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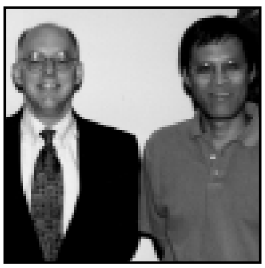
Summer 1998

TransForum

News From Argonne's Transportation Technology R&D Center



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Using Corn to Fuel Your Car: A Good Environmental Choice?

DOE technology assessments evaluate use of ethanol as a vehicle fuel

New vehicle technologies are one way to save the planet, but which strategy will offer the most benefit for the smallest trade-off? How do you even compare these diverse options? Argonne researchers are using a method called "full-fuel-cycle assessment" to evaluate the effects of using different alternative fuels. One alternative fuel seems to have some real advantages. Recent analyses show that using E85, a blend of 85% ethanol and 15% gasoline, reduces both greenhouse gas emissions (by 16-28%) and petroleum use (by 73-75%) as compared with using gasoline.

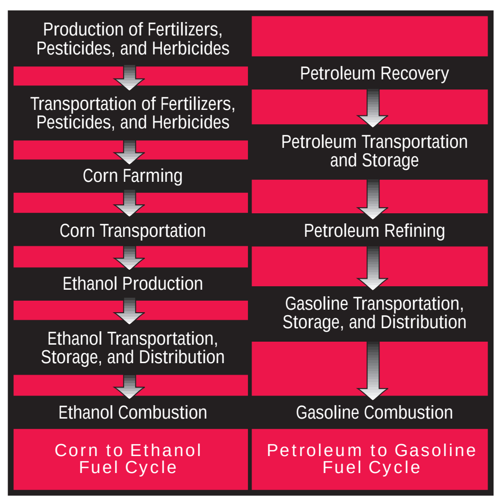
Marcy Rood (DOE-Clean Cities), David Rodgers (DOE-OTT), and Michael Wang (Argonne).

Argonne's assessments, sponsored by the U.S. Department of Energy (DOE), compare all the energy used and emissions resulting from each step in the production and use of a particular fuel (see diagram). David Rodgers, director of DOE's Office of Technology Utilization, finds that "technology assessments form an important part of DOE's regulatory and strategic planning. When assessing both the R&D and deployment needs of various alternative fuels, we need to know how much oil will be displaced, what the environmental impacts will be, the costs, and many other things. The assessments allow us to compare various fuels against each other on a life-cycle basis. In many cases, the assessments point out that certain fuels have strengths in one area, such as reduced carbon emissions, while others may be stronger in other areas."

An Argonne-developed model called GREET (Greenhouse gas, Regulated Emissions, and Energy use in Transportation) calculates total energy use and emissions per vehicle mile traveled, based on the full fuel cycle. Rodgers finds the model useful in several ways: "We use GREET both to answer questions about specific fuels and to compare the use of alternative fuels with other advanced transportation technologies, such as hybrid electric vehicles. This allows us to evaluate the relative energy and environmental benefits of a variety of transportation technologies."

Data for the ethanol studies were gathered from experts from the U.S. Department of Agriculture, universities, and authorities in the field of ethanol plant engineering, design, and operation. On a per-mile basis, corn-based ethanol outperformed both conventional and reformulated gasoline in energy use and greenhouse gas emissions. Rodgers explains: "The ethanol studies are important because DOE and many stakeholders believe that ethanol will be critical to a sustainable transportation system. Ethanol offers so many benefits and can be made from different feedstocks. Each feedstock has a different energy and environmental profile. So, in addition to comparing ethanol with other alternative fuels, we use the assessments to compare ethanol made from different feedstocks."

Rodgers concludes: "Argonne has done a great job at involving DOE and other stakeholders in the design and peer review of the alternative fuel models and assessment tools. DOE is supporting Argonne's responses to those who are seeking Argonne's help in applying the models at the local community level, for example, by the Clean Cities Program. I expect that in the next few years, other federal and state agencies and other organizations will be seeking to use these assessment tools. DOE and Argonne have to be ready to allocate resources to maintain and upgrade the models. I want to thank the Argonne team that has worked so hard on developing these important tools and will be working with us to promote their use."



From Wells to Wheels: total energy use and emissions from each stage in the production and use of fuels are used to evaluate different advanced vehicle technologies.

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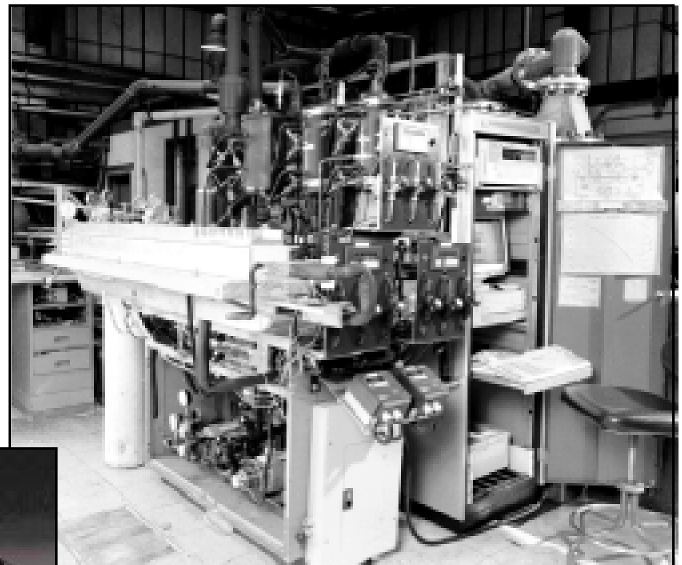
If You Can't Stand the Heat…Call Argonne

New compact heat exchanger keeps drivers and engines running cooler

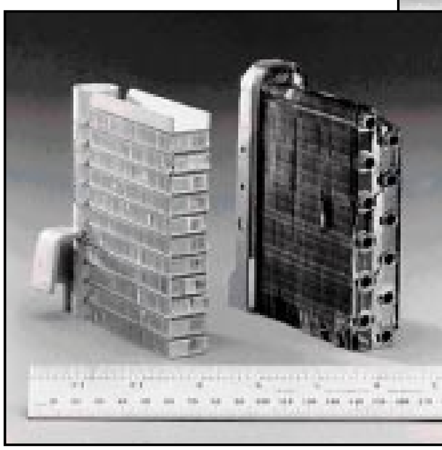
Thermal management technologies — including devices designed to manage the heat generated during combustion in a conventional engine — affect almost every aspect of automobile performance, from driver comfort to fuel economy, aerodynamics, and maintenance. Improved heat exchangers and heat transfer devices in vehicles have

- Reduced size and weight, which allow for more aerodynamic styling and improved fuel economy
- More effective cooling, which enables use of new, lightweight materials that otherwise could not withstand the high temperatures under the hood
- Increased component life



Argonne's small-channel condensation heat-transfer test apparatus.

Argonne is working to improve heat transfer technologies for the automotive industry. In a recent program, Argonne helped Modine Manufacturing (Racine, WI) to improve the performance of its energy-saving parallel-flow (PF) air conditioning condensers. Researchers investigated condensation in the small channels, including the effects of channel size and geometry on heat transfer, and provided developed from the data, to make the condensers smaller, lighter, more efficient, and less expensive than other condensers on the market. Modine's popular PF heat exchangers (air-conditioner condensers and oil coolers) are being used by vehicle manufacturers, such as Chrysler, for high-performance, compact cooling.



Microchannel heat exchanger.

In another program, Argonne is studying thermal management technologies in heavy vehicles, evaluating the current state of the art and identifying opportunities for improvement. Researchers are reviewing the literature and have met with manufacturers of heat exchangers, trucks, and diesel engines. According to Argonne's Martin Wambsganss, "The smaller the better — although a few ounces or inches may not seem like much compared to the size and weight of a multiton truck, all these little weight and space savings add up, allowing for more cargo, better fuel efficiency, and lower operating costs."

Engineers have known for years that phase change (i.e., evaporation and condensation) is the most efficient method of heat transfer. But the method has not typically been used by automotive manufacturers because of the potential for dryout and "hot spots." Wambsganss believes that, with today's more sophisticated sensors and controls, coupled with an improved understanding of flow boiling in small channels, now may be the perfect time to incorporate phase-change heat-transfer technologies into automotive and truck engine cooling systems.

More research is needed to develop heat exchangers and heat transfer devices that are compact, lightweight, reliable, and inexpensive; have a low fluid inventory; use advanced materials and environmentally friendly fluids; and require minimum pumping power. Much of this research is under way — with the help of industrial partners such as Modine, phase-change heat-transfer techniques may someday be used routinely to improve cooling systems and overall vehicle performance.

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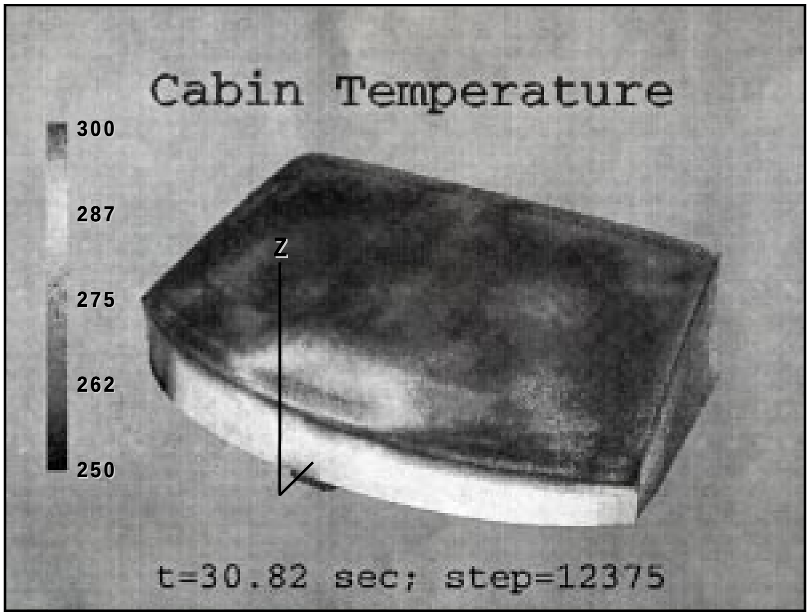
Modeling Cars Isn't Just Child's Play

Supercomputing applications speed automotive design

Argonne National Laboratory is playing an important role in the success of the United States Council for Automotive Research (USCAR) Supercomputer Automotive Applications Partnership (SCAAP). SCAAP is a government/ industry research partnership in which Chrysler, Ford, and General Motors are teaming with Argonne and four other U.S. Department of Energy research laboratories to bring advanced modeling and massively parallel supercomputing to automotive design engineers.



Computer modeling shows windshield defrosting patterns.

"Parallel supercomputing and advanced modeling will significantly speed the arrival of improved automotive design to market," said David Weber, SCAAP project leader for Argonne.

Massively parallel supercomputing simultaneously engages many central processing units to compute the behavior of complex automotive systems with thousands of computational cells. SCAAP's modeling calculations at the Argonne computing center busied as many as 64 central processing units, and most exercises took about one day. Had the algorithms been handled sequentially, as in traditional computing, they would have taken weeks to process.

SCAAP's efforts have focused on the development of computer codes that enable massively parallel supercomputing to be used in vehicle design: one code "crash-tests" composite frame components without damaging real cars, the other models airflow inside the vehicle passenger compartment.

The capability to model composite materials developed by SCAAP allows the simulation of the energy-absorption impacts on automobile frame parts made of various lightweight combinations of continuous strand mat and braided composites. Car manufacturers have long been looking for ways to make cars lighter to help boost fuel efficiency. But their challenge has been to do it without sacrificing safety. Using the SCAAP models, designers will be able to optimize frame designs by selectively placing lighter materials at sections of the frame that the modeling concludes are noncritical.

Automotive engineers model passenger-compartment airflow to achieve enhanced climate control and efficient windshield deicing in their designs. By predicting airflow patterns as it exits a duct, for example, duct design can be modified to improve air distribution and enhance passenger comfort. Convenience and safety are the benefits car makers are seeking by improving climate control and speeding up windshield deicing.

A new research partnership has been formed to continue SCAAP's work. Argonne and Oak Ridge National Laboratory, with assistance from Los Alamos National Laboratory, will again join the Big Three, and this time a commercial software company, Adapco, is being added. The group's goal is to adapt the airflow modeling programs developed by SCAAP for designing better systems for underhood thermal management.

"Massively parallel computing and advanced modeling open up new possibilities for broadening the applications of our research beyond the automotive," says Weber. He notes that fluid dynamics modeling can be adapted to study coolant flow in nuclear reactors, for example.

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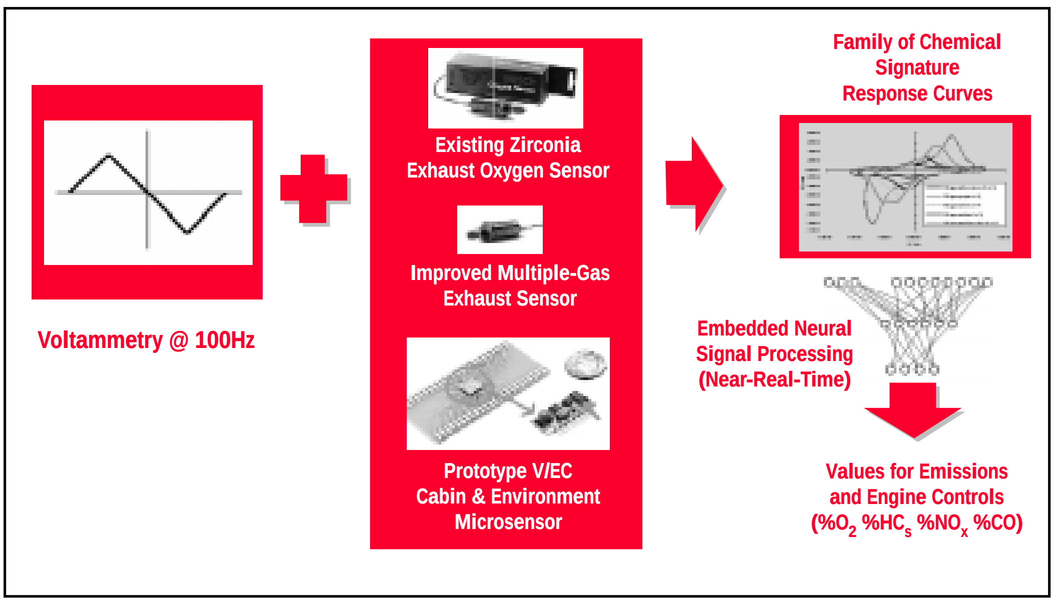
Lilliputian Sensors Could Help Solve a Gigantic Pollution Problem

Sturdy microsensor system detects specific chemicals in vehicle emissions

An advanced sensor that Argonne has developed for military use has the potential not only to reduce vehicle exhaust emissions but perhaps eventually to save lives. Argonne's voltametric/electrocatalytic chemical microsensor is a unique package, smaller than a thimble, that incorporates a tiny sensor only a few millimeters in size, a voltametric gas measurement method, and a neural-network pattern-recognition technique. Being developed now in two programs for the U.S. Department of Defense to detect constituents in fires and to identify chemical warfare agents, the microsensors could be effectively and inexpensively used in automobiles to identify and measure a wide variety of chemicals present in exhaust and engine emissions, including oxygen, carbon monoxide, carbon dioxide, nitrogen oxides, and all types of hydrocarbons. Their use could improve fuel economy and engine efficiency, satisfy government requirements for vehicle sensors that will help reduce pollutant emissions, and ultimately contribute to a cleaner environment.



This new sensor system is similar to the one already being used to determine oxygen levels in vehicles. But current sensor systems react passively — they infer air-to-fuel ratios and hydrocarbon emissions from oxygen measurements. When a narrow threshold range has been crossed, the sensor system simply detects that the car is running too lean or too rich. A general condition of failure is indicated when the "check engine" light goes on. The new microsensors can tell which chemicals are present and how much of each is being emitted. They employ an active measurement method, in which voltage is driven across the sensor to force normally nonreactive chemicals to react. A complex signal pattern results. These difficult-to-see patterns can be easily interpreted by the system's neural network pattern recognition program. Specific data are available in milliseconds.

Only a small engine control program would need to be added to the vehicle's current emissions-control computer system if the new system were to be replace the old one. Moreover, the cost of manufacturing the new system is expected to be only a few dollars per unit, so replacement costs would be minimal.

Another noteworthy feature of the new sensor is its adaptability. It is resistant to noise, vibration, high pressure, and heat, so it could be installed near a vehicle's catalytic converter or tailpipe. Moreover, because of its small size and low manufacturing and installation costs, it could also be placed inside. For example, if one microsensor were placed near the dome light and another near the brake pedal, they could alert the driver when a dangerous level of carbon monoxide results from a leak in the exhaust system or the stove in a recreational vehicle.

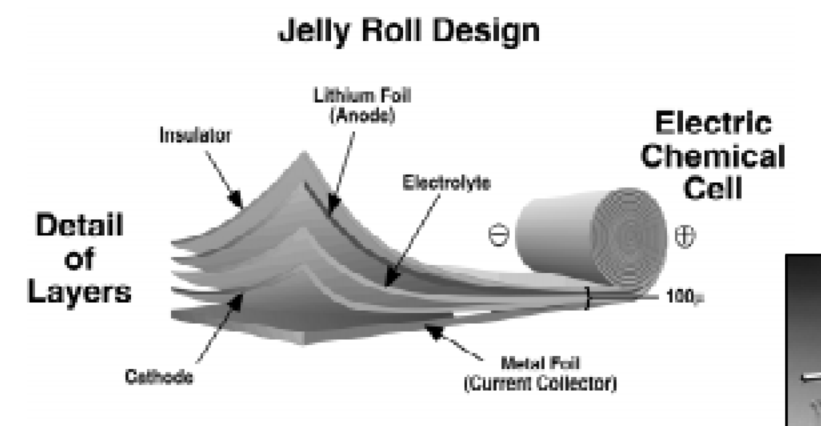
Researchers plan to test and demonstrate the applicability of voltametric/electrocatalytic chemical microsensors to measuring vehicle emissions. They will be placed at the back and front of catalytic converters and the ends of tailpipes.

For more information, contact Mike Vogt, phone: 630/252-7474, fax: 630/252-1342, e-mail: vogt@anl.gov.

Making a Material Difference in Advanced Batteries

Structurally stable material improves energy storage capacity of lithium-polymer battery by 30%

The Lithium-Polymer Battery Concept

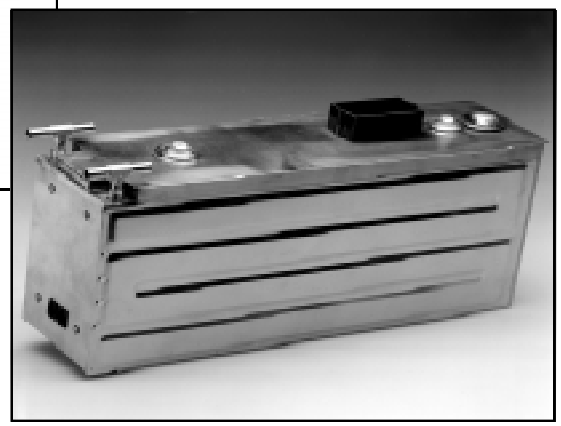


This new lithium-polymer battery is a "jelly roll" with a layer of lithium foil as the anode, a polymer film as the electrolyte, and a layer of vanadium oxide as the cathode.

For many years, scientists at Montreal-based Hydro-Québec had been studying lithium-polymer batteries, a technology that showed great promise for electric vehicles (EVs). However, its energy storage capacity had to be improved to give EVs the range consumers expect.

In 1993, a partnership was formed among 3M, Hydro-Québec, and Argonne, under the sponsorship of the U.S. Advanced Battery Consortium (USABC), to develop a solid-state lithium-polymer battery for automotive use. Among the advantages of such a battery is its light weight, relative to lead-acid or nickel-metal hydride batteries. Furthermore, the electrolyte is a dry polymer, which significantly enhances safety compared with lithium batteries that use liquid electrolytes. Argonne's charter was to find an alternative cathode material for the battery with 10% higher energy capacity — considered an ambitious goal. The achievements to date have exceeded everyone's expectations."We made seemingly minor modifications to an existing vanadium oxide cathode material that resulted in 25-30% more capacity, and that, in turn, made significant improvements not only to the energy density and but also to the power capability of the battery," says Dennis Dees, project manager of Argonne's lithium-polymer program.

During the charge and discharge of the lithium-polymer battery, lithium ions shuttle between a lithium metal anode and a vanadium oxide cathode via the solid polymer electrolyte. A common problem with all lithium-insertion batteries is the rate of capacity loss during electrochemical cycling resulting from structural degradation of the cathode material. Argonne researchers recognized that a modification to the vanadium oxide could reduce the problem. They produced a related material with a different composition and structure that provided significantly greater stability during charge and discharge. (Details of the materials composition and performance are proprietary).



A 2-kWh model of the 3M-Hydro-Québec-Argonne lithium-polymer battery.

The individual cells of the all-solid-state lithium-polymer battery have an innovative design in which very thin films, as thin as sheets of paper, of electrode and electrolyte materials are rolled together in a "jelly roll." Argonne's modified cathode material is now being used in 2-kWh battery modules that will be evaluated in EVs. The performance of these battery modules approaches the USABC commercialization criteria for power output (300 W/kg, for acceleration) and energy storage (150 Wh/kg for range).

Argonne is working to refine the properties of the cathode materials that could result in a further improvement of the electrochemical properties of the vanadium oxide. Candidate materials are synthesized and evaluated in Argonne's specialized cell-testing facilities. "We continue to seek for further modifications to the structure that might yield still better performance," says Dees.

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This issue of *TransForum* highlights the work of some areas of Argonne that have been involved in transportation research for two decades or more. The Center for Transportation Research, now in its 20th year, conducts environmental and technology assessments for U.S. Department of Energy (DOE) transportation programs. One of its many areas of expertise is the modeling of the total energy cycle of fuels and vehicles. In this issue, the results of a study of corn-based ethanol are presented — a timely topic as ethanol from corn has been a controversial energy pathway. Argonne's total-energy-cycle analysis has updated the data on farm productivity and by-products, resulting in some new insights.

Another Argonne group, the Electrochemical Technology Program, has been working with DOE and U.S. automakers to develop and test advanced batteries for electric vehicles for more than 25 years. This group holds than 100 patents in the area of advanced batteries and about 50 patents for fuel cell technology. A recent collaboration with two industrial partners has improved the capacity of lithium-polymer batteries by 30%.

TransForum is one of several ways of informing you of the results of Argonne's transportation research. Your response has been gratifying, especially the contacts some of you have made directly with our researchers. Now we've added another way of keeping you up to date on our work: an Argonne transportation web site, which can provide more in-depth information than is possible in a newsletter. You can find us at **<http://www.transportation.anl.gov>**.

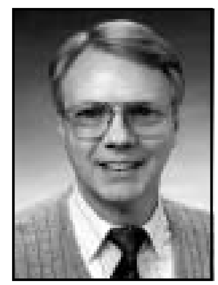
An electronic version of *TransForum* is available in the publications area. You'll also find descriptions of ongoing programs, staff biographies, technical papers, and links to other transportation-related web sites.

Another way to keep in touch is by visiting us at the Laboratory. Of the numerous guests from both government and industry who visited us over the past three months, we were especially pleased to host Robert Gee, DOE Assistant Secretary for Policy and International Affairs, and Thomas Todd, Director of Field Management, on separate visits to Argonne. They were both able to see first-hand some of our major research facilities, such as the Advanced Powertrain Test Facility and the Locomotive Engine Test Facility, which were highlighted in the first two issues of *TransForum*. We are always pleased to welcome visitors and glad to see that more of you are coming to see us.

As always, please feel to contact our research staff if you wish additional information on any of the topics covered in this issue.

Larry

Larry R. Johnson
Director



FASTRAX

Cathy Kaicher, editor of *FutureDrive*, our sister newsletter, has received a Silver Award from the Newsletter Clearinghouse. Of 75 newsletters entered in the "Organization" category of the clearinghouse's annual competition, *FutureDrive* was one of only three to win an award. *FutureDrive* reports on the advanced vehicle technology competitions for students, sponsored by the U.S. Department of Energy and managed by Argonne. You can find it on-line in the publications area of Argonne's new Transportation and Technology R&D Center web site <http://www.transportation.anl.gov>.

Larry Johnson has accepted a three-year term on the Board of Advisors for the Institute of Transportation Studies at the University of California, Davis.

Chris Saricks is a member of the National Research Council's Committee on the Ozone-Forming Potential of Reformulated Gasoline. The committee is investigating the effectiveness of gasoline reformulation in mitigated surface-level ozone. A report on the committee's findings is being prepared and is scheduled for release in fall 1998.

Argonne's process for producing ethyl lactate, an environmentally friendly solvent, has won another award — a 1998 Presidential Green Chemistry Challenge Award. Its developers, ***Rathin Datta, James Frank, Shih-Perng Tsai, Michael Henry, Tony Fracaro, Paula Moon,*** and ***Yuval Halpern,*** earlier received a 1998 Discover Magazine Award for Technological Innovation.

Argonne is seeking industrial partners to develop advanced transportation technologies. The following types of working arrangements can be made:

- In a *reimbursable R&D agreement*, Argonne's industrial partner pays the full cost of the research performed. The company generally takes title to any inventions, and proprietary information and research results are kept confidential.

- In a *cost-shared R&D agreement*, Argonne and its industrial partner share the costs of research. The company may obtain rights to intellectual property developed by Argonne. Proprietary information is kept confidential, and research results may be protected from disclosure for up to five years.

- *Licenses* for Argonne inventions and software may be granted to companies that wish to develop them into marketable products or processes. Licenses may also be part of other agreements.

- *Personnel exchanges* and *technical assistance* projects can be arranged with Argonne for short-term or rapid-turnaround work.

For more information about working with Argonne, contact:

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