TransForum

News from Argonne's Transportation Technology R&D Center
www.transportation.anl.gov

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President Barack Obama toured Argonne's transportation research facilities in March; while at the laboratory he announced the Energy Security Trust to support alternative energy research.

Make Mine a Burger, Fries and a Side of Extra Fuel *page 8*

That quick trip through the drive-through may seem like a real timesaver, but the cost might be higher than you think.

On the cover
President Barack Obama and Argonne mechanical engineer Henning Lohse-Busch are pictured in the laboratory's new Environmental Test Cell, which is a major upgrade to Argonne's world-class Advanced Powertrain Research Facility. (Photo courtesy of the White House)

Shown here
Mechanical engineer Mike Duoba describes electric vehicle testing in the extremes of cold and heat to President Obama. Former Secretary of Energy Steven Chu and transportation researchers Henning Lohse-Busch (left) and Mike Kern look on. (Photo courtesy of the White House)

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Research Reviews

President Calls for New Energy Security Trust During Visit

President Barack Obama visited Argonne National Laboratory in March, using the laboratory's world-leading transportation research program and its facilities as context for the announcement of his major new energy proposal, the Energy Security Trust.

The President talks with Argonne Director Eric Isaacs about the laboratory's unique ability to conduct transportation research that cuts across many scientific and engineering disciplines. Argonne battery researcher Lynn Trahey looks on. (Photo courtesy of the White House)

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Argonne scientists Lynn Trahey and Kevin Gallagher talk with President Obama about Argonne's discoveries in next-generation battery chemistries and materials, and advancements in energy storage technologies for electric and hybrid cars. (Photo courtesy of the White House)

The President's proposed Trust calls for investment in "breakthrough research that will make the technologies of the future cheaper and better—technologies that will protect American families from spikes in gas prices and allow us to run our cars and trucks on electricity or homegrown fuels." The announcement follows up on his State of the Union pledge to confront global climate change and should add momentum to the surge of clean technologies entering the market.

Under the President's proposal, the United States would set aside $2 billion over 10 years to support research into a range of cost-effective technologies, such as advanced vehicles that run on electricity, homegrown biofuels, fuel cells and domestically produced natural gas.

"Argonne stands ready to support the President's proposal," said Ann Schlenker, Director, Argonne's Center for Transportation Research, "but it will require a rapid increase in the rate of technology invention and development to meet these ambitious goals." Schlenker went on to say that strong industry collaboration will be needed to surmount the many technical challenges defined in Obama's proposal.

Argonne's highly successful transportation research program has historically demonstrated the value of public and private partnerships. Working with its industry partners, Argonne's multidisciplinary research teams are creating game-changing solutions that have already enabled Americans to use less petroleum and run their cars and trucks on electricity or alternative fuels, while lowering costs and reducing impacts on the environment. New developments in electric vehicle systems, combustion, battery chemistries, engines, vehicle-to-grid interface, materials, fuel cells, alternative fuels and systems modeling are occurring every day.

During his day at the laboratory the President toured Argonne's many one of-a-kind research facilities and met with transportation researchers to learn about their leading edge, energy-related work.

At the Advanced Powertrain Research Facility, he spoke with engineers Henning Lohse-Busch and Mike Duoba about the facility's new Environmental Test Cell. There, 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 conventional and electrified vehicles.

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Few areas hold more promise for creating good jobs and growing our economy than how we use American energy.

Battery researchers Lynn Trahey and Kevin Gallagher talked with the President about Argonne's many revolutionary advances in energy storage, including innovative battery materials that heal themselves and new anode compositions that enhance battery performance.

President Obama spoke with engine researcher Steve Ciatti about Argonne's groundbreaking work to develop and assess novel fuel regimes for gasoline and diesel engines.

The President's Energy Security Trust proposal is modeled after a plan submitted by a group of former military leaders and business executives who are committed to reducing U.S. oil dependence. Retired Marine Corps General P.X. Kelley and FedEx Corporation Chairman and chief executive Frederick W. Smith head the group, called Securing America's Future Energy, or SAFE.

For more information, contact Ann Schlenker, aschlenker@anl.gov.

For photos and videos on the visit, see http://www.anl.gov/articles/president-calls-new-energy-security-trust-during-argonne-visit

President Obama looks on while mechanical engineer Steve Ciatti details Argonne's development of an advanced combustion system that achieves diesel-like high efficiency and current level power density while producing ultra-low emissions. (Photo courtesy of the White House)

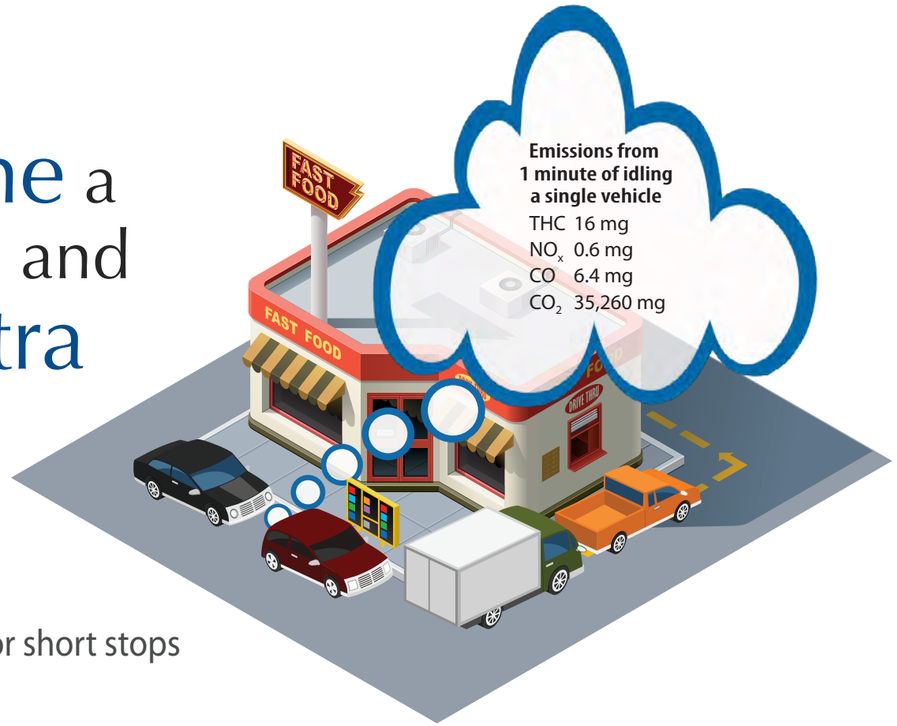
"The nature of America's miraculous rise has been a willingness to reach out to new horizons, a willingness to take new risks, a willingness to innovate. That's who we are. That's been the American story. Right now, few areas hold more promise for creating good jobs and growing our economy than how we use American energy. Some of the most high-tech, fuel-efficient cars in the world are once again designed, engineered and built here in the United States.

We've doubled the amount of renewable energy that we generate from sources like wind and solar, and we're sending less carbon pollution into the environment than we have in nearly 20 years.

That's why we have to keep investing in scientific research. We can't afford to miss these opportunities while the rest of the world races forward. But if we work at it, we will achieve it. That's the nature of America, that's what Argonne National Lab is about. We don't stand still, we look forward. We invent, we build, we turn new ideas into new industries. When somebody tells us we can't, we say yes we can. I'm absolutely confident that America is poised to succeed in the same way as long as we don't lose that spirit of innovation and recognize that we can only do it together."

President Barack Obama
Argonne National Laboratory
March 15, 2013

Make Mine a Burger, Fries, and a Side of Extra Fuel



Studying the effects of passenger vehicle idling for short stops

The American drive-through food window has become a mainstay of our busy lives. And although author Michael Pollan suggests that if it comes through the window of your car, it isn't food,[1] the reality is that many of us obtain at least one meal a week that way. Now, here's a quiz—which behavior produces the fewest greenhouse gas emissions and uses the least fuel—going through the drive-through with the engine running and the vehicle warm, or parking the vehicle and going inside to conduct your transaction?

Many people believe that parking and restarting your car for short stops uses more fuel and produces greater emissions than idling for the same amount of time. Argonne researchers Linda Gaines, Eric Rask and Glenn Keller decided to explore that hypothesis and determine just how long you really can idle a car in queue before the impacts of idling are greater than they are for restarting. The results might surprise you!

Most idling research over the years (much of it done at Argonne) has focused on heavy- and medium-duty vehicles; very few studies have considered the effects of passenger vehicle idling as a source of emissions and wasted fuel. While idling in traffic is important from a safety standpoint, vehicles can be turned off at train crossings, schools, banks and fast food establishments.


Linda Gaines


Glenn Keller


Eric Rask

Consider that if each car in the United States idles just 6 minutes a day, about 3 billion gallons of fuel are wasted annually at a cost of more than $10 billion per year!

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The U.S. Department of Energy's Clean Cities Program funded Argonne to measure idling fuel use and emissions from light-duty vehicles and to compare those measurements to start-up emissions. The Clean Cities Program's nationwide network of almost 100 Clean Cities Coalitions works to reduce transportation dependence on petroleum through the use of alternative fuels and efficiency measures, including idling reduction.

To conduct the research, Argonne engineers used a 2011 Ford Fusion mid-sized sedan with a 2.5-L, 4-cylinder engine (175 HP) and 6-speed automatic transmission (Figure 1). The U.S. Environmental Protection Agency (EPA) fuel economy ratings for this vehicle were 23 mpg city/33 mpg highway/26 mpg combined. The researchers equipped the vehicle to measure numerous engine parameters and temperatures, including the catalytic converter's inlet and core temperatures and vehicle oil and coolant temperatures. Argonne researchers collected data in Argonne's Advanced Powertrain Research Facility (APRF) using a SemtechD emissions analyzer for emissions and a direct fuel flow meter for fuel measurement. The vehicle was prepared and run using approximate Federal Test Procedure (FTP) standard ambient temperature testing criteria. The emissions of interest in this study include total hydrocarbons (THC), nitrogen oxides (NO_x), carbon monoxide (CO) and carbon dioxide (CO_2).

The findings? Testing at 70°F ambient conditions showed that **idling for more than 10 seconds uses more fuel (Figure 2) and emits more CO_2 (Table 1) than engine restarting**. In addition:

- Idling fuel usage varies from 0.2 to 0.5 gallons per hour for passenger vehicles across a range of sizes.
- For short stops, it makes sense to turn the vehicle off in order to minimize fuel use and CO_2 emissions. At least for the conditions evaluated in this work, a penalty in terms of criteria pollutant emissions (particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides and lead) is very small compared to cold-start emissions.
- The catalyst cooled down slowly, so that restarts after the amount of time equaling a short transaction at a bank or restaurant are unlikely to allow the temperature to drop below light-off (the temperature at which catalytic reactions are initiated within a catalytic converter) and incur large cold-start emissions.
- Criteria pollutant emissions were relatively low for idling following catalyst activation.

Figure 1. Ford Fusion test vehicle used in the research

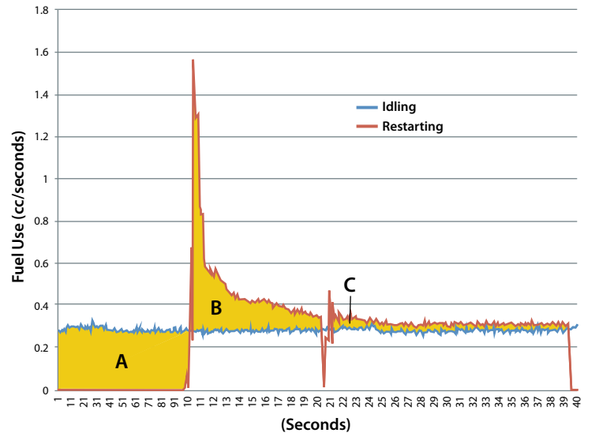

Figure 2. The shaded area under the blue line (A, idling fuel rate) and the red line (B, restart) before the engine is restarted (at 10.1 s) represents the quantity of fuel that the engine would have burned if it were idling instead of being off. The area between the red and blue lines after the engine is restarted (C) represents the excess fuel used on restart.

Table 1. Fuel Use and Idling Emissions per Second

Fuel (cc)	NO_x (mg)	THC (mg)	CO (mg)	CO_2 (g)
0.279	0.0097	0.266	0.108	0.588

NO_x = oxides of nitrogen, THC = total hydrocarbons, CO = carbon monoxide, CO_2 = carbon dioxide

[1] Pollan, Michael, *Food Rules* (New York: Penguin Books, 2009), p. 20.

Many people believe that parking and restarting your car for short stops uses more fuel and produces greater emissions than idling for the same amount of time.

It's important to note that the research was conducted with just one vehicle at a single temperature for a small number of runs. Future work will confirm the extent to which the results may apply more broadly. Factors that may influence broader applicability include the following:

- Hot and cold ambient conditions are likely to affect results, as well as the amount of power needed to supply passenger comfort at those temperatures.
- Older vehicles and diesels are both likely to behave differently.
- Because this research included no simulation of driving away immediately on restart, it does not compare idling warm-up to letting the vehicle warm up while it is driven.
- More information is needed to explain differences in THC emissions between the runs, as well as to make more generalizations regarding the emissions impacts of different restart/run times.

Additional research to fill in all these gaps would enable more conclusive statements concerning the differences in emissions between idling and restarts.

Argonne National Laboratory's work was supported by the U.S. Department of Energy, Office of Vehicle Technologies, Clean Cities Program. The researchers also wish to thank Steven McConnell, Christopher Saricks and Michael Duoba of Argonne's Center for Transportation Research (CTR), as well as Terry Levinson of Energetics (formerly of the CTR) for extremely helpful discussions and insights.

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Argonne Leads the Way in Idling Reduction Research

Argonne National Laboratory has been a leader in idling reduction research for nearly two decades. Argonne's 2000 report, *Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks* (ANL/ESD 43) written by the late Frank Stodolsky, Linda Gaines and Anant Vyas, set the stage for detailed analysis of petroleum use and emissions from idling that has extended into other vehicle categories as well. For instance, the 2002 paper by Gaines and representatives of CSX, *Trading of Locomotive NO_x Emissions: A Potential Success Story*, examined potential financial benefits from reducing locomotive idling.

Gaines and Terry Levinson (formerly of Argonne, now with Energetics) organized the National Idling Reduction Planning Conference in 2004, which brought together a wide range of industry, government and academic stakeholders under joint sponsorship of the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, U.S. Department of Transportation and New York State Energy Research and Development Authority. The conference led to the development of a model idle reduction law that influenced legislation at the state level, and to creation of the *National Idling Reduction Network News* (NIRNN), which Argonne has produced for DOE since 2004. To date, NIRNN is the only periodical publication for people interested in the latest information in this field.

The Argonne team has continued to publish and present extensively about the effects and costs of vehicle idling, and about comparative benefits of idling reduction alternatives. This work continues to influence technology development, policies and laws throughout the United States. Argonne researchers also participate in conferences, workshops and outreach efforts conducted through DOE's Clean Cities Program, which promotes idling reduction and alternative fuels as ways to reduce petroleum consumption.

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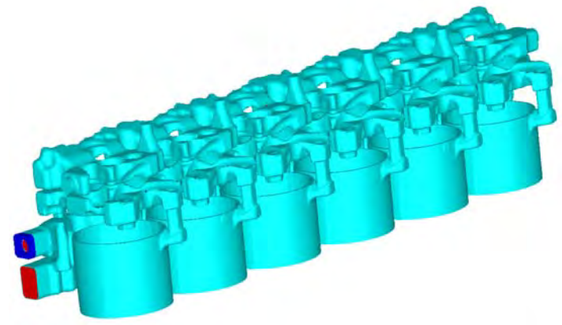
Optimizing Heavy-Duty Truck Engine Cooling

Heavy-duty trucks (HDTs) consume a lot of energy due to their size, weight and the power needed to run their cooling systems. Scientists looking to improve the design of heavy vehicle cooling systems need both advanced cooling technologies and sophisticated computer modeling capabilities that enable them to visualize cooling performance.

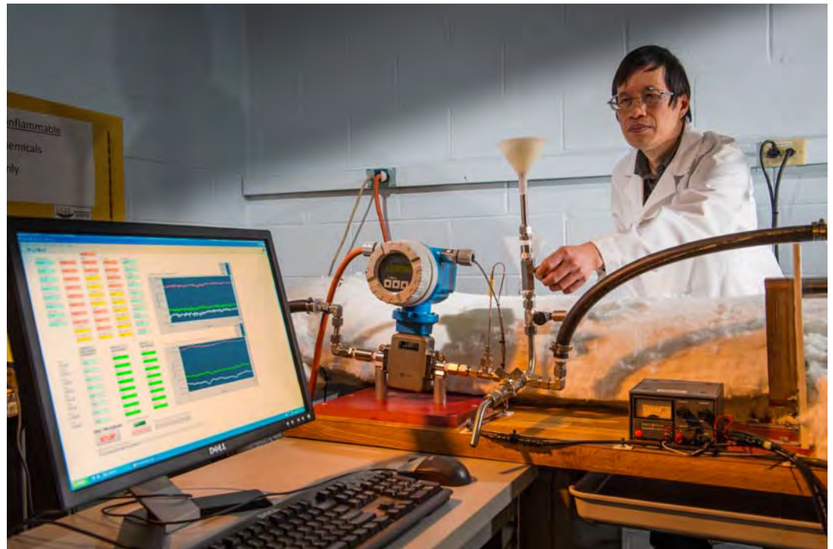
To address these needs, Argonne scientist Dileep Singh and his team are partnering with heavy truck manufacturer PACCAR, Inc., to study the behavior of engine coolant boiling heat transfer in HDTs. Understanding and quantifying this behavior could lead to innovations in truck cooling systems, as well as enhanced cooling system performance and engine thermal efficiencies, which will in turn improve fuel economy. Improved engine block cooling can also help to eliminate hot spots, leading to longer engine life. Argonne is conducting the coolant flow boiling experimental work and developing mathematical models for the boiling heat transfer, and PACCAR is optimizing and validating the computer code. The partners will work together to interpret and evaluate the experimental results to establish overall benefits to HDT fuel economy. "The nucleate boiling work with Argonne helps us understand the heat transfer process in the engine and how we can improve it," said Jason Ritter, Project Manager at PACCAR.



Computer model of the cooling channels in a heavy-duty truck engine's cylinder head region. Image courtesy of PACCAR.

In order to study engine coolant heat transfer behavior, the Argonne team (which includes Wenhua Yu, David France and Roger Smith), developed a unique experimental test facility consisting of preheaters, a heat exchanger, a pump and a test section that simulates the cooling channels in an HDT engine cylinder head region. In addition to building the test facility, the Argonne team identified two-phase flow boiling curves and heat transfer coefficients under various coolant temperature and flow rate conditions, and determined that significant increases in heat transfer rates can result under coolant flow boiling when compared to traditional single-phase convective heat transfer (when there is no boiling). This implies reduced flow rates and less power needed to pump the coolant.

Researcher Wenhua Yu adjusts equipment used to conduct experimental laboratory work on the HDT coolant flow boiling heat transfer at Argonne.



This work is being funded by the U.S. Department of Energy's Energy Efficiency and Renewable Energy's Vehicle Technologies Office, under the direction of Lee Slezak, through a Cooperative Research and Development Agreement (CRADA) with PACCAR, Inc.

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Nanoscale 'Goldilocks' Phenomenon Could Improve Biofuel Production

In a case of the Goldilocks story retold at the molecular level, scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory and Northwestern University have discovered a new path to the development of more stable and efficient catalysts.

The research team sought to create "nanobowls"—nanosized bowl shapes that allow inorganic catalysts to operate selectively on particular molecules.

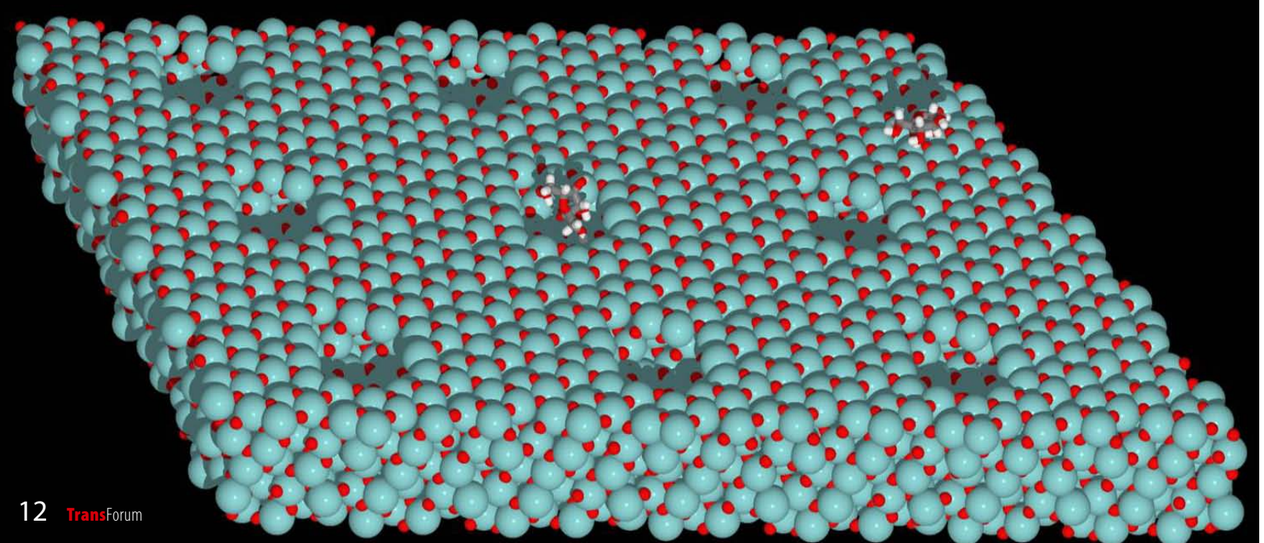
Catalysts are vitally important substances that enable the production of everything from petroleum to soap. In 2009, Argonne and Northwestern, along with the University of Wisconsin at Madison and Purdue University, jointly founded the Institute for Atom-Efficient Chemical Transformations (IACT) to research new catalyst designs that would help improve the efficiency of producing fuels from biomass. IACT is one of the Energy Frontier Research Centers funded by DOE's Office of Science to accelerate research toward meeting our critical energy challenges.

"Nanobowls are intended to mimic the selective enzymes found in nature," said Argonne chemist Jeffrey Elam. "We can tailor the nanobowl size and shape to accept certain molecules and reject others."

Although nanobowls and enzymes both use a lock-and-key mechanism, they serve different purposes and operate in dramatically different environments. "Enzymes are composed of organic materials suitable for the relatively low-temperature, low-pressure environments of living organisms," Elam said. "But the extremely harsh conditions necessary for biomass conversion would cause the enzyme proteins to unravel. In contrast, the nanobowls are inorganic, and this makes them very durable."

> Nanobowls are intended to mimic selective enzymes found in nature

According to Elam, the design's effectiveness correlates with the size and depth of the bowl; if the bowl is too large or shallow, practically any molecule can access the catalyst, which can lead to uncontrolled and often undesirable side reactions. Likewise, if the bowl is too small or deep, even the intended molecule will not fit into the bowl. However, if the nanobowl structure is "just right," only the intended molecule will reach the catalyst and react.



A computer graphic showing a fructose molecule (white, gray and red chain-like structure) within a zirconium oxide nanobowl (at center). Other nanobowls in the array are unoccupied. The red atoms are surface oxygen and the blue atoms are zirconium. Image courtesy of Larry Curtiss, Argonne National Laboratory.

The trick to building a nanobowl with a specific shape and depth is to use a nano-sized template. In the first proof-of-concept nanobowl experiments, bulky organic molecules called calixarenes were used as the template. They were grafted onto a titanium dioxide surface that served as both the catalyst and the "table" for the nanobowl to rest on. Next, the walls of the bowl were built around the template, one atomic layer at a time, using atomic layer deposition (ALD), a technology borrowed from the semiconductor industry. Once the scientists grew the nanobowl to the proper height, they burned away the organic template, leaving behind a cavity with the same shape.

Since the titanium dioxide is in the form of a nanopowder with lots of surface area, the experiment required the scientists to create millions of these nanobowls. Fortunately, the processing techniques that Elam and his colleagues employed can be scaled up so that successful nanobowls identified in these bench-scale studies can eventually have a real-world impact.

> If the nanobowl structure is "just right," only the intended molecule will reach the catalyst and react

The next step, Elam said, involves applying the knowledge gained in these studies to make nanobowl catalysts tailored for biofuel production. "The overarching problem in these reactions is to selectively remove oxygen without breaking carbon-carbon bonds."

Elam and his colleagues also used the 12ID-C X-ray beamline at the laboratory's Advanced Photon Source to characterize the structure of the nanobowls.

The work was reported in the journal *Nature Chemistry*.

Funding for this research was supported as part of the Institute for Atom-Efficient Chemical Transformations, an Energy Frontier Research Center funded by the U.S. Department of Energy's Office of Science.

Jeffrey Elam

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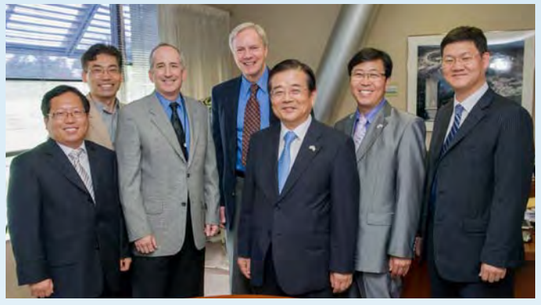
Larry Johnson Retires After 34 Years

Following a 34-year career marked by exceptional nationally and internationally recognized achievements, our colleague and Distinguished Fellow Larry Johnson has retired. Larry served as the director of the Transportation Technology R&D Center at Argonne since its inception in 1998. During his time at the lab, Larry provided the critical technical leadership that fostered and nurtured the growth of major, complex, high-priority programs that positively impacted Argonne's future direction and its mission.

When Larry came to Argonne, the transportation section consisted of six analysts. Through his tireless dedication and wide-ranging work with the U.S. Department of Energy (DOE) and many major automakers and industrial partners, that small program has grown to become one of the largest at the laboratory—with funding of more than $70 million per year. Two of Argonne's major research initiatives have grown from his program: Batteries and Energy Storage, and Sustainable Transportation.



From left: Korean Automotive Technology Institute (KATECH) Director Sung-Jin Choi, Argonne mechanical engineer Kyeong Lee, Argonne Laboratory Director Eric Isaacs, Argonne Transportation Technology R&D Director Larry Johnson, KATECH President Ki-Sub Lee, KATECH Director Chun-Boom Lee, and KATECH Director Baek-Haeng Lee (photo taken in 2009).

Although he is always quick to point out that it is a team effort, Larry's vision and strategic leadership have brought us to where we are today. Argonne's transportation program now spans all four of the laboratory's research directorates, several of the largest divisions, and multiple core areas including theory, testing, modeling, analysis and user facilities. His efforts, and the technical successes that have grown out of them, have positioned Argonne as the nation's lead laboratory for many areas of transportation research including, but not limited to, energy storage, advanced vehicle systems, combustion sciences, life cycle analysis, applied materials, and modeling and simulation. The lab's transportation researchers have won dozens of awards and hold hundreds of patents. In fact, Larry holds one of those patents (in null-flux levitation, suspension and propulsion systems). He has been known to joke that he is the only economist with a patent in maglev transportation.

Because of Larry's international reputation as a thought leader for transportation, DOE relies on Argonne for a critical role in the U.S.-China Electric Vehicles Initiative. Political and technical leadership from the very highest levels in China have sought Larry's technical expertise in transportation. Research agreements with other countries, including India and South Korea, have been fostered under Larry's leadership.

Argonne will miss Larry's long-range vision and foresight into the transportation needs of the nation, and his persistence in building an internationally recognized program.

His transportation research colleagues will miss his astute guidance and advice, his selfless promotion on our behalf and his crazy wicked sense of humor—but most of all we'll miss our daily interactions with a good friend.

Best wishes, Larry!

Research Results

Recent Patents and Technologies Licensed

Licensed

Argonne National Laboratory and California Lithium Battery, Inc., a Los Angeles Cleantech Incubator portfolio company, have signed a licensing agreement for an Argonne-developed, silicon-graphene composite anode material for high-energy lithium batteries. U.S. Patent Pending 13,100,579, "Silicon-graphene Anodes."

New Patents

"Electrochemical Energy Storage Device Based on Carbon Dioxide as Electroactive Species," **Karoly Nemeth**, **Michel Antonius van Veenendaal** and **George Srajer**, United States Patent 8,389,178.

"Surface Stabilized Electrodes for Lithium Batteries," **Michael M. Thackeray**, **Sun-Ho Kang** and **Christopher S. Johnson**, United States Patent 8,383,077.

"Lithium-ion Batteries with Intrinsic Pulse Overcharge Protection," **Zonghai Chen** and **Khalil Amine**, United States Patent 8,367,253.

"Autothermal and Partial Oxidation Reformer-based Fuel Processor, Method for Improving Catalyst Function in Autothermal and Partial Oxidation Reformer-based Processors," **Shabbir Ahmed**, **Dionissios D. Papadias**, **Sheldon H.D. Lee** and **Rajesh K. Ahluwalia**, United States Patent 8,349,035.

"Positive Electrode for a Lithium Battery," **Sang-Ho Park** and **Khalil Amine**, United States Patent 8,338,037.

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

Recent Presentations

"Project-based Learning through Advanced Vehicle Technology Competitions," **Kristen De La Rosa**, presented at the ASEE 2013 Engineering Deans Institute, Manhattan, NY, April 14–16, 2013.

"Effect of Microstructure and Thickness on the Friction and Wear Behavior of CrN Coatings," **C. Lorenzo-Martin**, **O. Ajayi**, **A. Erdemir**, **G. Fenske** and **R. Wei**, presented at the 19th International Conference on Wear of Materials, Portland, OR, April 14–18, 2013.

"Project-based Learning through Advanced Vehicle Technology Competitions," **Kristen De La Rosa**, presented at the ASME International Mechanical Engineering Education Leadership Summit 2013, San Diego, CA, March 16, 2013.

"Cathode Material is Key to Evaluating EV Battery Life Cycle Impacts," **Linda Gaines**, **Jennifer B. Dunn** and **Christine James**, 30th International Battery Seminar and Exhibit, Ft. Lauderdale, FL, March 14, 2013.

Recent Publications

"Thermodynamics and Kinetics of Platinum Dissolution from Carbon-supported Electrocatalysts in Aqueous Media under Potentiostatic and Potentiodynamic Conditions," **Rajesh K. Ahluwalia**, **Srikanth Arisetty**, **Xiaoping Wang**, **Xiaohua Wang**, **Ram Subbaraman**, **Sarah C. Ball**, **Stacy DeCrane** and **Deborah J. Myers**, *Journal of The Electrochemical Society* 160 (4): F447–F455, 2013.

"A Carbon-nanotube-supported Graphene-rich Non-precious Metal Oxygen Reduction Catalyst with Enhanced Performance Durability," **Gang Wu**, **Karren L. More**, **Ping Xu**, **Hsing-Lin Wang**, **Magali Ferrandon**, **Arthur J. Kropf**, **Deborah J. Myers**, **Shuguo Ma**, **Christina M. Johnston** and **Piotr Zelenay**, *Chemical Communications* 49: 3291, 2013.

"New Class of Nonaqueous Electrolytes for Long-life and Safe Lithium-ion Batteries," **Zonghai Chen**, **Yang Ren**, **Andrew N. Jansen**, **Chi-Kai Lin**, **Wei Weng** and **Khalil Amine**, *Nature Communications* 4:1513, 2013.

"Which is Greener: Idle, or Stop and Restart? Comparing Fuel Use and Emissions for Short Passenger-Car Stops," **L. Gaines**, **E. Rask** and **G. Keller**, Proceedings of the 92nd Annual Transportation Research Board Meeting, Washington, DC, January 2013.

"Understanding Long-term Cycling Performance of $Li_{1.2}Ni_{0.15}Mn_{0.55}Co_{0.1}O_2$-Graphite Lithium-ion Cells," **Y. Li**, **M. Bettge**, **B. Polzin**, **Y. Zhu**, **M. Balasubramanian** and **D.P. Abraham**, *Journal of The Electrochemical Society* 160: A3006–3019, 2013.

"Stress Evolution in Composite Silicon Electrodes during Lithiation/Delithiation," **V.A. Sethuraman**, **A. Nguyen**, **M.J. Chon**, **S.P.V. Nadimpalli**, **H. Wang**, **D.P. Abraham**, **A.F. Bower**, **V.B. Shenoy** and **P.R. Guduru**, *Journal of The Electrochemical Society* 160: A739–746, 2013.

"Improving High-capacity $Li_{1.2}Ni_{0.15}Mn_{0.55}Co_{0.1}O_2$-based Cells by Modifying the Positive Electrode with Alumina," **M. Bettge**, **Y. Li**, **B. Sankaran**, **N.D. Rago**, **T. Spila**, **R.T. Haasch**, **I. Petrov** and **D.P. Abraham**, *Journal of Power Sources* 233: 346–357, 2013.

"Atomistic Modeling of the Electrode-Electrolyte Interface in Li-ion Energy Storage Systems: Electrolyte Structuring," **R. Jorn**, **R. Kumar, D.P. Abraham** and **G. Voth**, *Journal of Physical Chemistry* C 117: 3747, 2013.

"Electrochemical Modeling of a Lithium-ion Positive Electrode Single Particle," **D.W. Dees**, **K.G. Gallagher**, **D.P. Abraham** and **A.N. Jansen**, *Journal of The Electrochemical Society* 160: A478–486, 2013.

"Evaluation of Efficiency and Drive Cycle Emissions for a Hydrogen Direct Injection Engine," **T. Wallner**, **R. Scarcelli**, **N.S. Matthias** and **J. Kwon**, Proceedings of the Institution of Mechanical Engineers, Part D, *Journal of Automobile Engineering* 227 (1): 99–109, 2013.

"Setting a Best Practice for Determining the EGR Rate in Hydrogen Internal Combustion Engines," **S. Verhelst**, **J. Vancoillie**, **K. Naganuma**, **M. De Paepe**, **J. Dierickx**, **Y. Huyghebaert** and **T. Wallner**, *International Journal of Hydrogen Energy* 38 (5): 2490–2503, 2013.

"Blend Ratio Optimization of Fuels Containing Gasoline Blendstock, Ethanol, and Higher Alcohols (C3-C6): Part I — Methodology and Scenario Definition," **K. Lawyer, A. Ickes**, **T. Wallner**, **D. Ertl**, **R. Williamson**, **S. Miers** and **J. Naber**, Proceedings of the SAE World Congress, Detroit, Mich., April 16–18, 2013.

"Blend Ratio Optimization of Fuels Containing Gasoline Blendstock, Ethanol, and Higher Alcohols (C3-C6): Part II — Blend Properties and Target Value Sensitivity," **K. Lawyer, A. Ickes**, **T. Wallner**, **D. Ertl**, **R. Williamson**, **S. Miers** and **J. Naber**, Proceedings of the SAE World Congress, Detroit, Mich., April 16–18, 2013.

"Multi-component Alcohol Blends: A Case Study to Address the Ethanol Blend Wall Challenge," **A. Ickes**, **T. Wallner** and **K. Lawyer**, Proceedings of the International Symposium on Alcohol Fuels, Cape Town, South Africa, March 25–27, 2013.

"Development of Film-on-Foil Ceramic Dielectrics for Embedded Capacitors for Power Inverters in Electric Drive Vehicles," **Balu Balachandran**, **Manoj Narayanan**, **Shanshan Liu** and **Beihai Ma**, *Japanese Journal of Applied Physics* (in press).

Recent Publications continued

"Dense PLZT Films Grown on Nickel Substrates by PVP-modified Sol–gel Method," **Beihai Ma**, **Sheng Chao**, **Manoj Narayanan**, **Shanshan Liu**, **Sheng Tong**, **Rachel E. Koritala** and **Balu Balachandran**, *Journal of Material Science* 48:1180–1185, 2013.

"Electrical Properties of $Pb_{0.92}La_{0.08}Zr_{0.52}Ti_{0.48}O_3$ Thin Films Grown on $SrRuO_3$ Buffered Nickel and Silicon Substrates by Chemical Solution Deposition," **Manoj Narayanan**, **Beihai Ma**, **Sheng Tong**, **Balu Balachandran** and **Rachel Koritala**, *International Journal of Applied Ceramic Technology* 9 (1): 45–51, 2012.

"Temperature Dependent Polarization Switching Properties of Ferroelectric $Pb_{0.92}La_{0.08}Zr_{0.52}Ti_{0.48}O_3$ Films Grown on Nickel Foils," **Beihai Ma**, **Zhongqiang Hu**, **Shanshan Liu**, **Manoj Narayanan** and **Balu Balachandran**, *Applied Physics Letters* 102: 072901, 2013.

"Residual Stress of $(Pb_{0.92}La_{0.08})(Zr_{0.52}Ti_{0.48})O_3$ Films Grown by Sol-Gel Process," **Beihai Ma**, **Shanshan Liu**, **Sheng Tong**, **Manoj Narayanan**, **Rachel E. Koritala**, **Zhongqiang Hu** and **Balu Balachandran**, *Smart Materials and Structures* (in press).

"Estimation of Intrinsic Contribution to Dielectric Response of $Pb_{0.92}La_{0.08}Zr_{0.52}Ti_{0.48}O_3$ Thin Films at Low Frequencies using High Bias Fields," **Manoj Narayanan**, **Sheng Tong**, **Shanshan Liu**, **Beihai Ma** and **Balu Balachandran**, *Applied Physics Letters* 102: 062906, 2013.

"Lead Lanthanum Zirconate Titanate Ceramic Thin Films for Energy Storage," **Sheng Tong**, **Beihai Ma**, **Manoj Narayanan**, **Shanshan Liu**, **Rachel Koritala**, **Balu Balachandran** and **Donglu Shi**, *ACS Applied Material Interfaces* 5: 1474–1480, 2013.

"Cost Effective Annual Use and Charging Frequency for Four Different Plug-in Powertrains," **D.J. Santini**, **T.S. Stephens**, **N. Kim**, **Y. Zhou** and **K.G. Gallagher**, Paper 2013-01-0494, Proceedings of the SAE World Congress, Detroit, Mich., April 16–18, 2013.

"Positive Electrode Passivation by LiDFOB Electrolyte Additive in High-capacity Lithium-ion Cells," **Y. Zhu**, **Y. Li**, **M. Bettge** and **D.P. Abraham**, *Journal of The Electrochemical Society* 159: A2109–2117, 2012.

"A Volume Averaged Approach to the Numerical Modeling of Phase-transition Intercalation Electrodes Presented for Li_xC_6," **K.G. Gallagher**, **D.W. Dees**, **A.N. Jansen**, **D.P. Abraham** and **S.-H. Kang**, *Journal of The Electrochemical Society* 159: A2029–2037, 2012.

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

Argonne Teams with FedEx Express to Test E-Trucks

Argonne's Advanced Vehicle Testing group has been selected to test two of the most popular electric truck (E-truck) models in its Advanced Powertrain Research Facility (APRF) and to collect performance data under various operating conditions. The E-trucks, provided by FedEx Express (FedEx), are models used in their package delivery operations: the Navistar E-Star® and the Smith Electric Newton® Stepvan.

E-trucks are a viable alternative for many commercial vehicle applications because they can meet many urban duty cycle requirements while using zero petroleum. Batteries provide all the energy for the electric motors that power the truck. Depending on the weight they are carrying and their energy storage capacity, current E-truck models can cover 50 to 100 miles per charge.

Argonne researchers will perform comparative performance tests on the two electric trucks and an Isuzu Reach®, a lighter-weight standard diesel-powered delivery truck with a composite body. Data will be collected while driving a customized cycle representative of all the speeds and loads encountered in typical inner city deliveries, plus testing with some standard drive cycles developed by the U.S. Environmental Protection Agency (EPA). The E-trucks' electric energy consumption will be measured at various ambient temperatures to simulate real-world operating conditions, including measurement of the energy consumed in truck cab heating and cooling. The trucks will be tested with various payload weights to match daily operations.

Argonne mechanical engineer Kevin Stutenberg plugs in the FedEx electric truck to recharge its batteries following testing.

Argonne will also install instrumentation in the trucks that can transmit the performance data to the FedEx operations office, enabling FedEx to monitor vehicle energy consumption during in-service deliveries.

The data Argonne collects will help determine the total cost of operating an E-truck fleet. All aspects of vehicle use will be tracked—from the cost of the electricity, to down time for recharging the batteries, to total range. This analysis will provide fleet operators like FedEx the information needed to support future investments in E-trucks.

The success of the E-truck market will depend on how well it overcomes key technology and market barriers to adoption, including cost, performance validation and vehicle quality issues. Argonne's testing program is designed to help address some of these potential barriers, and to provide technical support and direction for determining their solutions.

Funding for this project is provided by the U.S. Department of Energy and FedEx Express.

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

Argonne-BRP Collaboration Evaluates Butanol-Extended Fuels for Marine Applications

Bombardier Recreational Products, Inc. (BRP), is testing a butanol-extended fuel in a variety of recreational marine engines in collaboration with Argonne National Laboratory and with support from the National Marine Manufacturer's Association (NMMA) and the American Boat and Yacht Council (ABYC). The U.S. Environmental Protection Agency recently approved the use of E15—a blend of 85 percent gasoline and 15 percent ethanol—for vehicles newer than model year 2001. However, because E15 can damage marine engines and components, up to 16 percent butanol is seen as a promising ethanol substitute for marine applications.

With oversight from Argonne and the U.S. Department of Energy, the project is evaluating several types of recreational marine inboard and outboard engines from several engine manufacturers in both laboratory settings and on-water trials to determine the effects of butanol-extended fuel on engine power, performance, emissions and overall durability.

Funding for this work is provided by the U.S. Department of Energy's Vehicle Technologies Office.

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

Above, researchers testing a new butanol fuel blend for marine engines in the Chesapeake Bay area aboard an Alamar test craft equipped with a 5.7-liter Volvo Penta GXi engine. Left to right, student Jim Sevik (now with Electro-Motive Diesel), John McKnight of the NMMA, Rich Waggoner of Indmar Marine Engines, Rich Kolb of Volvo Penta, Jerry Oliver of BRP, Jeff Wasil of BRP and Brian Goodwin of the ABYC.

General Motors to Co-Sponsor 11th Advanced Vehicle Technology Competition

The U.S. Department of Energy (DOE) has selected General Motors (GM) as its co-headline sponsor for the 11th Advanced Vehicle Technology Competition (AVTC) series that will kick off in Fall 2014. Argonne established the AVTC program with DOE in 1988. In the years since, more than 16,500 alumni from 91 different universities in North America have participated in the competition series.

Through this program, DOE and Argonne help accelerate the development and demonstration of promising automotive technologies, and train and educate future leaders who will help bring these technologies to market. The AVTC program allows college engineering students to gain real-world, hands-on experience while tackling the challenges associated with building more fuel-efficient vehicles.

Competition participants will work with General Motors-donated production vehicles to improve their energy efficiency and meet the toughest emissions standards, while maintaining performance, consumer acceptability and safety. Data collection is an important aspect of the competition, as students learn to measure real-world performance of the advanced technologies used and to benchmark their developmental status.

The 11th AVTC series began in May 2013 with a Request for Proposals to select new institutional participants. Competition organizers expect that 15 to 17 university teams from across North America will be selected to participate, based on evaluations of team proposals from the pool of applicants.

For more information on the competition, including a video documenting the current AVTC *EcoCAR 2: Plugging In to the Future* and this year's 25th anniversary celebration, visit www.avtchistory.org.

For information on Argonne's participation, contact Kristen De La Rosa, kdelarosa@anl.gov.

EcoCar 2 teams gathered for Year Two Competition in May at the General Motors Desert Proving Grounds in Yuma, Arizona (seen here), and at locations throughout San Diego, California, to compete in more than a dozen technical, communications and business events. Throughout the ten-day competition, teams put the vehicles through engineering tests similar to those conducted by the automotive industry to determine a prototype's readiness for production, and ultimately prove the viability of their advanced technology vehicles.

Argonne and KIAT to Partner in Transportation Technology Research

Argonne and KIAT (Korea Institute for Advancement of Technology) have entered into a memorandum of understanding (MOU) to partner in the development of advanced transportation system technologies. The MOU was signed by Argonne Director Eric Isaacs and KIAT President Yong-Geun Kim and finalized on October 16, 2012.

Argonne and KIAT will cooperate in technical areas related to automotive transportation systems (including diesel emissions control systems), exchange publicly available research data and schedule visits to both countries to enable collaboration. The partners will also discuss cooperation in other mutually agreed-upon transportation technology areas and identify detailed research subjects of interest and benefit to the auto industry in both countries.

KIAT President Yong-Geun Kim (left) joins Argonne's Deputy Laboratory Director Mark Peters to finalize the MOU between KIAT and Argonne.

Information exchange is an important part of the agreement, and the partners have agreed to discuss technical issues related to emerging technologies that may result in unique solutions to current problems in industry. In addition, Argonne and KIAT will promote the commercialization of energy-efficient engineering technologies in both countries.

KIAT was founded by the Korea Ministry of Knowledge Economy to explore and support emerging technologies.

For more information, contact Kyeong Lee, klee@anl.gov.

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Fastrax

Ann Schlenker Featured in Spotlight Video

Ann Schlenker

Ann Schlenker, Director of Argonne's Center for Transportation Research, talks about advanced vehicle research, mentoring and working at Argonne on an Argonne's Employee Spotlight video. Watch the video at http://tinyurl.com/cs4bbj2. Recently, Schlenker introduced President Barack Obama when he spoke at a White House press conference staged in Argonne's Advanced Powertrain Research Facility on March 15, 2013.

Jim Miller Named Energy Rock Star

Electrochemical engineer **Jim Miller** was recently named an Energy Rock Star by the U.S. Department of Energy for his hard work in planning, communicating and executing the EV Everywhere workshops, EV Everywhere Grand Challenge and continued work in vehicle technologies. The award was presented at a celebratory coffee with EERE Assistant Secretary David Danielson held on January 16 to recognize Jim's achievements.

TransForum Named Chicago STC Best of Show

TransForum, this newsmagazine, was recently awarded a 2012 Best of Show award from the Society for Technical Communication, Chicago Chapter. The award is given for distinguishing excellence in a publication communicating technical or scientific information. A crystal trophy was presented to Cindi Andersen (communications designer), Jim Collins (writer/editor) and Else Tennessen (writer/editor) at a banquet on March 22, 2013, to mark this achievement. To view all issues of *TransForum*, visit http://tinyurl.com/aw3rwjs.

Ted Bohn Named SAE J2953 Committee Chairperson

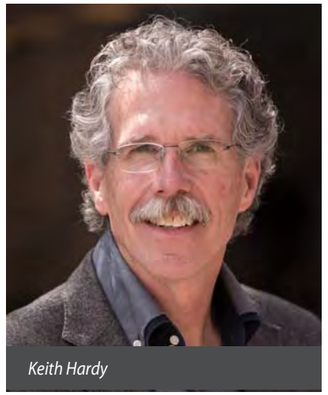
Ted Bohn is the new chairperson of the committee developing the SAE J2953 Electric Vehicle-EV Supply Equipment Interoperability standard. The SAE J2953 standard supports other related standards to ensure a method of validating compliance assumptions and generating test cases to investigate those areas where interoperability of charging system elements tend to fail. Assuring interoperability of the wide variety of charging equipment types, manufacturers and utility communications will aid in creating a positive user experience that will contribute to greater deployment of electric mobility in the United States and Europe.

ARG-US Wins Industry Award for Innovation in RFID Technology

Argonne's ARG-US radio-frequency identification (RFID) technology recently received the Association for Automatic Identification and Mobility's (AIM's) first-ever Active RFID Award. ARG-US provides tools for real-time tracking and monitoring of nuclear and other hazardous materials during storage, processing, transportation and disposal.

Known as the "Watchful Guardian," the ARG-US system consists of customizable long-life RFID sensor tags, readers and software that Argonne developed for the U.S. Department of Energy and patented in September 2011. ARG-US offers benefits that enhance the environmental health, safety and protection of materials and personnel in operations involving sensitive nuclear and other radioactive materials, streamlining information management and inventory control and extending the lifetime maintenance cycles of storage drums.

AIM established the Active RFID Award to capture successful RFID case histories of actual installations that have proven measurable benefits, increase RFID technology demand and have the potential to accelerate RFID adoption. "We are extremely honored to be selected by the leading RFID organization for our ARG-US applications," said principal investigator **Yung Liu**, Group Leader in Argonne's Decision and Information Sciences division.



Keith Hardy

Argonne Participates In New SAE Plug-in Hybrid Standard

Ted Bohn, **Jason Harper** and **Keith Hardy** participated in the formulation of SAE International's much-anticipated technical standard for plug-in hybrid electric vehicles and electric vehicles published in October 2012. Developed in a consensus environment by more than 190 global experts representing automotive, charging equipment, utilities industries and national labs, the standard, called *J1772™: SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Couple*, enables charging time to be reduced from as long as eight hours to as short as 20 minutes.

Argonne Researchers Share Top ASME Honors

F. Zak Tilocco, former Argonne co-op student and Kettering University senior, shared top honors for undergraduate research at the recent 2012 ASME Internal Combustion Engine Division Fall Technical Conference in Vancouver, British Columbia. The research project was part of his professional co-op experiences at Argonne. He shared the research credit with his Argonne supervisors **Alan L. Kastengren** and **Christopher F. Powell**. All work was performed at Argonne's Transportation R&D division, which was led by Kettering University Trustee and former Director of Argonne's Transportation Technology R&D Center, **Larry Johnson**.

Argonne Researchers Receive IMAPS Best Paper Award

Beihai Ma, **Manoj Narayanan**, **Shanshan Liu**, **Sheng Tong** and **Balu Balachandran** received a Best Paper Award at the 45th International Symposium on Microelectronics (IMAPS 2012), Sept. 9–13, 2012, in San Diego, Calif. Their paper was titled, "Development of High Dielectric Strength Ceramic Film Capacitors for Advanced Power Electronics."

Thomas Wallner Chairs SAE Sessions

Thomas Wallner attended the 2012 SAE International Powertrains, Fuels and Lubricants Meeting in Malmo, Sweden, and chaired sessions on "Advanced Vehicle Technology Competitions," "Gaseous Fueled Engines and Vehicles" and "Fuel/Additive Effects on SI Engine Performance," held on September 18–20, 2012.

Jason Harper Receives Early Career Alumni Award

Electrical engineer **Jason Harper** has received the 2013 Early Career Alumni Award from Purdue University, his alma mater. The award is given on an annual basis to an alumnus who has elevated the University and College by using his or her education to improve and move the world forward.

Harper's current research involves power line communication (PLC) technology and plug-in electric vehicle (PEV) communication protocols. Harper has been asked to meet and discuss PLC testing and SAE standards implementation with a variety of U.S. national laboratories and companies including Maxim, Qualcomm Atheros, EPRI, BTC Power, Chrysler, Ford and General Motors. He is also the author of numerous journal articles and holds two patents.

Jason Harper

Henning Lohse-Busch Connects with EcoCAR 2

Advanced Vehicle Technology Competition (AVTC) alumnus and Argonne research engineer **Henning Lohse-Busch** found a way to stay connected to the EcoCAR 2 program long after graduation. Formerly a Team Leader on Virginia Tech's FutureTruck team, Henning currently dedicates his time to AVTCs as a judge and event captain. Watch his video interview on the *Green Garage Blog* at http://tinyurl.com/bqb2zkv.

Media Highlights

***Forbes:* Can Caesar Rescue Obama's Energy Legacy?** **George Crabtree**, Director of the Joint Center for Energy Storage Research (JCESR), was quoted in a Forbes article about JCESR's efforts to advance battery technology beyond today's state-of-the-art lithium-ion batteries. JCESR will research, develop and build prototypes of batteries that combine three promising technologies that exist but are under-explored. "All three of these ideas have enormous potential," Crabtree said. "They're not very well understood, and not many people are working on them because 90 percent of battery people are working on lithium-ion batteries." Headquartered at Argonne, JCESR has 13 major partners, including four other national laboratories, five midwestern universities, three private companies—including Dow Chemical—and an incubator, the Clean Energy Trust. Read the complete article at **http://tinyurl.com/m3fhj3h**.

George Crabtree

***The Atlantic:* The Sequester Is Going to Devastate U.S. Science Research for Decades.** Argonne Director **Eric Isaacs** was one of three national laboratory directors warning about the long-term consequences of cuts to federal science funding that will result from the sequestration. The group warned that the severe impact of the automatic spending cuts will only be felt years—or even decades—in the future, when the nation begins to feel the loss of important new scientific ideas that now will not be explored, and of brilliant young scientists who now will take their talents overseas or perhaps even abandon research entirely. Read the complete article at **http://tinyurl.com/b6f4h2g**.

Eric Isaacs

***Yahoo News:* Electric Vehicle Market Looks for a Recharge.** Finding an advanced battery that comes in the perfect package—high in energy density, small in size and lower in price—remains one of the largest hurdles to getting more electric vehicles on the road. "If we want to change things dramatically in the next 10 years, we have to find a new material set—a new cathode–anode electrolyte set that will hopefully decrease the cost and increase energy density," says **Venkat Srinivasan**, deputy director of the Joint Center for Energy Storage Research (JCESR). "If we can achieve that, something dramatic would happen and significantly change the penetration curve." JCESR was established in 2012 at Argonne with the far-reaching goal of finding batteries with five times the current energy storage at one-fifth the price in five years. Read the complete article at **http://tinyurl.com/cq6q8o9**.

Venkat Srinivasan

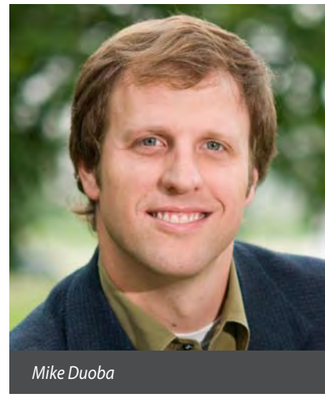
***Washington Post:* U.S. Bringing Green Vehicle Technology to Auto Racing.** **Forrest Jehlik**, a research engineer at Argonne, was featured in an article about the Green Racing initiative of the U.S. Department of Energy, the U.S. Environmental Protection Agency and SAE International. Jehlik's cutting-edge research has taken him into the world of auto racing through a public-private initiative that uses motorsports to promote advanced vehicle technologies and nonpetroleum fuels that can be used on high-speed race tracks. The aim of this Green Racing program, according to Jehlik, is to make racing cars more fuel efficient and environmentally friendly, and hopefully to transfer the new technology to the commercial market. Read the complete article at **http://tinyurl.com/af5s8ar**.

Forrest Jehlik

***Batteries International:* The Bottom Line—Costs vs. Benefits.** Argonne researcher **Linda Gaines** discussed the costs, benefits and challenges associated with recycling lithium-ion battery materials. Gaines explained that, because of evolving battery chemistries, it is difficult to know the future value of any given cathode material. She also described Life Cycle Analysis, a method Argonne uses to estimate energy use and environmental impacts for a given product. Read the complete story on page 77 of **http://tinyurl.com/mhptl4a**.

Linda Gaines

***Breaking Energy:* Fuel Economy Ratings Fall Short for EVs.** According to **Mike Duoba**, Argonne Vehicle Systems Research Engineer, the U.S. Environmental Protection Agency's fuel economy measurement system fails to factor in several metrics that could shed light on the fuel efficiency of electric and plug-in hybrid electric vehicles. Fuel economy data for all vehicles are provided in miles per gallon. For some alternative fuel vehicles, that makes sense, but in the case of electric vehicles and plug-in hybrids, it can ignore considerations that might factor into a consumer's cost-benefit analysis, according to Duoba. "For CNG [compressed natural gas], and maybe ethanol, as well, there are some merits to saying 'here's the mpg equivalent,'" Duoba told *Breaking Energy*. "What they've done for electric cars is to extend that same process, but it's a little bit different when you compare thermal energy and fuel," he said. Read the complete story at **http://tinyurl.com/maaltjh**.

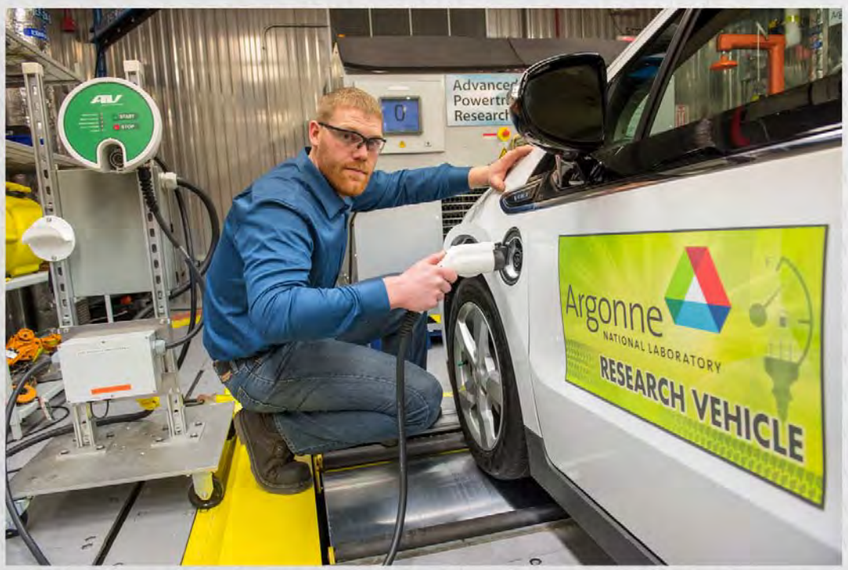


Mike Duoba

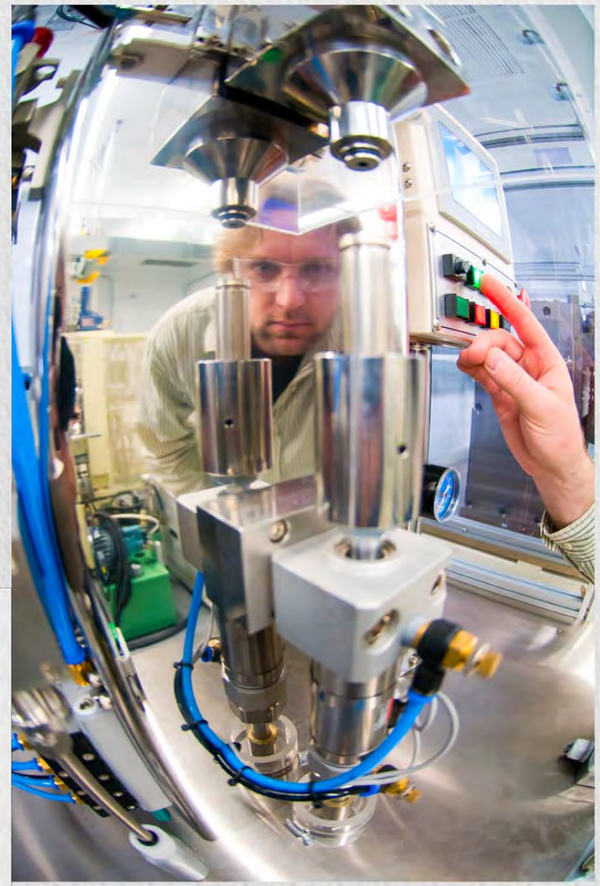
For complete Argonne transportation research press coverage, visit http://www.transportation.anl.gov/media_center/press_coverage.html.

Parting Shots

Below: Ann Schlenker welcomes President Barack Obama to Argonne National Laboratory on March 15, 2013. The president toured the Transportation research area; spoke to vehicle test, combustion and battery principal investigators; and filmed three of his weekly White House remarks.

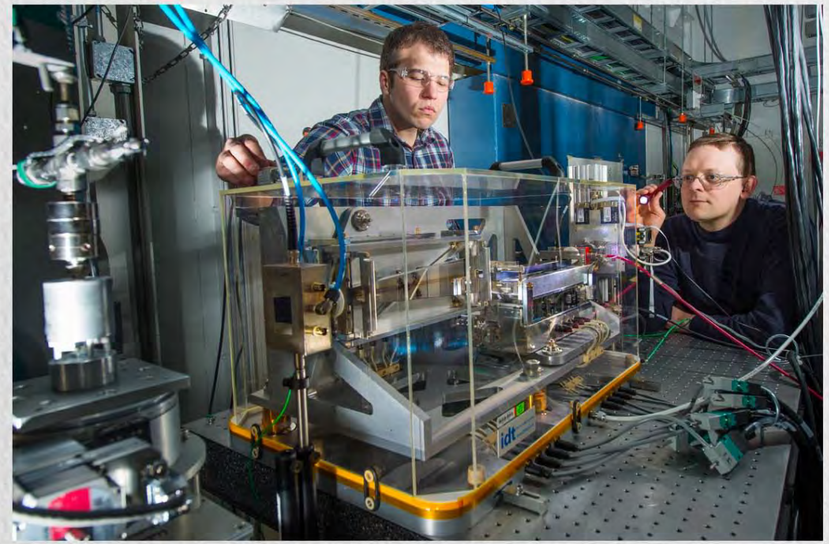


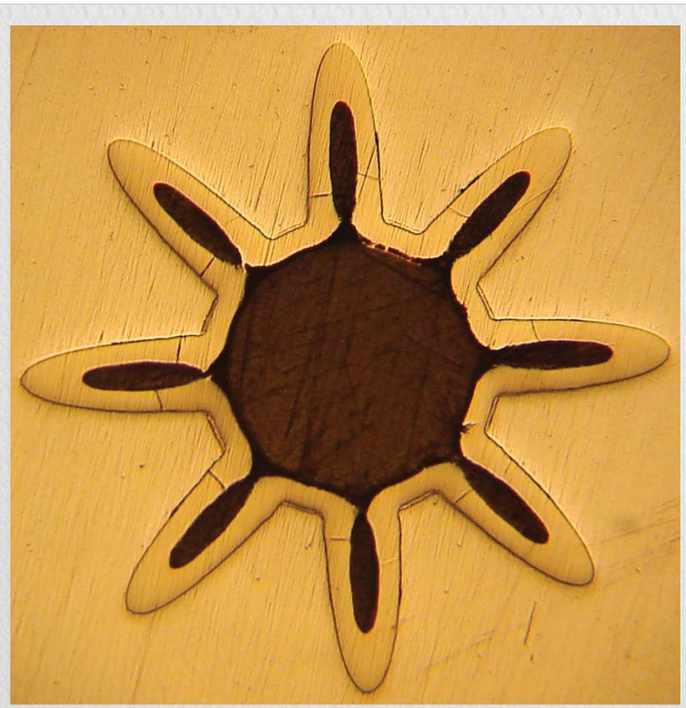
Left: Kevin Stutenberg plugs in electric vehicle supply equipment to charge the battery of a Chevrolet Volt in the thermal test chamber at Argonne's Advanced Powertrain Research Facility. Argonne researchers conduct vehicle component tests to monitor electrical energy use and optimize the energy efficiency of plug-in electric vehicles.



Above: Bryant Polzin fills a lithium-ion prototype cell with electrolyte at Argonne's Cell Fabrication Facility, which is housed in a 500-square-foot dry room. With moisture content less than 100 parts per million, the atmosphere in the dry room plays a critical role in the assembly and performance of a finished cell.

Right: Andrew Swantek (left) and Alan Kastengren inspect the X-ray focusing optics at the Vehicle Technologies beamline at Argonne's Advanced Photon Source. The beamline uses one of the world's brightest sources of X-rays to study fuel injection and sprays. Optimizing the fuel injection promotes better fuel and air mixing, leading to engines with improved efficiency and lower emissions.





Above: Fuel Injector Flower (Photo by Nicholaos Demas)

The nozzle of the fuel injector in a car sprays gasoline through tiny holes, designed to create as fine a mist as possible so that the fuel burns better. Researchers at Argonne, attempting to make the engine even more efficient, reduced the size of the holes to less than the size of a single human hair. This is a nozzle with eight holes—polished from the tip down to reveal a flower-like pattern—as seen under a microscope. The dark areas are the holes, the yellow area is the iron nozzle, and the petals are the nickel-phosphorous material used to reduce the size of the holes.

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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 costs 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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