needed. For example, more than 30 million tons of lignin are burned each year in U.S. paper mills to produce power and recycle inorganic chemicals.
- Renewable domestic materials such as lignin and recycled plastics typically are not impacted by price swings for energy and imported petroleum.
- Use of a secure domestic feedstock could protect domestic manufacturers and help secure U.S. economic independence.
- Using carbon fibers from renewable and recycled materials would cut greenhouse gas emissions both by reducing the burning of these raw materials and by reducing the weight of vehicles, causing them to emit less pollution.

In addition to automotive applications, economical carbon fibers are an attractive material for use in much of the country's infrastructure and consumer goods.

Contact: Alicia Compere, 865-574-4970, compereal@ornl.gov
Sponsor: Office of Advanced Automotive Technologies

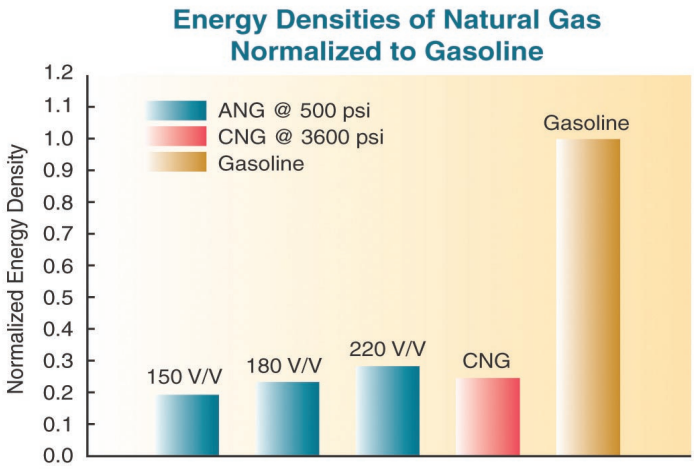
Carbon composite offers compact natural gas storage for vehicles

Natural gas is an attractive vehicle fuel because it is cleaner-burning than gasoline. Its major disadvantage is its low density: it is light and, even when compressed to >3000 psi, fills about three times more space than enough gasoline to travel the same distance. ORNL researchers are working toward technologies that will allow vehicles to carry enough natural gas for an acceptable driving range, but at a lower pressure.

Vehicles fueled by methane (the main constituent of natural gas) typically use compressed natural gas (CNG). Because CNG must be stored at a pressure of at least 3000 lb/in.^{2} (psi), CNG tanks are heavy and expensive to fill. Therefore, DOE is researching methods of storing adsorbed natural gas (ANG; i.e., gas adhered in a thin layer onto a solid surface). ANG can be stored at around 500 psi, so ANG vessels can be lighter, and the process of filling them is cheaper and safer.

ORNL has developed a porous, adsorbent carbon composite with several advantages over conventional ANG storage materials: The seamless material resists abrasion. Because its structure is a continuous carbon skeleton, it releases practically all adsorbed gas under low-voltage electrical stimulation. (Typically, 10–20% of the gas adsorbed onto a material is retained as pressure drops during discharge.) The carbon skeleton also is more thermally conductive than conventional ANG storage materials of packed carbon powders or granules. Consequently, temperature changes during filling and discharging, which interfere with both processes, are smaller.

DOE had a storage capacity target of 150 V/V (i.e., 150 standard liters of gas per liter of tank volume) at a pressure of 500 psi and a temperature of 294 K. ORNL has reached that target and expects to exceed the new target of 180 V/V this year. A capacity of 150 V/V is comparable to that of the best commercially available materials. At 180 V/V, ANG would provide about 25 to 35% of the driving range of a gasoline tank of an equivalent size.



Compressed natural gas energy density, estimated on the basis of the external volume envelope of the tank.

Contact: Tim Burchell, 865-576-8595, burchelltd@ornl.gov
Sponsor: Heavy Vehicle Technologies Program

Clean Energy Future—Transportation

The transportation sector of the economy accounts for about 27% of the energy used in the United States and, perhaps more important, about 66% of the oil consumed. It also produces substantial amounts of air pollution and a third of U.S. carbon emissions.

Policies that underlie the energy savings projected in the *Clean Energy Future* study include increased federal R&D funding; voluntary energy efficiency targets for light-duty vehicles, freight trucks, and aircraft; "pay-at-the-pump" auto insurance; and a domestic carbon trading system. The advanced scenario also includes improved air traffic management; intelligent traffic system controls; tax credits for buying efficient vehicles; and promotion of cellulosic ethanol production.

Technological advances that result in cleaner, more efficient transportation in the CEF scenarios include

- Direct-injection gasoline and diesel engines
- Blending of cellulosic ethanol with gasoline
- Hybrid electric drivetrains
- Fuel cell vehicles
- Lightweight materials
- Blended wing body passenger aircraft

In the business-as-usual scenario, energy used for transportation increases by some 32% by 2010 and 47% by 2020; carbon emissions increase at the same pace. The moderate scenario cuts the forecasted transportation energy use by 3% in 2010 and 7% in 2020, and carbon emission reductions are comparable. The advanced scenario cuts the forecasted energy use by 10% in 2010 and 21% in 2020, and carbon emissions are reduced by 11% and 23%, respectively.

The CEF results show that transportation use and greenhouse gas emissions will continue to grow at a rapid rate without substantive policy changes. Only in the advanced scenario, where policies focus on both developing technology and influencing markets, does growth in energy use and greenhouse gas emissions slow markedly.

Contacts: David Greene, 865-946-1310, dlgreene@ornl.gov
Steve Plotkin, 202-488-2403, splotkin@anl.gov

Delphi and ORNL celebrate success of nickel aluminide

Delphi Corporation in Saginaw, Michigan, is so pleased with the performance of its nickel aluminide furnace fixtures that it threw a party to celebrate. Delphi sponsored a "success event" in April that included a news conference to publicize the successful development, manufacture, and commercial use of the high-performance alloy.

ORNL researchers Peter Angelini (left) and Vinod Sikka (second from right) with Delphi Corporation executives and DOE officials at the celebration at the company's Saginaw plant.

Delphi announced that it is making Ni_3Al fixtures standard in its facilities worldwide and is in the process of casting and installing hundreds of Ni_3Al assemblies to replace other fixtures in its carburizing furnaces.

Delphi, ORNL, and DOE's Office of Industrial Technologies have worked together on Ni_3Al fixtures since an initial cooperative research and development agreement was signed in 1992. ORNL researchers invented the alloy as part of an effort to develop heat-resistant materials. The alloy has a highly ordered structure that results in its becoming stronger as it is heated to 900°C.

Delphi engineers worked with ORNL to apply the material in Delphi's heat-treatment furnaces, replacing steel rack assemblies that fail in high heat. The assemblies hold automotive parts to be heat-treated and consist of trays, support posts, and fixtures. Together, Delphi and ORNL developed an Ni_3Al fixture casting process, modified the alloy to optimize its manufacturability and performance under typical heat-treating furnace operating conditions, and tested and evaluated prototype parts.

The Ni_3Al fixtures last from three to five times longer than current high-performance steel alloys and are at least three times stronger at operating temperatures. These properties enable improved energy and production efficiencies. The use of Ni_3Al fixtures enabled Delphi to meet its production goals at its Saginaw plant by building only two new furnaces instead of the three that would have been required with fixtures of conventional materials.

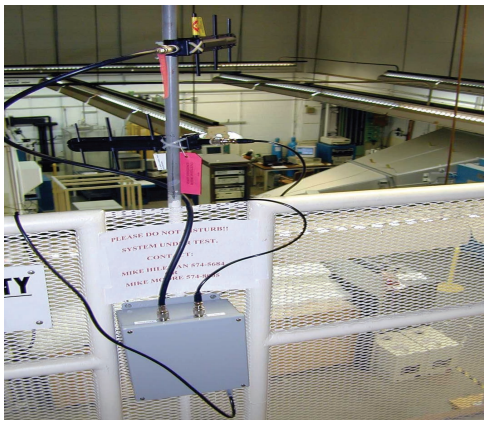
Contact: Peter Angelini, 865-574-4565, angelinip@ornl.gov, or Vinod Sikka, 865-574-5112, sikkavk@ornl.gov
Sponsor: Industrial Materials for the Future Program

Remote sensing—the next best thing to being there

A team from ORNL has successfully demonstrated robust industrial wireless communication at a South Carolina paper mill. The team from ORNL's Instrumentation and Controls Division installed and verified the operation of three ORNL-developed devices.

Managers at the Bowater Paper Mill in Catawba, South Carolina, were concerned because a vendor-supplied wireless voice communication system demonstrated there previously had shut down their facility. However, the ORNL system, designed to function at 0.01% of the power density of most commercial systems, operated without adverse effects.

With little or no operator intervention, the system recorded readings from commercial sensors at distances of from 3 to 140 feet. A 4–20 milliamp pressure sensor transmitted finger pressure while a 0–5 V temperature sensor simultaneously transmitted air temperature from another location. The network communicated sensor readings over a radio link that uses the latest direct-sequence, spread spectrum technology with code division, multiple access protocol using data structures based on the IEEE 1451 smart sensor standard. A laptop tied to the network maintained a real-time display of the readings. The spectrum analyzer showed substantial background electromagnetic inference, indicating the demanding plant environment.



Radio frequency experimental set-up at ORNL. The apparatus sporting the white "X" (top center) sends signals to a transceiver, which communicates with a computer that provides system control and output display.

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ORNL, Vortek partnership sheds light on surface processing

The most powerful lamp in the world has found a new home at ORNL and a new mission—helping manufacturers improve their processes for fusing coatings to lightweight materials.

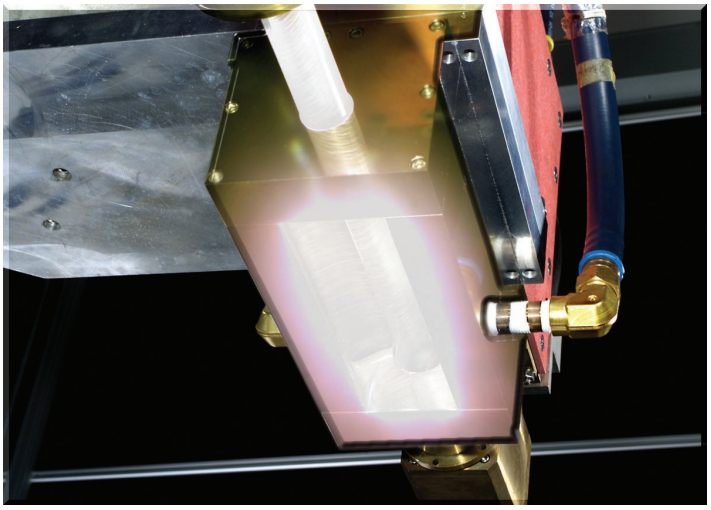
The 300,000-watt radiant plasma source, manufactured by Vortek Industries Ltd. of Canada, is now available for use by manufacturers in ORNL's Plasma Infrared Processing Center through a memorandum of understanding between ORNL and Vortek.

The lamp, which converts electricity into radiant energy, was developed to light large areas such as football stadiums. However, ORNL's Craig Blue discovered it is also a great tool for fusing wear-resistant coatings to aluminum and other alloys. It can be used for coating applications ranging from auto and heavy equipment parts to the insides of large-caliber gun barrels. It may also be used to apply the skin to parts of aircraft and the space shuttle.

The lamp installation at ORNL includes several adaptations to make better use of its power for materials processing: PC-based control of the lamp and robotics, laser positioning, atmosphere control systems, water window protection of the lamp, 3-dimensional mapping, data acquisition systems, PC-based part rotation systems and optical temperature measurement systems. The changes enable users to process materials in a controlled manner while gathering data useful for industrial applications.

"We're concentrating on working with industrial partners who have very specific needs," Blue said. "The relationship can be for a one-time project or we can set up a cooperative research and development agreement that would be more long term."

While lightweight alloys are critical to reducing the weight of, for example, automobiles, they lack the durability needed for long life. Coating them with very thin coatings of nickel (or copper) and tungsten carbide preserves the advantages of light weight without sacrificing longevity. The radiant plasma source enables quicker processing with better results. It produces the same power density as high-powered industrial lasers but over a much larger area. Blue likens using the lamp to painting with a roller instead of a brush. "We can treat an area 35 centimeters wide with one pass instead of the industry standard of 3 millimeters."



This 300,000-watt plasma lamp in ORNL's Plasma Infrared Processing Center is used to fuse coatings to lightweight metals and alloys.

With the Vortek plasma lamp and ORNL's materials expertise, coatings can be applied 10 times faster than with conventional techniques with no degradation of the wear-resistant coating. The lamp also uses less energy than conventional coating processes.

Contact: Craig Blue, 865-574-4351, blueca@ornl.gov
Sponsor: Office of Industrial Technology Implementation C

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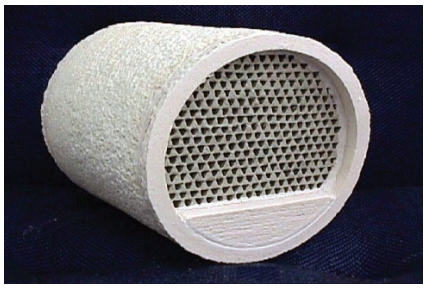
engine idling returned the filter to 95–100% of the exhaust flow capacity of a new filter. These results indicate that the technology can comply with the Environmental Protection Agency 2007 Tier II Particulate Matter Standards for diesel particulates.



Particulate filter

During early stages of the development, ORNL worked with the inventor to deposit and test various silicon carbide coatings, measure the interaction of the filter material with microwaves, and fabricate the initial filters. ORNL's technical support and assistance helped move the invention from the idea stage to testing of a commercial prototype in on-road diesel vehicles. Successful results in the prototype tests will move this technology into everyday use on future diesel automobiles and trucks.

Potential uses of the microwave-regenerated particulate filter are not limited to diesel engines. Other applications may include restaurants, industrial processes, and medical surgical operations.

Contact: Dave Stinton, stintondp@ornl.gov, 865-574-4556
Sponsor: Office of Advanced Automotive Technologies, Office of Heavy Vehicle Technologies

Best Practices point industry toward energy savings

The Office of Industrial Technologies Best Practices Program has awarded grants to 13 industrial plants during the past 18 months for plantwide assessments to evaluate their processes and improve energy efficiency. So far, the cost savings opportunities identified in the assessments average more than $1 million per plant annually, and the projected payback periods are usually less than 18 months.

ORNL provides technical assistance to the Best Practices Program for OIT by selecting the sites for assessments, monitoring their performance, and publishing the results. Best Practices helps participants in the Industries of the Future (IOF) program use energy more efficiently, reduce waste, and increase productivity. Technical assistance includes a continuum of services from energy assessments, to information on industrial equipment and systems, to resources for measuring the effectiveness of new technologies.

Daryl Cox of ORNL takes a flow reading on a plant pumping system using an ultrasonic flow meter. The ORNL engineer provides technical assistance to help industries identify energy-saving opportunities.

Facilities chosen for the assessments have expressed an interest in identifying projects that demonstrate the benefits of a system-wide approach. An assessment usually proceeds in two phases: (1) profiling energy consumption at a site to identify projects that offer the most conservation potential and (2) assessing specific actions in each high-potential area.

One of the goals of the plantwide energy assessments is to establish a database that can be used to assess and disseminate energy-efficiency technologies among IOF member industries. Lessons learned from the assessments and resulting projects will be used to conduct similar projects at other plants.

Five plants have completed their assessments and are implementing the recommended projects. Eight others will complete their assessments during 2001. Selection of a third round of grant recipients is in progress.

Contact: Mitch Olszewski, 865-946-1350, olszewskim@ornl.gov
Sponsor: Office of Industrial Technology Implementation A

Clean Energy Future—Industry

The industrial sector consumes around 37% of the primary energy used in the United States. The *Clean Energy Future* study indicates the energy intensity of this sector (amount of energy required to produce a product) can be dramatically decreased. This diverse, complex group of energy users includes agriculture, mining, construction, energy-intensive industries, and non-energy-intensive manufacturing.

The policy pathways to industrial energy savings modeled in the *Clean Energy Future* study include voluntary agreements between government agencies and industry groups to achieve defined energy and emissions reduction goals, in combination with supportive government programs. Measures to improve the implementation and expand the penetration of combined heat and power (CHP) systems also are included.

Technological advances that drive down energy intensities in the CEF scenarios include

- Near-net-shape and thin-slab steel casting
- Black liquor gasification
- Extended nip press for paper drying
- Pre-heater, pre-calciner kilns for cement manufacturing
- CHP systems with aero-derivative gas turbines
- Improved motor and drive systems

Substantial energy savings result from both the moderate and advanced scenarios of the study. Under the business-as-usual scenario, industrial energy consumption grows to about 41 quads in 2020. This growth is reduced by 7% to 38 quads in a moderate scenario and by 17% to 34 quads in an advanced scenario. In 2020, industrial carbon emissions are projected to be 10% lower in the moderate and 29% lower in the advanced scenario relative to the business-as-usual forecast.

Contacts: Ernst Worrell, 510-486-6794, eworrell@lbl.gov
Lynn Price, 510-486-6519, lkprice@lbl.gov

News Briefs

David named MMMS fellow

Stan David of ORNL's Metals and Ceramics Division has earned a 2001 Fellow award from the Minerals, Metals, and Materials Society. David directs ORNL's Basic Energy Welding Sciences Program.

ORNL EE/RE projects receive awards

Three projects funded through ORNL's EE/RE Program have received 2001 Excellence in Technology Transfer awards from the Federal Laboratory Consortium: the RABiTS substrate, used to make a base material for superconducting wire production; graphite foam, a lightweight carbon foam with superior heat transfer qualities; and the polymer boot heater, a rapid infrared heating device that reduces repetitive motion injuries on vehicle assembly lines.

Mariappan Paranthaman of ORNL's High-Temperature Superconductivity program was one of several ORNL staff participating in "Real Science for the Real World: An Environmental Symposium for 8th-Grade Students."

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The devices are being developed for ORNL's "wireless test bed" that will be used for R&D on protocols, formats, and error correction mechanisms that might be appropriate for the harsh industrial environments represented in DOE's Industries of the Future program. This first demonstration, highlighted in *Sensors Magazine*, resulted in contacts from industries volunteering as the next test site for the system. Additional work is being considered to extend the range and raise throughput without increasing power demand, examine options for distributed intelligence to reduce bandwidth, and reduce the footprint and power requirements.

Contact: Wayne Manges, 865-574-8529, mangesww@ornl.gov
Sponsor: Sensors and Controls Crosscut Program

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