Sustainable Transportation Program
Update

Oak Ridge National Laboratory
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

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Boosting the battery industry

Future automotive batteries could cost less and pack more power because of ORNL's new Battery Manufacturing Facility. Co-located with the National Transportation Research Center and Manufacturing Demonstration Facility off Hardin Valley Road, the $3 million DOE facility allows for collaboration with industry and other national labs while protecting intellectual property of industrial partners. The laboratory is attracting battery manufacturers, chemical and materials suppliers, system integrators, and original equipment manufacturers.

"We're able to integrate advanced material components into a complete battery, analyze how it performs, and better understand how to improve it," said Claus Daniel, deputy director of ORNL's Sustainable Transportation Program. "With this capability, we can isolate and evaluate a material or process and quantify any advantage that each would provide."

Through the nation's largest open access battery manufacturing R&D facility, American businesses could gain a competitive advantage in the global market.

"R&D facilities such as these are critical in the development of advanced battery technology that is more affordable and more durable than today's batteries," said Patrick Davis, program manager of DOE's Vehicle Technologies Program.

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Research Support Technician Brad Brown places electrodes into the fully-automatic stacking machine inside the new Battery Manufacturing Facility.

ORNL hosts United States Council for Automotive Research

Special thanks to everyone involved in planning and hosting representatives of the United States Council for Automotive Research in June. The group was accompanied by representatives from the DOE Vehicle Technologies Program: Patrick Davis, Program Manager; Christy Cooper, US DRIVE Partnership Director; and Yury Kalish, Partnership Support. Also accompanying the group were DOE Hydrogen and Fuel Cells Program Manager Sunita Satyapal and Deputy Program Manager Rick Farmer. During the two-day whirlwind visit, ORNL researchers led by Sustainable Transportation Program Director Ron Graves provided tours and overviews of transportation-related research including vehicle technologies, materials, manufacturing, carbon fiber, supercomputing, biosciences, and neutron sciences.

Power Electronics and Electric Machinery Research Group's John M. Miller, far left, briefs USCAR and DOE guests on ORNL's wireless power transfer technology.

In a letter sent to Laboratory Director Thom Mason following the USCAR visit, DOE representatives noted, "The feedback we have received from our partners has been excellent. They uniformly expressed their satisfaction with the visit (noted as one of the best laboratory visits to date), as well as their great respect and appreciation for the breadth and depth of work performed at your facility. We are confident that the automotive industry's understanding of your laboratory's capabilities will lead to broader and closer cooperation between the OEMs (original equipment manufacturers) and ORNL."

Driving the speed limit makes cents

According to new information on fueleconomy.gov, gas mileage usually decreases rapidly at speeds above 50 miles per hour. The bottom line–one can assume that each 5 miles per hour you drive over 50 is like paying an additional $0.26 per gallon for gas.

To generate the new information, Fuels, Engines, and Emissions Research Center's John Thomas, Shean Huff, and Brian West quantified vehicle fuel economy for a range of highway cruising speeds. Using 67 vehicles, the research included data for 51 vehicles from an original equipment manufacturer partner and data for 16 vehicles collected at the FEERC vehicle research laboratory. The work is ongoing and will result in further fueleconomy.gov updates and more detailed website information in the future. Fueleconomy.gov is managed by the Center for Transportation Analysis.

ARPA-E project aims to accelerate vehicle electrification

The future of America's energy security is tightly coupled to the advancement of electric and hybrid vehicle technologies. Efficiencies in the traction drive and charging systems are critical parameters for researchers and designers who are creating these next-generation vehicles, and cost and reliability remain vital parameters, especially to consumers.

With long track records for successfully developing highly integrated, low-power electronics in a number of semiconductor processes, research engineers in the Power Electronics and Electric Machinery Research Group and the Measurement Science and Systems Engineering Division are addressing the traction drive and charging system challenges through new research funded through ARPA-E, DOE's Advanced Research Projects Agency–Energy.

Working in collaboration with Toyota USA, Arkansas Power Electronics Center, the University of Arkansas, and CREE, Inc., PEEMRG's Laura Marlino and MSSED's Chuck Britton, Nance Ericson, and Shane Frank are integrating gate drivers into the same substrate as the power transistors using Cree's silicon carbide (SiC) power electronic semiconductor process. Although risks to successful implementation exist, the outcome of this work has the potential to revolutionize power electronics for electric and hybrid electric vehicles by reducing overall part count and the need for ancillary systems, increasing overall efficiency and reliability.

So far the ORNL team has been successful in implementing, for the first time, gate drivers in the SiC process. These gate drivers are currently undergoing in-lab testing, and the results are promising. In August researchers will attempt to integrate the isolation architecture and the gate drivers onto one substrate. The final step, projected to occur in the spring of 2013, will be to integrate the isolation architecture, gate drivers, and power transistors onto a single SiC substrate configured to function as a bidirectional charging system, which will be tested later in a plug-in hybrid electric vehicle.

Boosting the battery industry...continued from p.1

The facility features two chambers totaling 1,400 square feet of space along with state-of-the-art battery manufacturing equipment. One chamber allows researchers to maintain relative humidity levels of between 0.5 and 15 percent. This room houses equipment that allows for mixing of various slurries, stabilization, coating, and drying.

The second chamber provides a dew point of minus-40 degrees Celsius, which translates to a relative humidity of 0.5 percent. This is necessary to prevent moisture from entering and degrading battery cells. In this chamber, electrodes, cathodes, and anodes are assembled automatically into pouches that are filled with a precise amount of electrolyte. The pouches are then trimmed and sealed through a heating and vacuum process.

Researchers can make batteries with up to 7 ampere-hours capacity, a size that provides good demonstration capability but requires less material, reducing the burden on smaller companies that lack large-scale production capacity.

Working with others, Daniel looks forward to many successes.

"ORNL's combination of equipment and expertise allows collaborators to develop and optimize processes, manufacturing schemes, perform diagnostics, and maximize yield," Daniel said. "Working with industry, we're advancing the field and moving closer to creating a battery that will allow automobiles to travel longer distances on a single charge."

ORNL has a dozen contracts with eight battery-related companies in their quest to compete in a global marketplace. Funding for this project was provided by DOE's Office of Energy Efficiency and Renewable Energy.

Dow team including ORNL receives $9 million for carbon fiber R&D

ORNL is a member of a team led by Dow Chemical that was recently awarded $9 million to pursue development of a low-cost carbon fiber production process. Under the award from the DOE EERE Advanced Manufacturing Office, Dow, ORNL, and Ford Motor Company will scale up current R&D efforts on polyolefin feedstock in ORNL's Carbon Fiber Technology Facility to demonstrate commercial viability for automotive composite components. Dow and Ford are providing in-kind cost sharing, and Michigan Economic Development Corporation is also providing funding for the $13.5 million project.

Carbon fiber already has a number of commercial applications such as vehicle bodies, wind turbines, and other industrial uses and would be more widely used if costs for the material could be reduced.

Polyolefins offer a low-cost alternative to the more expensive polyacrylonitrile (PAN) feedstock that accounts for about 90% of today's carbon fiber. The materials and process being pursued under this award have the potential to reduce carbon fiber production costs by 20% and to reduce the total CO_2 emitted in the manufacturing process by 50% by dramatically cutting the amount of energy required. The higher chemical yield of the polyolefin-based process is a large factor in the energy efficiency advantage: about 1.4 lb of polyolefin is needed to produce 1 lb of carbon fiber, versus 2 lb of PAN for the same yield.

The effort is one of 13 advanced manufacturing projects across the United States that were awarded $54 million in DOE funding. The projects are part of a strategy for promoting emerging technologies that create domestic manufacturing jobs and enhance the competitiveness of US companies in global markets while improving energy efficiency, reducing pollution, and boosting industrial productivity. ORNL is home to the Carbon Fiber Technology Facility, an advanced carbon fiber scale-up facility for developing and demonstrating low-cost manufacturing processes that can be transferred to industry.

Fully carbonized fiber exiting the microwave-assisted plasma carbonization unit.

ORNL to partner in ARPA-E natural gas vehicle technology project

Project lead United Technologies Research Center, along with ORNL and other partners, has been awarded an estimated $4,400,000 to engineer a low-cost natural gas tank for light-duty vehicles using modular designs and construction materials including low-cost carbon fiber. The goal is to allow tanks to be manufactured into shapes that easily fit into the tight spaces of light duty vehicles, replacing today's bulky storage tanks at a lower cost and without sacrificing driving range.

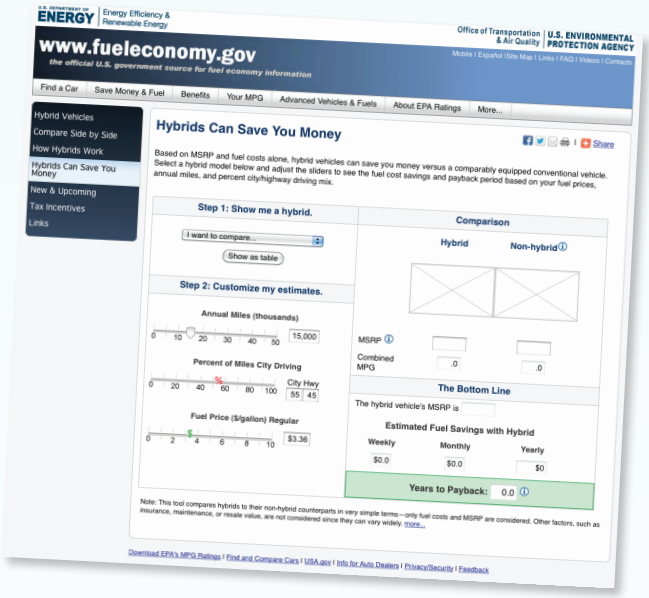
The project is among 13 new cutting-edge research projects that will receive a total of $30 million to find new ways of harnessing America's abundant natural gas supplies for cars and trucks and expand the use of natural gas as a vehicle fuel. Through its Advanced Research Projects Agency–Energy (ARPA-E), DOE's new Methane Opportunities for Vehicular Energy (MOVE) program aims to engineer light-weight, affordable natural gas tanks for vehicles and develop natural gas compressors that can efficiently fuel a natural gas vehicle at home.

"These innovative projects will leverage the ingenuity of US scientists, engineers, and entrepreneurs to develop breakthrough technologies to fuel cars with natural gas," said Deputy Secretary Poneman. "These projects could transform America's energy infrastructure and economy by utilizing domestic energy sources to power our vehicles, reducing our reliance on imported oil, and increasing American energy security."

Today's natural gas vehicle technologies require tanks that can withstand high pressures, are often cumbersome, and are either too large or too expensive to be suitable for smaller passenger vehicles. ARPA-E's new projects are focused on removing these barriers, which will help encourage the widespread use of natural gas cars and trucks.

Consumer tool compares hybrid and conventional vehicles

The fueleconomy.gov website, managed by the Center for Transportation Analysis, launched a new calculator that allows users to easily compare hybrid vehicle models against comparably-equipped conventional vehicle models. Users select a hybrid model from a drop down menu and then adjust sliders to customize annual miles, percent city and highway, and fuel prices. As the sliders are adjusted, fuel savings and years to payback (when fuel savings equal the manufacturer's suggested retail price difference) are instantly calculated. The calculator has received positive reviews and media coverage.



Do you have news or information you would like to share?

Please submit to Kathy Graham,
ORNL Sustainable Transportation Program Office
865-946-1861 or grahamkj@ornl.gov

Employee Excellence

John Hsu

- John Hsu has been selected to receive the 2012 Cyril Veinott Electromechanical Energy Conversion Award, presented by the Institute of Electrical and Electronics Engineers (IEEE) Power and Energy Society. John is a distinguished engineer and lead scientist for the Power Electronics and Electric Machinery Research Group. An ORNL employee since 1992, John presently focuses on motor and inverter technologies for electric vehicles, including one of his ongoing pioneer works, the brushless non-permanent magnet motor. In contrast to the permanent-magnet synchronous motor that requires costly rare-earth materials, the brushless non-permanent magnet motor concept generates magnetic flux in the stator that is injected into the rotor. The prototype motor built according to this concept has successfully passed validation tests, and ongoing improvements are in progress. A UT-Battelle Distinguished Inventor, John holds 48 US patents. He is the author and co-author of more than 100 technical publications and is a Fellow of the Institution of Engineering and Technology.

- Materials Science and Technology Division's Felix Paulauskas received a 2012 DOE Vehicle Technologies Program R&D Award during the DOE Vehicle and Fuel Cell Technologies Annual Merit Review in May in recognition of his significant contribution to plasma oxidation of carbon fiber as an enabler to reduce the cost of this advanced material. Felix, left, accepts the award from Patrick Davis, program manager of DOE's Vehicle Technologies Program.

- ORNL interns visited Volkswagen Chattanooga as part of the Volkswagen Distinguished Scholars Program, an enhanced internship for undergraduate and graduate students studying scientific and technical fields. Sponsored by the manufacturer, the program selects students from Volkswagen's Partners in Education group of Tennessee universities to participate in research projects geared toward manufacturing, engineering, and transportation science. Several ORNL researchers, including Fuels, Engines, and Emissions Research Center's John Thomas, third from right, serve as mentors to the students during their internships and accompanied the students on the tours.

- Special thanks to Materials Science and Technology Division's David Wood and staff for hosting the United States Council for Automotive Research Hydrogen Storage Tech Team meeting, a two-day visit that included various facility tours and overviews of ORNL's hydrogen and fuel cell research and development portfolio.

- Fuels, Engines, and Emissions Research Center's Andreas Malikopoulos has been named an Associate of the American Society of Mechanical Engineers (ASME) Internal Combustion Engine Division.

- The American Welding Society (AWS) has elected the Materials Science and Technology Division's Zhili Feng to its 2012 Class of Fellows. Zhili leads the Materials Joining Group. The AWS recognized his outstanding contributions in several important areas such as computational welding mechanics, friction-stir welding and processing, characterization of weld by advanced neutron and synchrotron scattering, and novel solid-state joining processes of dissimilar metals. He has published more than 120 journal publications and conference proceedings, and holds 3 US patents. Zhili will be inducted at the AWS annual business meeting in November.

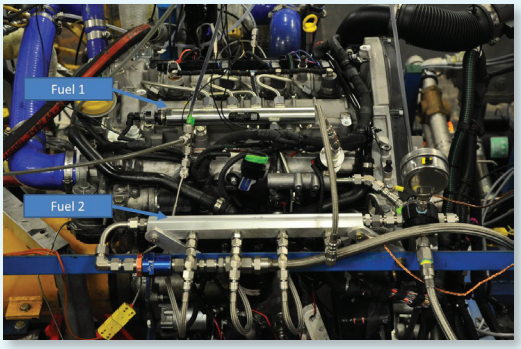
Zhili Feng

- Fuels, Engines, and Emissions Research Center's Robert Wagner was invited to be an Associate Editor of the *Society of Automotive Engineers International Journal of Engines*. This journal includes peer-reviewed and authoritative papers on in-depth work in engine research. Topics span low temperature combustion, conventional gasoline and diesel combustion, controls, sensors, fuel economy, etc. Robert also serves on the editorial board of the *International Journal of Engine Research.*

Robert Wagner

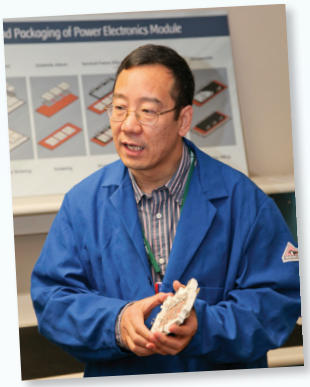
- Diane Davidson, Center for Transportation Analysis, presented "Making it (Tele)Work at Oak Ridge National Laboratory" on June 19. Telework is a sustainable workplace strategy that could reduce ORNL's carbon footprint. Diane described the potential benefits of telework and explained ORNL's current telework policy and procedures.

Diane Davidson



- Fuels, Engines, and Emissions Research Center's Scott Curran, Robert Wagner, and University of Wisconsin student Reed Hanson published the paper "Reactivity Controlled Compression Ignition on a Multi-Cylinder Light-Duty Diesel Engine" in the *International Journal of Engine Research* special issue on fuel efficiency. The paper investigated reactivity controlled compression ignition (RCCI) operation with gasoline and diesel fuels on a light-duty diesel engine with the stock diesel pistons. Significant findings from this paper include a new understanding of the robustness of the RCCI approach on multi-cylinder engines. Pictured above, the RCCI engine uses two fuels such as diesel (Fuel 1) and gasoline (Fuel 2) to tailor the fuel reactivity for the engine speed and load.

- Congratulations to Power Electronics and Electric Machinery Research Group's Zhenxian Liang, whose tutorial "Power Module Packaging: A Multidisciplinary Integration Approach" has been accepted by the Institute of Electrical and Electronics Engineers Energy Conversion Congress and Exposition committee and will be presented at the event in Raleigh, North Carolina this September.



Zhenxian Liang

- David Greene, Center for Transportation Analysis, has accepted an appointment to the Transportation Research Board of the National Academies' Special Task Force on Climate Change and Energy, A0020T. The term is for 3 years beginning April 15, 2012.