TransForum

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News from Argonne's Transportation Technology R&D Center
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On the cover
Argonne engineer Henning Lohse-Busch uses a thermal camera to check temperatures during "hot" testing in the new Environmental Test Cell.

Shown here
Lohse-Busch (left) and Eric Rask discuss the results of a dynamometer test in Argonne's Advanced Powertrain Research Facility (APRF). The APRF's new Environmental Test Cell is examined in this issue of TransForum (see story on page 4).

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Research Reviews


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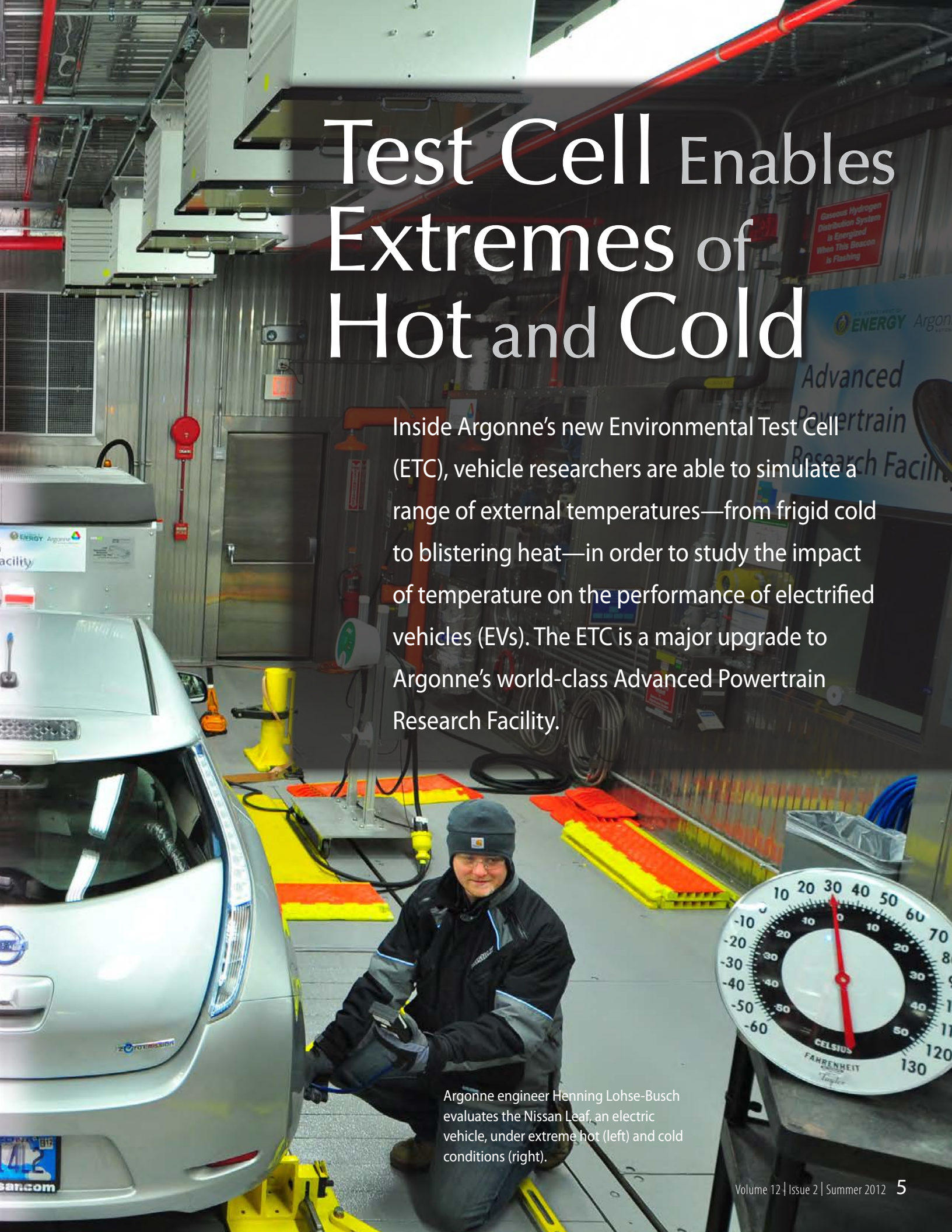
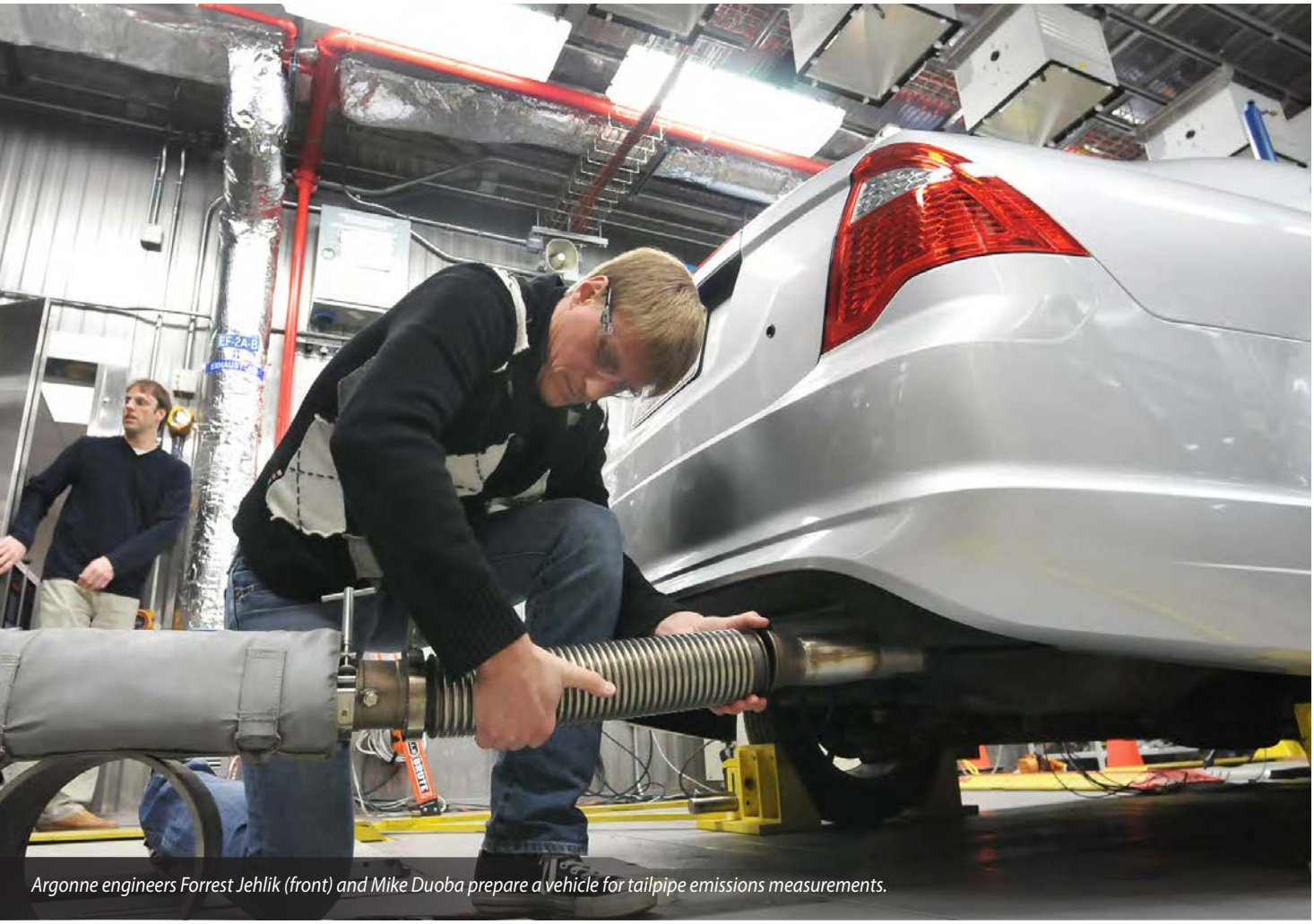
Test Cell Enables Extremes of Hot and Cold

Inside Argonne's new Environmental Test Cell (ETC), vehicle researchers are able to simulate a range of external temperatures—from frigid cold to blistering heat—in order to study the impact of temperature on the performance of electrified vehicles (EVs). The ETC is a major upgrade to Argonne's world-class Advanced Powertrain Research Facility.



Argonne engineer Henning Lohse-Busch evaluates the Nissan Leaf, an electric vehicle, under extreme hot (left) and cold conditions (right).

NEW ARGONNE ENVIRONMENTAL TEST CELL



Argonne engineers Forrest Jehlik (front) and Mike Duoba prepare a vehicle for tailpipe emissions measurements.

It may feel like winter in Argonne's Environmental Test Cell (ETC), but it's actually July. Researchers have cranked the temperature down below freezing to test how an electric vehicle performs in the extreme cold.

The ETC can perform the new U.S. EPA 5-Cycle fuel economy certification test.

The ETC, an upgrade to Argonne's Advanced Powertrain Research Facility, allows vehicles to be tested at a temperature range between 20°F to 95°F under simulated sunshine. Previously, Argonne researchers were only able to test from 72°F to 95°F without a solar load.

Argonne researchers Dave Shimcoski (left) and Ann Schlenker measure the electrical charge of a hybrid vehicle in the new Environmental Test Cell.

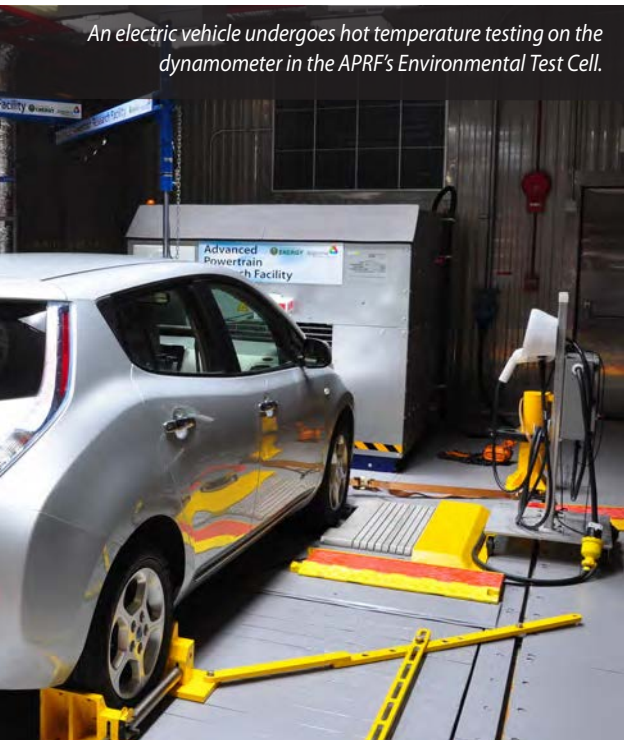
"Having the capability to subject electric vehicles to extremes of cold and heat gives us new insight on the weaknesses of battery-powered vehicles," said Vehicle Testing Team Leader Glenn Keller. "The data collected from the ETC will provide clues on how to improve the performance of EVs across all regions of the country."

In addition, in the upgraded test cell researchers can now perform the new U.S. EPA 5-Cycle fuel economy certification test (used to calculate the fuel economy numbers posted on the window sticker of every new car).

With the addition of the ETC, Argonne's already world-renowned electric-vehicle research program takes a significant leap forward. Researchers can now

- Study hot and cold effects on powertrain components and their influence on vehicle-level control, and
- Investigate vehicle accessory use, such as air conditioning, and the impacts on EV energy consumption.

The upgrade included a two-story building addition, refrigeration equipment and the utilities required to maintain 20°F in the test chamber even during a summer heat wave and a full solar spectrum array system mounted to the ceiling of the test chamber. The array is used during hot testing sessions (95°F) to replicate sun loading on a vehicle's air conditioning system, enabling accurate measurement of the energy consumed in cooling the car's interior. A large air blower unit, which can be regulated to match vehicle speed, was also added to simulate air movement across the vehicle as if it is being driven on the road.



An electric vehicle undergoes hot temperature testing on the dynamometer in the APRF's Environmental Test Cell.

The ETC is funded by the U.S. Department of Energy's (DOE's) Vehicle Technologies Program and is the only DOE vehicle R&D facility of its kind.

For more information, contact Glenn Keller, gkeller@anl.gov

Advanced Powertrain Research Facility webpage:
http://www.transportation.anl.gov/facilities/aprf.html

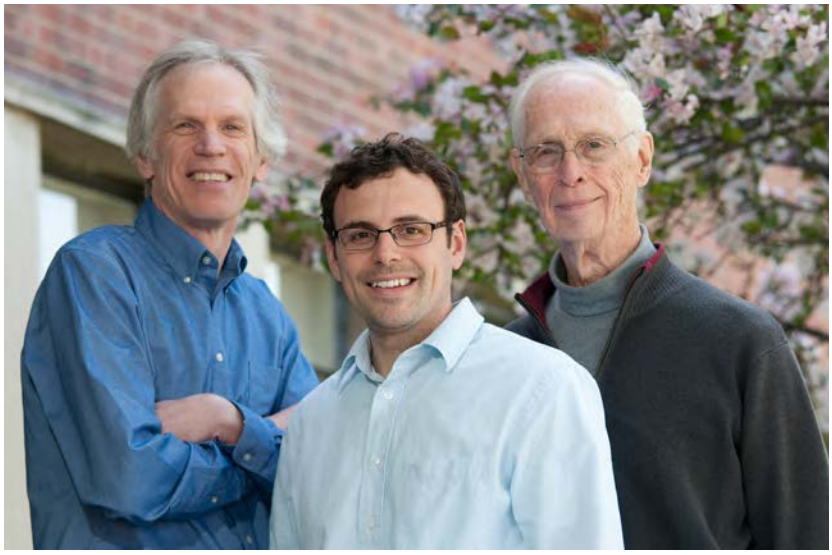
BatPaC: A Lithium-ion Battery Performance and Cost Model for Electric-drive Vehicles

BatPaC is a one-of-a-kind, free public domain model designed for policymakers and researchers who are interested in estimating the cost of lithium-ion batteries after they have reached a mature state of development and are being manufactured at high volumes. The model captures the interplay between the design and cost of these batteries for transportation applications.

"For the first time, researchers anywhere in the world can translate their materials discoveries to real-world battery dimensions and cost. A test on a sample the size of a penny can now tell you how much cheaper or smaller it would make the battery in a Chevrolet Volt. This tool should help researchers find the fastest and most effective pathways to building a better battery," said BatPaC creator and Argonne chemical engineer Kevin Gallagher.

The model was publicly and privately peer-reviewed by experts in the field and was selected as the cost model of choice by the U.S. Environmental Protection Agency (EPA). The EPA is using BatPaC in its rule-making process for reducing greenhouse gas emissions and improving fuel economy in light-duty vehicles.

Argonne's BatPaC, a battery performance and cost model, projects bench-scale battery research results to real-world battery pack values.



BatPaC developers from left to right: Ira Bloom, Kevin Gallagher and Paul Nelson.

BatPaC examines the trade-offs that result from different user requirements such as power (vehicle acceleration) and energy (vehicle electric range). Furthermore, the choice of a specific Li-ion chemistry may have a significant influence on the ultimate battery cost, weight and volume. BatPaC calculates these pack-level quantities by adding together all of the various components that are designed to meet user-defined specifications.

Using BatPaC, researchers can simulate and design Li-ion batteries to predict:

- Precise battery mass and dimensions,
- Cost and performance characteristics, and
- Battery pack values from bench-scale results.

BatPaC builds on decades of battery design work at Argonne, notably at the hands of researcher Paul Nelson. While BatPaC is still based in Microsoft Office Excel, Argonne researcher Ira Bloom has created BatPro (Battery Production Cost), a hard-coded, Windows-based software package with a user-friendly environment for design and cost modeling.

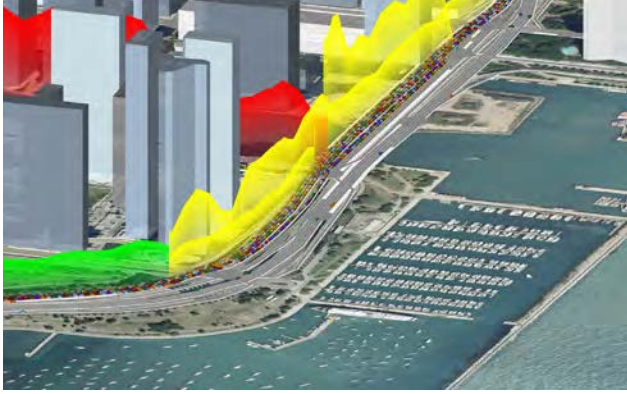
BatPaC is free. To download and use BatPaC, visit http://www.cse.anl.gov/BatPaC. BatPro is available for a nominal fee from the Argonne Software Shop at http://web.anl.gov/techtransfer/Software_Shop/index.html.

This work was funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Program under David Howell.

For more information, contact Kevin Gallagher, kevin.gallagher@anl.gov

BatPaC website:
http://www.cse.anl.gov/BATPAC

Simulating an Emergency City Evacuation



In this example of RTSTEP output, visual elements, such as semi-transparent red, green and yellow graphs superimposed on the individual streets shown above, allow planners to assess congestion patterns rapidly and interactively at various magnification levels.

Argonne's RTSTEP (Regional Transportation Simulation Tool for Evacuation Planning) allows first responders to develop evacuation strategies and play them out in a virtual world before they are needed, preventing speculation when real emergencies strike.

This approach balances what the brain does best (developing strategies) with what computers do best (crunching numbers to create a rich virtual world for our eyes that our brains can easily understand). "The human brain learns quickly when given good visual input: think board and computer games," said Hubert Ley, TRACC (Transportation Research and Analysis Computing Center) director.

> With the push of a button, computers play out evacuation scenarios.

TRACC researchers developed RTSTEP (called Right Step) by creating computer models that simulate the movements of a city's population throughout every second of the day. Simulating such complex behavior requires a lot of data. Much of this comes from anonymous census data that allows researchers to create an artificial population having aggregate statistics similar to that of a real population. Other data comes from travel behavior surveys, zoning information, traffic volume measurements, sensors in the road, data from the transit agencies, city departments, state agencies, surrounding municipalities and more.

When computers crunch through this data, they must calculate all of the second-by-second movements that drivers have to make to change lanes, stop at intersections, observe traffic signals and still arrive on time at their destinations. Planners can use these simulation tools to work through many different scenarios: closing roads and intersections, establishing evacuation roads, providing transit vehicles, cordoning off larger areas to prevent traffic to flow into the area and placing virtual emergency evacuation shelters in suitable locations.

With the push of a button, computers play through these scenarios and show responders the likely effects of their actions as they play out over time. Responders can see the results of sending too many people through limited-capacity streets—maybe their strategy gets people caught in dangerous areas because they can't get out—and they can see the most critical intersections and send additional police officers to help speed traffic.

RTSTEP partners included transportation system planners, emergency responders, consultants, and city and state representatives. The model was implemented in less than a year.

This project was funded by Chicago's Office of Emergency Management and Communications.

RTSTEP developers Hubert Ley (left), Joshua Auld and Vadim Sokolov.

For more information, contact Hubert Ley, hley@anl.gov

TRACC website: http://web.anl.gov/TRACC/

Fact or Friction

Friction losses significantly impact fuel consumption

Every time we fill up our gas tanks, as much as one-third of the fuel is used to overcome friction. Some friction is productive. After all, you need friction to brake and you wouldn't move if there wasn't friction to create traction.

Argonne National Laboratory teamed with the VTT Technical Research Centre in Finland to look at global energy consumption in cars due to friction. Argonne materials scientist Ali Erdemir co-authored the study with Kenneth Holmberg and Peter Andersson of VTT.

"Worldwide on average, one passenger car uses 90 gallons (340 liters) of fuel to overcome all forms of friction," said Erdemir, an Argonne Distinguished Fellow. "We also found that friction energy losses in electric cars are only about half that of cars with internal combustion engines."

Friction loss in vehicles includes the energy used to overcome the rolling resistance of tires, brake contact, pumping losses, and the rubbing and turning of various mechanical parts in the engine and transmission systems.

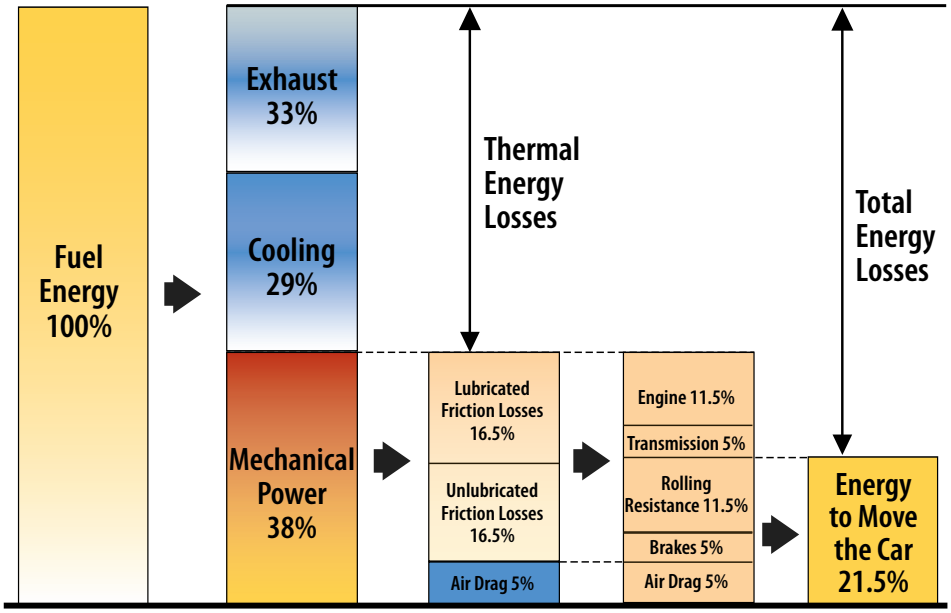
According to the study, the energy output of fuel in a car engine breaks down like this: 33 percent is spent in exhaust, 29 percent is used for cooling and 38 percent for mechanical energy (33 percent for friction losses and 5 percent for air resistance). When compared to a conventional car with an internal combustion engine, an electric car with no such engine has only half of the friction loss.

With current technology, the authors concluded that only 21.5 percent of the fuel's overall energy output is actually used to move the car (see chart below).

On the bright side, there are technologies that can reduce the impact of friction. These include new surface coatings, surface textures, lubricant additives, low-viscosity lubricants, ionic liquids and low-friction tires.

> With current technology, only **21.5 percent** of the fuel's overall **energy output** is actually used to move the car.

"We want to bring attention to the fact that many of these technologies exist today," Erdemir said. "By 2020, implementing these technologies will bring frictional losses down significantly, thus improving fuel economy."



A breakdown of passenger car energy consumption.

Argonne researcher Jair Giovanni Ramirez Gonzalez prepares a nanolubricant for friction and wear measurement.

Argonne researchers Ali Erdemir (front) and Osman Eryilmaz prepare for a pin-on-disk friction test on a new lubricant. Erdemir holds the test load that will be placed on top of the pin holder of the friction test machine.

Funding for this work is provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, Vehicle Technologies and Industrial Technologies programs.

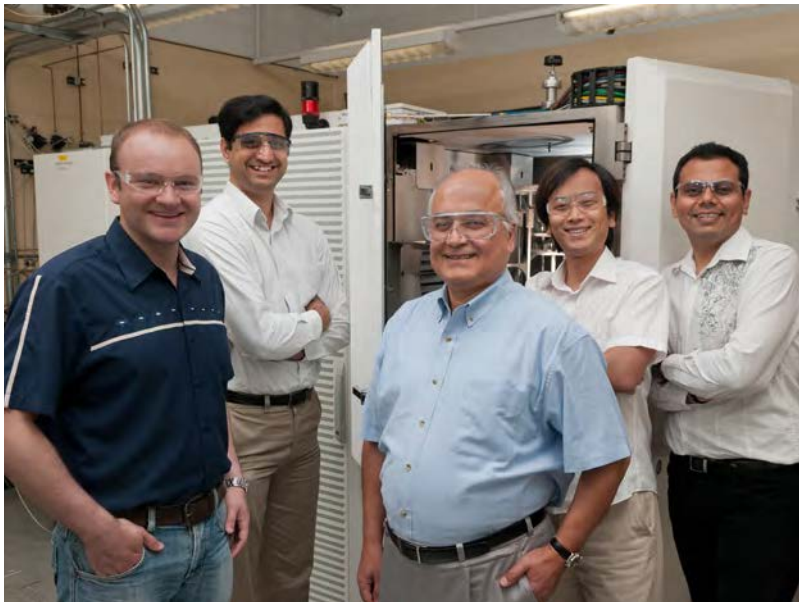
Reference

Holmberg K, et al. Global Energy Consumption Due to Friction in Passenger Cars. *Tribology International* (2011), doi:10.1016/j.triboint.2011.11.022

http://www.sciencedirect.com/science/article/pii/S0301679X11003501

As part of Argonne's tribology (the study of friction, wear and lubrication) research group, Erdemir is involved with many projects that aim to reduce friction, including:

- **Boron-based advanced nanolubricants** that can be added to existing oils to improve lubricity by up to 50 percent. Argonne's boron-based additives are environmentally safe, inexpensive, and have an unusual capacity to enhance the anti-friction and anti-wear properties of sliding surfaces in diesel- and gasoline-powered engines. The unusual lubricating mechanism of boric acid in these oils and fuels is controlled by its very special chemical structure and its ability to form a strongly bonded protective boundary film on rubbing surfaces.
- **Superhard and slick nanocomposite coatings** that improve the reliability and performance of all kinds of moving mechanical systems, including engines. Argonne's material reduces friction by 80 percent, increasing energy efficiency, eliminating wear and scuffing-related failures and extending the life of mechanical components. This technology won an R&D 100 Award in 2009 and has been licensed to automotive manufacturers.
- **Ultrafast boriding** is an innovative heat treatment process that uses boron compounds to convert surfaces into extremely hard and thick layers providing superior wear resistance. Compared to existing thermal treatment processes, Argonne's ultrafast boriding method provides much higher energy efficiency, productivity and near-zero emissions. After successfully boriding multiple quantities of industrial parts with a pilot-scale reactor, the Argonne technology is now being transitioned to Bodycote, one of the world's largest thermal processing companies, for full-scale commercialization.



From left to right: Jair Giovanni Ramirez Gonzalez, Vivekanand Sista, Ali Erdemir, Jong Hyoung Kim and Kuldeep Mistry stand in front of a high-power impulse magnetron sputtering system used for the deposition of superhard and slick nanocomposite coatings.

For more information, contact
Ali Erdemir, erdemir@anl.gov

Roundups

Checklist Makes Transition to New Fuels Easier

A new, easy-to-use checklist created by Argonne alternative fuels researchers Chuck Risch and Dan Santini identifies the many variables that must be addressed in order to successfully introduce alternative fuels into the marketplace. The list can be applied to any fuel and could be used by government, industry, academia or advocacy groups.

The two Argonne scientists combined their decades of experience in industry and policy assessment to develop the checklist with advice from other veteran colleagues. By creating the list, the authors hope to increase the use of alternative fuels to help lower our nation's dependence on foreign petroleum and ensure future fuel security.

The checklist contains the broadest collection of consideration points ever assembled in one place and looks at the "whole picture" of fuel adoption. It describes the needs of all four primary players in the adoption process: consumers, government, fuel industry and automotive manufacturers. For example, the checklist for consumers includes such issues as environmental impacts, safety, cost of ownership, vehicle function, refueling method and purchase incentives.

Risch and Santini presented the list to the Transportation Research Board's Alternative Fuels Committee, and plans are being made to introduce the list to college engineering classes. The list can be used by anyone and will hopefully ensure more thorough research and investigation into a particular fuel. The list was peer-reviewed by experienced researchers, policy analysts, academics and members of industry. View the checklist at http://tinyurl.com/d7rqavk.

Funding for this project was provided by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Program.

For more information, contact Chuck Risch, crisch@comcast.net.

GM Selects Autonomie to Accelerate Advanced Technologies to Market

General Motors recently selected Argonne's Autonomie to be the standard software-in-the-loop tool for the development of its next generation of hybrid and electric vehicle controls.

"Before using Autonomie, the process to manually integrate the controls software with the hardware models took two or more weeks. Now, it takes seconds to minutes to accomplish," said Greg Hubbard, Senior Manager of Electrification Controls at GM. "With Autonomie, we expect to accelerate our development of the next-generation Chevrolet Volt as well as the next-generation Chevrolet Malibu with eAssist."

Launched in 2010, Autonomie replaces vehicle-level integration of hardware and components with a more efficient vehicle design tool. It has now been licensed to more than 150 companies worldwide.

The innovative "plug and play" modeling tool allows users to integrate legacy models, controls, data and processes into a single environment that can be used throughout the different steps of the vehicle development process. This accommodates the automotive industry's interest in reducing costs by accelerating the development and introduction of advanced automotive technologies.

For more information, contact Aymeric Rousseau, arousseau@anl.gov, or visit www.autonomie.net.

The End of the Omnivorous Engine Era

Argonne engineers took the flexible fuel concept to another level with the development of the omnivorous engine. Not only could the engine run on any spark-ignited fuel (gasoline, ethanol, butanol, etc.), it also had the ability to calibrate itself to run at peak efficiency with any fuel or fuel mixture.

"There are a lot of vehicles out there that can run on alternative fuels like ethanol, but usually they are calibrated for gasoline so they don't run at maximum efficiency on the alternative fuels," said Thomas Wallner, mechanical engineer.

Earlier this year, the omnivorous engine was craned out of its home in Argonne's Engine Research Facility, marking the end of the era.

The story began in 2007 when the GM 2.2L Ecotec Direct engine was first installed at the laboratory.

The first project was part of a DOE-funded program led by Mahle Powertrain that used the engine as a baseline for comparison to its three-cylinder concept engine. The project also included research on ion-sensing technology in combination with various blends of gasoline and ethanol. The idea was to develop an engine control strategy that used ion-sensing feedback to determine combustion phasing and engine knock and even derive fuel composition to optimize the engine controls regardless of fuel properties—and thus the GM 2.2L was nicknamed "omnivorous."

While the project and partners changed over the years, the nickname stuck. Other projects focused on assessing butanol as an alternative to ethanol in collaboration with BP and Gevo, as well as on integrating the engine into an engine-in-the-loop setup in collaboration with Argonne's vehicle systems group. This integration triggered a range of projects: the development of catalyst warm-up strategies for hybrid vehicles together with Oak Ridge National Laboratory; a project to assess the potential of exhaust heat recovery using a thermal electric generator with partner GM; and most recently, a project with the Iowa Corn Promotion Board focusing on higher alcohol fuels blended with gasoline and ethanol, and their effects on engine efficiency and emissions.

Argonne engineer Thomas Wallner adjusts the delay on an ion-sensing circuit that allows the omnivorous engine to register real-time combustion feedback.

Over the course of about five years, research on the omnivorous engine resulted in 12 conference papers, two journal publications and several presentations at the Directions in Engine-Efficiency and Emissions Research (DEER) conference. The omnivorous engine has also been featured in several videos and a display at Chicago's Museum of Science and Industry.

A modern Hyundai Theta II GDI engine is currently being installed at Argonne to replace the omnivorous engine. Projects that will use this engine include a study of particulate morphology and gasoline particulate filters, and work in support of a joint project on higher-alcohol fuels with the Iowa Corn Promotion Board.

Funding for this work was provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Program.

For more information, contact Thomas Wallner, twallner@anl.gov.

EcoCAR 2 Announces Year One Winner: Mississippi State University

In May, *EcoCAR2: Plugging into the Future* named Mississippi State University the Year One winner at its 2012 competition in Los Angeles.

Above: The Mississippi State EcoCar2 team gathers around a 2013 Chevrolet Malibu.

Below: Team members are pictured with David Danielson, assistant secretary for DOE's Office of Energy Efficiency and Renewable Energy.

The 15 universities competing in *EcoCAR 2* gathered for six days of judged competition with $100,000 in prize money up for grabs. *EcoCAR 2*, a three-year competition sponsored by the U.S. Department of Energy (DOE), General Motors (GM) and 25 other government and industry leaders, gives students the opportunity to gain real-world, eco-friendly automotive engineering experience while striving to improve the energy efficiency of an already highly-efficient vehicle—the 2013 Chevrolet Malibu.

Year One of the competition series emphasized engineering design though modeling and simulation to select and virtually test their plug-in hybrid electric vehicle architecture. Teams also started developing their hybrid control strategy using hardware-in-the-loop (HIL) simulation tools and designing major vehicle subsystems, including hybrid powertrain, energy storage and high-voltage electrical systems.

Throughout the competition events in Los Angeles, *EcoCAR 2* teams put their designs to the test, giving presentations to industry and government professionals based on their mechanical, electrical, control and HIL strategies, project initiation approval, outreach and business plans, and trade show display.

Mississippi State University was named the Year One winner after impressing more than 100 judges representing various *EcoCAR 2* sponsors with its series-parallel plug-in hybrid electric vehicle design.

"The design and simulation portion of this competition really challenged us to balance detailed engineering analysis with overall vehicle design trade-offs," said Matthew Doude, Mississippi State team leader. "We are excited to receive the keys to our 2013 Malibu and start implementing our series parallel plug-in hybrid electric vehicle design."

While Mississippi State won the top prize, it wasn't the only winning team at the Year One Finals. The eco-engineering teams participated in more than a dozen different events ranging from outreach to powertrain design as they competed for more than $100,000 in prize money. In addition, the second place team is The Ohio State and University of Waterloo took third place overall. Now that their vehicle architectures are finalized, the 15 teams also received the keys to the GM-donated 2013 Chevrolet Malibu they will spend the next two years rebuilding, testing and refining.

For more information, visit the *EcoCAR 2* website at http://www.ecocar2.org.

Research Results

Patents

"Method of Fabricating Electrode Catalyst Layers With Directionally Oriented Carbon Support for Proton Exchange Membrane Fuel Cell (As Issued)," **Di-Jia Liu** and **Junbing Yang**, U.S. Patent 8,137,858 issued March 20, 2012.

"Subnanometer and Nanometer Catalysts, Method for Preparing Size-Selected Catalysts (As Filed)," **Stefan Vajda**, **Michael J. Pellin**, **Jeffrey W. Elam**, **Christopher L. Marshall**, **Randall A. Winans** and **Karl-Heinz Meiwes-Broer**, U.S. Patent 8,143,189 issued March 12, 2012.

"Non-Platinum Bimetallic Polymer Electrolyte Fuel Cell Catalysts," **Deborah Myers**, **Xiaoping Wang** and **Nancy Kariuki**, U.S. Patent 8,129,306 issued March 6, 2012.

For more information, contact
Argonne's Technology Development and Commercialization Office at 800.627.2596

Recent Publications

"Alternative Fuels Heat-up," **Sibendu Som**, SAE Powertrain and Energy Quarterly issue, January 2012.

"Comparison and Standardization of Numerical Approaches for the Prediction of Non-reacting and Reacting Diesel Sprays," **S. Som**, **D.E. Longman**, **G. D'Errico** and **T. Lucchini**, SAE Paper No. 2012-01-1263, *SAE 2012 World Congress*, Detroit, Mich., April 2012.

"Evaluating Benefits of Idling Restrictions in a Large Northern City," poster by **H. Pohnan** and **L. Gaines**, Green Truck Summit, Indianapolis, Ind., March 7, 2012.

"Fabrication of Micro-orifices for Diesel Fuel Injectors," **George R. Fenske** and **Nicholaos Demas**, DOE FY 2011 Progress Report.

"Global Energy Consumption Due to Friction in Passenger Cars," **Kenneth Holmberg**, **Peter Andersson** and **Ali Erdemir**, *Tribology International*, 47: 221–234, 2012.

"Influence of Nozzle Orifice Geometry and Fuel Properties on Flow and Cavitation Characteristics of a Diesel Injector," **S. Som**, **D.E. Longman**, **A.I. Ramirez** and **S.K. Aggarwal**, book chapter in *Fuel Injection in Automotive Engineering* INTECH Open Access Publisher (April, 2012): ISBN: 979-953-307-771-9.

"Low-friction Hard Coatings," **A. Erdemir** and **O.L. Eryilmaz**, DOE EERE FY 2011 Progress Report.

"Materials Challenges and Opportunities for Enhancing the Sustainability of Automobiles," **Gregory A. Keoleian** and **John L. Sullivan**, *MRS Bulletin*, Materials for Sustainable Development.

Continued on page 16

Research Results

Publications continued

"Methane and Nitrous Oxide Emissions Affect the Life Cycle Analysis of Algal Biofuels," **Edward D. Frank**, **Jeongwoo Han**, **Ignasi Palou-Rivera**, **Amgad Elgowainy** and **Michael Q. Wang**, *Environmental Research Letters* 7: 014030, 2012.

"Simulated Impact of Future Biofuel Production on Water Quality and Water Cycle Dynamics in the Upper Mississippi River Basin," **May Wu**, **Eugene Yan** and **Yonas Demissie**, *Biomass and Bioenergy*, 41: 44–56, June 2012, http://dx.doi.org/10.1016/j.biombioe.2012.01.030.

"Status of Life Cycle Inventories for Batteries," **J.L. Sullivan** and **L. Gaines**, *Energy Conversion and Management*, in press, doi:10.1016/j.enconman.2012.01.001.

"Tribological Behavior of Ti-based Thin Film Coatings under Boundary Lubrication Regime," **C. Lorenzo-Martin**, **O.O. Ajayi**, **S. Torrel**, **N. Demas** and **G.R. Fenske**, Proceedings of *STLE2012 Annual Meeting of the Society of Tribologist and Lubrication Engineers,* May 6–10, 2012, St. Louis, Mo.

"Tribological Studies of Coated Pistons Sliding against Cylinder Liners under Laboratory Test Conditions," **Nicholaos G. Demas**, **Robert A. Erck**, **Oyelayo O. Ajayi** and **George R. Fenske**, *Lubrication Science*, in press.

"White Light Interferometry for Quantitative Surface Characterization in Ion Sputtering Experiments," **S.V. Baryshev**, **A.V. Zinovev**, **C.E. Tripa**, **R.A. Erck** and **I.V. Veryovkin**, *Applied Surface Science* (2012), in press.

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http://www.transportation.anl.gov/publications/papers_presentations.html

Recent Presentations

"Electric Drive Vehicles in the U.S.: Markets, Research and Strategies," **Larry Johnson**, EV Technology Innovation Forum, Beijing, China, July 12, 2012.

"A Microsimulation of Energy Demand and Greenhouse Gas Emissions from Plug-in Hybrid Electric Vehicle Use," **Thomas Stephens**, **John Sullivan** and **Gregory A. Keoleian**, EVS26, Los Angeles, Calif., May 6–9, 2012.

"Ultra-fast Synthesis of Superhard Borides: A Paradigm Shift in Surface Engineering for Tooling and Automotive Applications," **A. Erdemir**, **O.L. Eryilmaz**, **S. Timur**, **O. Kahvecioglu**, **G. Kartal** and **V. Sista**, 39th International Conference on Metallurgical Coatings and Thin Films, April 22–27, 2012, San Diego, Calif.

"Electrochemical Boriding of Molybdenum in Molten Borax," **O. Kahvecioglu**, **V. Sista**, **O.L. Eryilmaz**, **A. Erdemir** and **S. Timur**, 39th International Conference on Metallurgical Coatings and Thin Films, April 22-27, 2012, San Diego, Calif.

"Evaluation of Electrochemical Boriding of Inconel 600," **V. Sista**, **O. Kahvecioglu**, **G. Kartal**, **Q. Z. Zeng**, **J.H. Kim**, **O.L. Eryilmaz**, and **A. Erdemir** and **S. Timur,** 39th International Conference on Metallurgical Coatings and Thin Films, April 22-27, 2012, San Diego, Calif.

"Standards and Codes Related to PEV Charging and Communication," **Jason D. Harper**, presented at a meeting of the Fox Valley Subsection IEEE (FVSS), Illinois Institute of Technology Rice Campus, Wheaton, Ill., April 18, 2012.

"A Comparison of Li-Ion Battery Recycling Options," **Linda Gaines** and **Jennifer Dunn**, SAE World Congress, Detroit, Mich., April 2012.

"Thermoelectric Generator (TEG) Fuel Displacement Potential Using Engine-in-the-Loop and Simulation," **Ram Vijayagopal**, 2012 DOE Thermoelectric Applications Workshop III, Baltimore, Md., March 19–22, 2012.

"Reduction of Electric Vehicle Life Cycle Impacts through Battery Recycling," **Linda Gaines**, 29th International Battery Seminar and Exhibit, Ft. Lauderdale, Fla., March 15, 2012.

"KH-ACT Primary Breakup Model Enabling Integrated Nozzle flow and Spray-Combustion Simulations," **Sibendu Som** and **Douglas E. Longman**, presented at the ACEC Meeting-USCAR, March 15, 2012

"Impact of the Manufacturing and Recycling Stages on Battery Life Cycles," **J.B. Dunn**, **L. Gaines**, **M. Barnes** and **J.L. Sullivan**, 2012 TMS Annual Meeting and Exhibition, Orlando, Fla., March 11–15, 2012.

"Engine-in-the-Loop Analysis of Series PHEV under 'Hot' Conditions," **Neeraj Shidore**, **Aymeric Rousseau**, **Andrew Ickes** and **Ram Vijayagopal**, IAMF Conference, Geneva, Switzerland, March 8, 2012.

"Evaluating Benefits of Idling Restrictions in a Large Northern City," poster by **Heather Pohnan** and **Linda Gaines**, Green Truck Summit, Indianapolis, Ind., March 7, 2012.

"Life Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum," **Andrew Burnham**, IPIECA Workshop: The Expanding Role of Natural Gas, Arlington, Texas, March 7, 2012.

"Plug-in Electric Vehicle (PEV) Standards, Upcoming PEVs/Features, Charging System Overview," **Ted Bohn**, Clean Cities Electric Vehicle Winter 2012 Quarterly Discussion Webinar, February 27, 2012.

"Water Quality Assessment of Pesticide Usage for Biofuel Production," **David Lampert**, 2012 ARPA-E Energy Innovation Summit, February 26–27, 2012.

"Implications of Biofuel Water Footprint in Water Sustainability," **Y.W. Chiu** and **M. Wu**, ISTC Sustainability Seminar Series, Illinois Sustainable Technology Center (ISTC) at the University of Illinois, Urbana-Champaign, Ill., Feb. 23, 2012.

"Life Cycle Environmental Impacts of Geothermal Systems," **C. Clark**, **J.L. Sullivan**, **C. Harto**, **J. Han** and **M. Wang**, Proceedings, Thirty-Seventh Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, Calif., January 30–February 1, 2012.

"Progress in Spray and Combustion Modeling for Internal Combustion Engine Applications: Validation Against ECN Data," **Sibendu Som** and **Douglas E. Longman**, presented at the AEC/HCCI Working group meeting at Sandia National Laboratory, February 2012.

"Employment Impacts of Non-Automotive Fuel Cells and Natural Gas Vehicles," **M. Mintz**, **J. Molburg**, **C. Mertz** and **E. Stewart**, presented at the 91st Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 23, 2012.

"Advances in Multi-functional Nanocomposite Coatings for Demanding Automotive Applications" (Invited paper), **A. Erdemir**, 36th International Conference and Exposition on Advanced Ceramics and Composites, Daytona Beach, Fla., January 22–27, 2012.

"Assessing Water Sustainability of Biofuels in the United States," **May Wu**, EERE Clean Cities Program webinar, January 11, 2012.

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http://www.transportation.anl.gov/publications/papers_presentations.html

Media Highlights

January–May 2012

***Green Car Congress* website, May 18.** Preliminary findings from a study by **Aymeric Rousseau** and other Argonne researchers show that current compressed natural gas (CNG) technology applied in conventional light-duty vehicles leads to a two-percent fuel consumption penalty when the engine is not resized (i.e., the CNG-fueled engine has lower performance) and up to a 12-percent fuel consumption penalty when the engine is resized (i.e., "up-sizing") to deliver comparable performance to the gasoline-fueled version. Read the study at http://tinyurl.com/7eqcgjo.

***Scientific American* website, May 17.** Researchers at **Argonne** are now tackling the challenges of designing batteries by the molecule in computers to perform postmortem battery analyses. This comprehensive report describes Argonne's facilities for creating the lithium-ion battery of the future. Read everything about how to build a better lithium battery at http://tinyurl.com/ca44dte.

Algae

***Environmental Research Letters* website, March 26.** **Edward Frank** and colleagues from Argonne carried out a life-cycle analysis of the energy use and emissions for algal biofuels, using the GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model. The scientists considered the energy input required, including the energy to keep the algae suspended in the growth pond. They also assessed the methane produced during anaerobic digestion and the nitrous oxides emitted if algal residues were used as crop fertilizers. Taking all of these issues into account, they showed that algal biofuels nearly halved greenhouse gas emissions (from 101,000 g of CO_2 equivalent per million BTU for low-sulphur diesel to 55,400 g for algal biodiesel), making these fuels attractive compared to liquid fossil fuels. Read the article at http://tinyurl.com/ctfk7j4.

***Nightly Business Report* website, March 16.** Argonne engineer **Mike Duoba** was interviewed on how natural gas could fuel new ways to travel in the video. Watch the video at http://tinyurl.com/8yglfwt.

Mike Duoba

***Digital Journal* website, March 15.** California Lithium Battery, Inc., has announced that it has entered into a Work for Others agreement with **Argonne National Laboratory** to commercialize a breakthrough, low-cost "GEN3" lithium battery. This new transformational battery will offer the highest energy density and longest life cycle of any lithium battery made today. CalBattery believes that it will be able manufacture this GEN3 lithium-ion battery in the United States at a comparable cost reduction up to 70 percent. Read the story at http://tinyurl.com/6t3979r.

***Green Car Reports* website, March 14.** Ford has created a tool that models the total cost of ownership and lifetime emissions for different vehicles. It's based on **Argonne's GREET** (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model and estimates the vehicle's lifetime wells-to-wheels emissions of carbon dioxide (CO_2)—allowing users to compare the carbon profile of miles covered via power from their regional electric grid versus those covered by burning gasoline or diesel fuel. Users of Ford's tool enter local electricity prices and gasoline and diesel fuel costs, as well as the mileage they expect the vehicle to cover, how much of that will be city travel versus highway miles, and how many years they plan to own the vehicle. The tool then compares any two specified vehicles based on those inputs and the EPA's ratings for fuel efficiency and (in the case of plug-in vehicles) electric efficiency. Read the article at http://tinyurl.com/72n8369. For more on GREET, visit http://greet.es.anl.gov/.

Andy Burnham

***PhysOrg* website, February 3. Thomas Wallner, Andy Burnham** and other researchers at Argonne have begun to investigate the addition of one more contender to the list of possible energy sources for light-duty cars and trucks: compressed natural gas (CNG). Read the story at http://tinyurl.com/6t8sdfn.

For complete Argonne transportation research press coverage, visit http://www.transportation.anl.gov/media_center/press_coverage.html

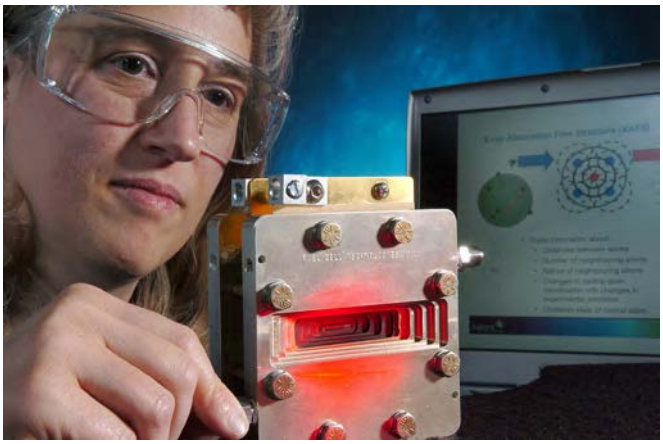
Fastrax

Seth Snyder

Seth Snyder and his team received a 2012 Federal Laboratory Consortium (FLC) Award for Excellence in Technology Transfer for a separations technology that improves the processing of biomass-based feedstocks into biofuels and chemicals. Argonne developed the innovative resin wafer electrodeionization technology to significantly reduce the cost of producing clean energy and of the chemicals and water used in industry.

Argonne researchers **John Kopasz**, **Debbie Myers** and **Walt Podolski** are members of the U.S. Drive Fuel Cell Tech Team, which received a 2011 USCAR Team Award. The award was presented on May 30, 2012, at Michigan State University. The tech team promotes the development of a fuel cell power system for an automotive powertrain that meets U.S. DRIVE objectives. Learn more about the tech team at http://tinyurl.com/bm47wqw.

Marcy Rood Werpy was selected by the U.S. Department of Energy to represent the Clean Cities Program as part of the George C. Marshall Visit to Austria Program, sponsored by the Austrian government (April 8–15). The focus of the exchange was "Smart Cities and Urban Technologies." She was also interviewed by *Profil*, a weekly Austrian newspaper focusing on politics, economics and science.



Debbie Myers demonstrates a fuel cell fixture created to allow an in situ X-ray study of transition metals.

Forrest Jehlik and **Danny Bocci** received Argonne Pacesetter Awards for designing and developing a Green Racing Simulator to provide a DOE public outreach venue for green transportation technologies. The simulator combined significant hardware and software development with appealing graphics to create an engaging tool to convey key alternative fuel and powertrain messages to the public.

Danny Bocci received an Argonne Pacesetter award for creating an innovative means to enable Chevrolet Volt testing on a 2WD dynamometer with emulation of rear-wheel speed sensors with signal boosting and isolation. The solution was conceived and implemented in 48 hours, yielding full-vehicle operational parameters to be measured and analyzed.

Danny Bocci (standing)

Kuilin Zhang is the newest member of the Committee on Transportation Network Modeling of the Transportation Research Board of the National Academy of Sciences. The committee promotes research and information exchange in transportation network modeling—an interdisciplinary field spanning computer science, logistics, mathematics, operations research, telecommunications and transportation science. Members of the committee are recognized as experts in their fields.

Three Argonne scientists received the 2012 DOE Vehicle Technologies Program R&D Award for quick response in the use of Autonomie to help DOE set the U.S. DRIVE program targets. The researchers, **Namdoo Kim**, **Ayman Moawad** and **Phillip Sharer**, supported DOE's analysis by using the Autonomie systems modeling tool, developed by Argonne's Vehicle Model Simulation and Control Section under the management of Aymeric Rousseau, to run vehicle simulations that predicted the fuel economy benefits of advanced vehicles such as hybrid electric vehicles, plug-in hybrid electric vehicles and fuel cell vehicles for the 2015 and 2020 timeframes. These predictions helped DOE and the U.S. Drive program set their component technology targets for engines, batteries, fuel cells and electric machines. U.S. DRIVE is a partnership between U.S. auto manufacturers and DOE to develop targets and strategic roadmaps and evaluate progress on a range of advanced vehicle technologies.

In May, Argonne scientists were recognized at the DOE Annual Merit Review of work in their Vehicle Technologies and the Fuel Cell programs. Honored were:

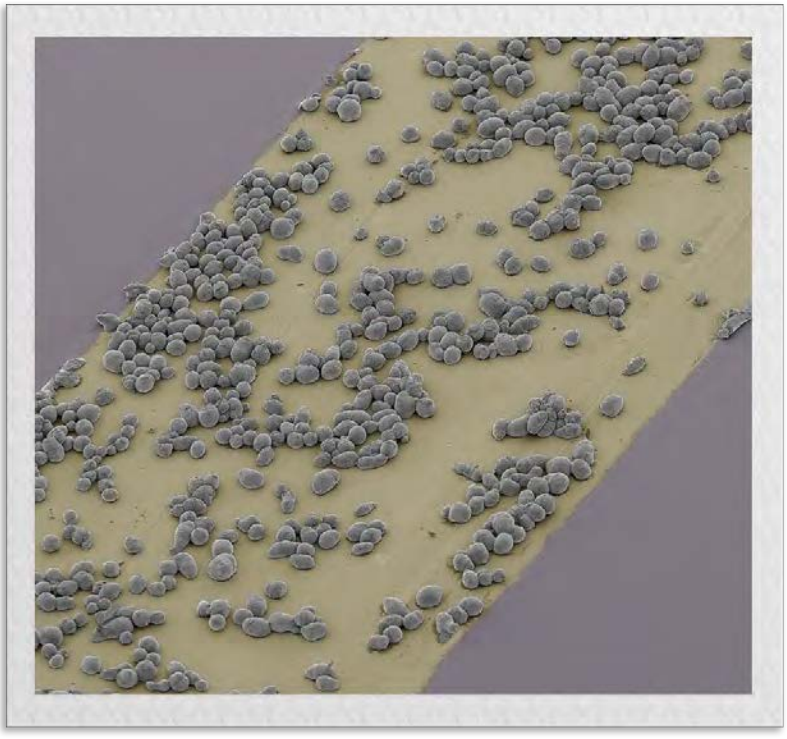
- **Amgad Elgowainy** received the 2012 DOE Hydrogen and Fuel Cell Program/Hydrogen Delivery award for outstanding modeling and analysis of hydrogen delivery in the fuel cell program; and
- **Walt Podolski**, **Tom Benjamin** and **John Kopasz** received the 2012 DOE Hydrogen and Fuel Cell Program award for their extensive and comprehensive support to DOE in connection with U.S. DRIVE's Technical Team for Fuel Cell and Hydrogen Storage.

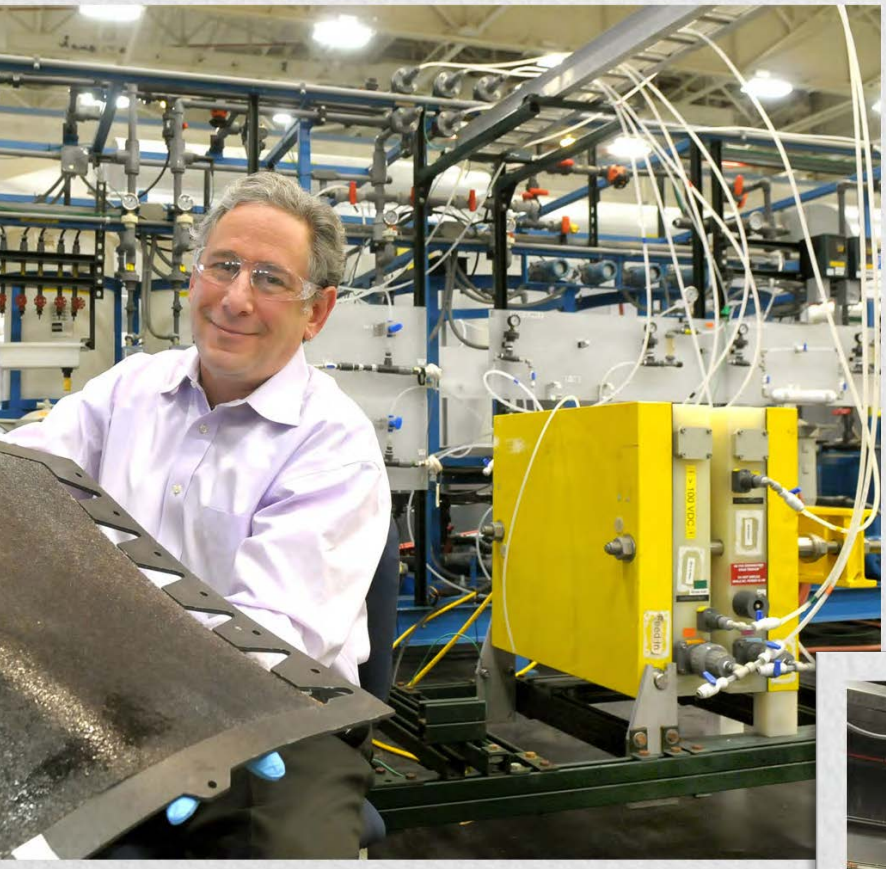
For more information, visit the DOE's 2012 Annual Merit Review Awards webpage at http://www.hydrogen.energy.gov/annual_review12_awards.html.

Parting Shots

Right: The cover of Argonne's new brochure on vehicle systems research, available at http://tinyurl.com/cunxjsm.

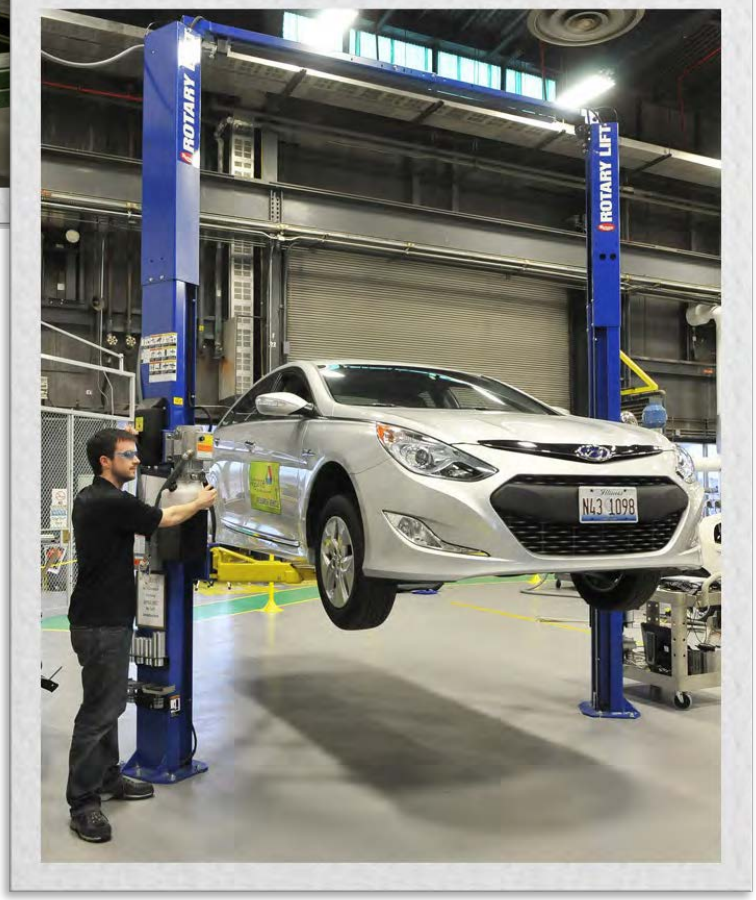
Below: These microcapsules, filled with liquid metal, sit on a gold conductive layer. If a battery circuit is mechanically damaged, the capsules burst to restore the conductive pathway; the circuit "self-heals." Argonne is developing and testing these systems to increase the life and efficiency of aging batteries. They could be used in vehicles. Each capsule is just 10 microns across; 10 could fit side by side in a human hair (image by Amanda Jones and Ben Blaiszik). More on this in the next issue of TransForum.





Left: Argonne biochemical engineer Seth Snyder with the laboratory's resin wafer technology, which won a 2012 Federal Lab Consortium award.

Below: Argonne engineer Patrick Walsh lifts a research vehicle to inspect the car's undercarriage.



Left: Argonne process R&D chemist Trevor Dzwiniel prepares a 20-liter reactor for the synthesis of a kilo-scale batch of a lithium-ion battery overcharge protection redox shuttle.

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Working with Argonne

Industrial technology development is an important way for the national laboratories to transfer the benefits of publicly funded research to industry to help strengthen the nation's technology base. The stories highlighted in this issue of **Trans**Forum represent some of the ways Argonne works with the transportation industry to improve processes, create products and markets and lead the way to cost-effective transportation solutions, which in turn lead to a healthier economic future.

By working with Argonne through various types of cost-sharing arrangements, companies can jump-start their efforts to develop the next generation of transportation technologies without shouldering the often prohibitive cost of initial R&D alone. Argonne has participated in dozens of these partnerships and has even been involved in helping to launch start-up companies based on the products and technologies developed here.

If working with world-class scientists and engineers, having access to state-of-the-art user facilities and resources and leveraging your company's own capabilities sound like good business opportunities to you, please contact our Technology Development and Commercialization Division and see how we can put our resources to work for you.

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