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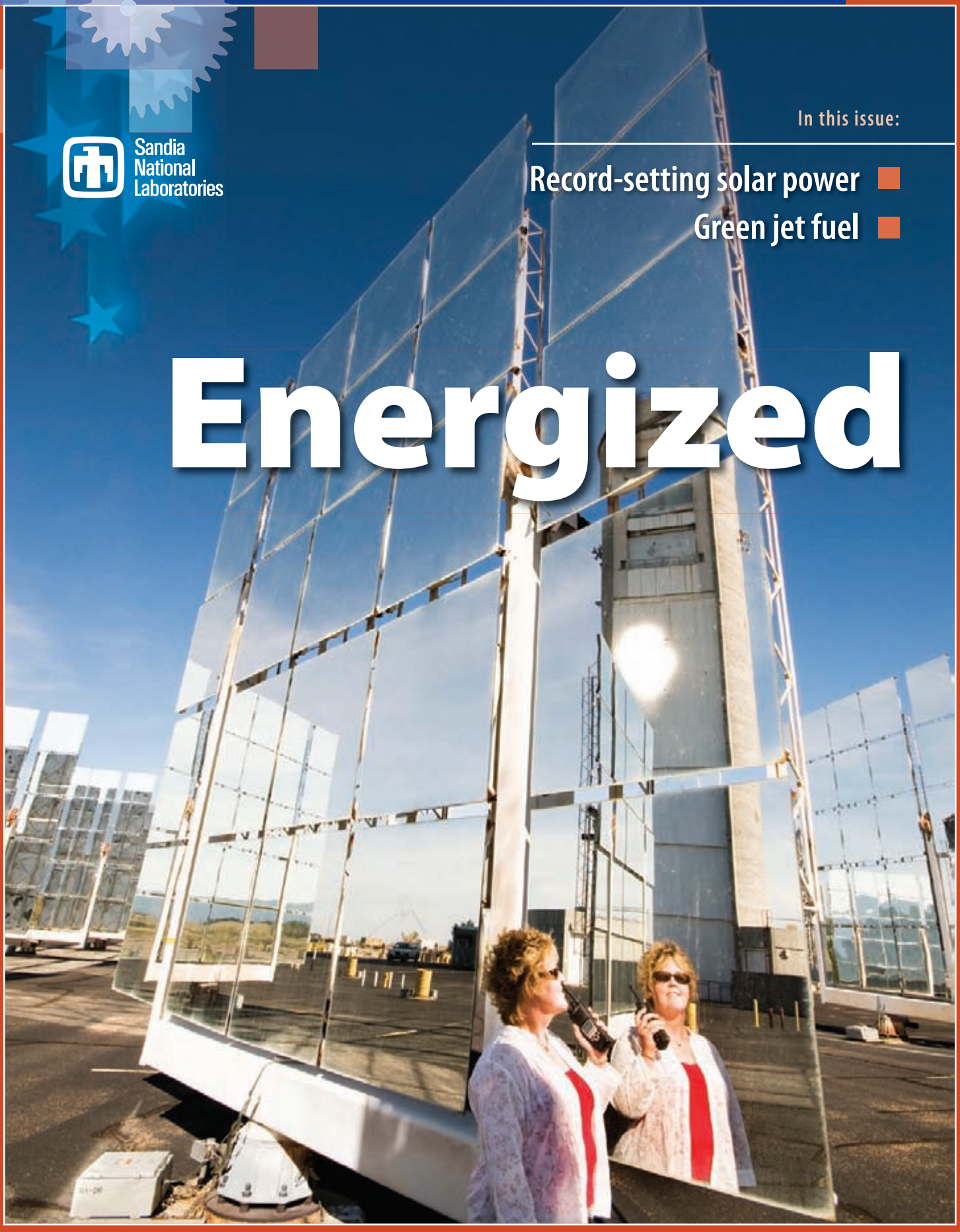
Sandia National Laboratories

In this issue:

Energized



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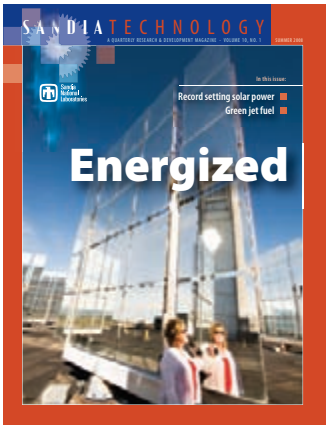
What is LDRD?

The Laboratory Directed Research and Development (LDRD) program provides Sandia the flexibility to invest in discretionary research and development that stretches the Labs' science and technology capabilities.

LDRD supports Sandia's four primary strategic business units: nuclear weapons; defense systems and assessments; energy, resources, and nonproliferation; and homeland security and defense. LDRD also promotes creative and innovative R&D by funding projects that are short term, often high risk, and potentially high payoff, attracting exceptional research talent from across many disciplines.

When the LDRD logo appears in this issue, it indicates that at some stage in the history of the technology or program, LDRD funding played a critical role.



On the cover:

At Sandia's Solar Tower, chief test engineer Cheryl Ghanbari inspects a heliostat, a mirrored fixture that moves to focus solar energy. *(Photo by Randy Montoya)*

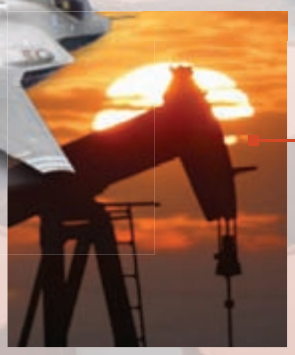


Table of Contents

Dear Readers,

Fuel prices now force some Americans to both choose between food and fuel and to make other tough tradeoffs in how they spend their money and what they do in their everyday lives.

During the two oil crises in the 1970s large-scale energy research projects on solar, wind, and geothermal energy went on all over the country. Most of those projects were defunded or discontinued as oil prices stabilized, and we as a nation clung stubbornly to fossil fuel as our primary source of energy.

This edition features a wide range of energy projects. Some of them are long-term projects, some are LDRD projects that seek new approaches to a growing problem, and others are repurposing equipment and research developed for other programs to examine this complex national problem.

In this issue, we speak with researchers assessing the batteries that will appear in electric plug-in vehicles and hydrogen fuel cars. We see a project evaluating biofuels for use in military jets. Economist Arnie Baker explains what goes into the price of gasoline and describes possible future impacts on our primary fuel choice.

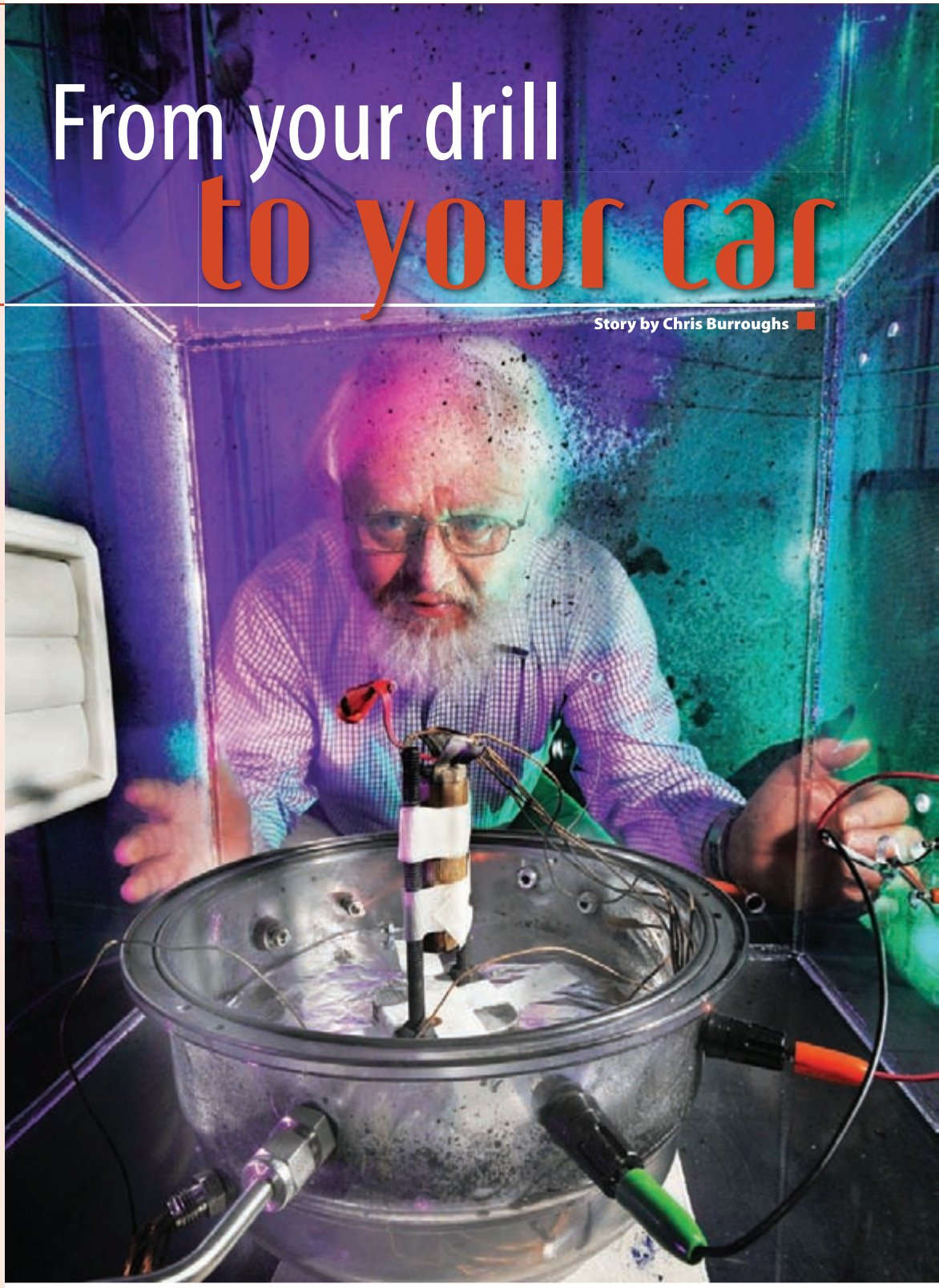
Whether gas prices go back down or stabilize higher over the long term, Americans now have energy on their minds. Researchers with energy on their minds are contributing their insights and their innovation in service to a nation that must now examine other options for powering our lives.

Stephanie Holinka
Sandia Technology Guest Editor

From your drill to your car

Story by Chris Burroughs

Researchers test batteries in adverse situations to determine when and how they fail.



Researcher Peter Roth prepares to blow up a battery to see how robust it is. The work is part of the DOE-funded FreedomCAR program. *(Photo by Randy Montoya)*

Lithium-ion batteries like those that power your drill and your nail gun could someday power your car.

Lithium batteries have six times the energy density of lead-acid batteries and two to three times the energy density of nickel-metal hydride batteries. But before they can replace the nickel-metal-hydride batteries that power current-model hybrid cars and trucks, lithium batteries must be proven safe for the task.

"The lithium-ion batteries that will go into vehicles will be similar to computer laptop batteries," says Peter Roth, lead researcher of Sandia's FreedomCAR battery efforts. "One main difference is there will be a lot of them."

The FreedomCAR program at Sandia tests lithium-ion batteries like those used with power tools for safety and strength. Researchers in Sandia's Power Sources R&D group drive nails into batteries, heat them to extreme temperatures, overcharge them, and put them into some of the most adverse conditions possible to discover how much they can endure before failure.

The Sandia research group studies the stability of battery materials, their flame-retardance, high-temperature integrity of separators between the cathode and anode, and general thermophysical properties. Sandia's work helps confirm that lithium-ion batteries are indeed safe and can operate for long periods of time.

Researchers test batteries in adverse situations to also determine when and how they fail or leak their electrolyte.

"We look at fundamental chemistry, wanting to discover the kinds of gases they emit when they are heated and explode," Roth says. "We also build smaller prototype batteries that, once we get the chemistry right, may eventually be built full size to go into vehicles."

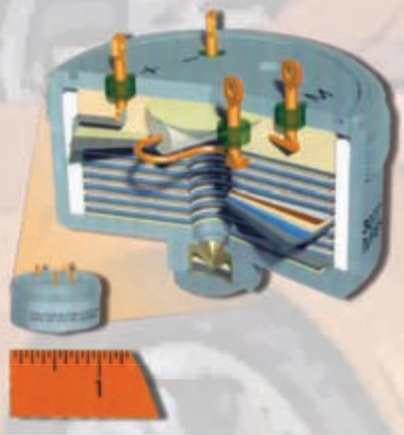
Some types of lithium-ion batteries can take a lot of abuse.

"The new lithium/iron phosphate batteries used in handheld power tools are hardier and less reactive when subjected to extreme conditions, says Roth.

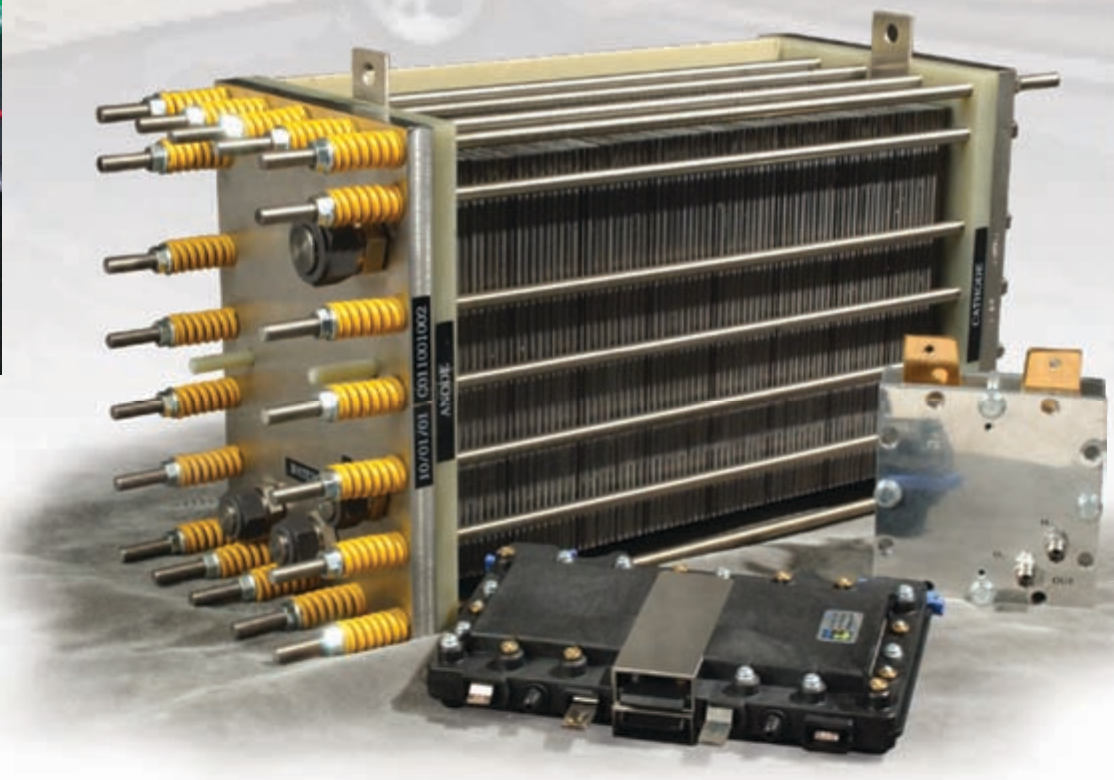
Safe, dense batteries will be particularly important for plug-in hybrid electric vehicles (PHEV). PHEVs operate both on gas and a battery, but they also have an extension cord, so it can be filled with gas at the gas station or plugged into any home 120-volt outlet for all-electric driving. "The battery industry has made great strides in manufacturing safe, long-lasting, and affordable batteries," Roth says. "We expect to see lithium/iron phosphate batteries in hybrids later this year and possibly even in short-range PHEVs within two years."

Industry experts predict that plug-ins that can run 10 miles on all electric are two to three years away while plug-ins that can run 40 miles on all electric are three to four years away. The first hybrids using lithium-ion batteries will be on the market later this year.

Fuel-cell vehicle from the coast-to-coast Hydrogen Tour, sponsored in part by DOE



Sandia's work helps confirm that lithium-ion batteries are safe and can operate for long periods of time.



Safe, dense batteries will be particularly important for plug-in hybrid vehicles. *(Photo courtesy of NREL)*

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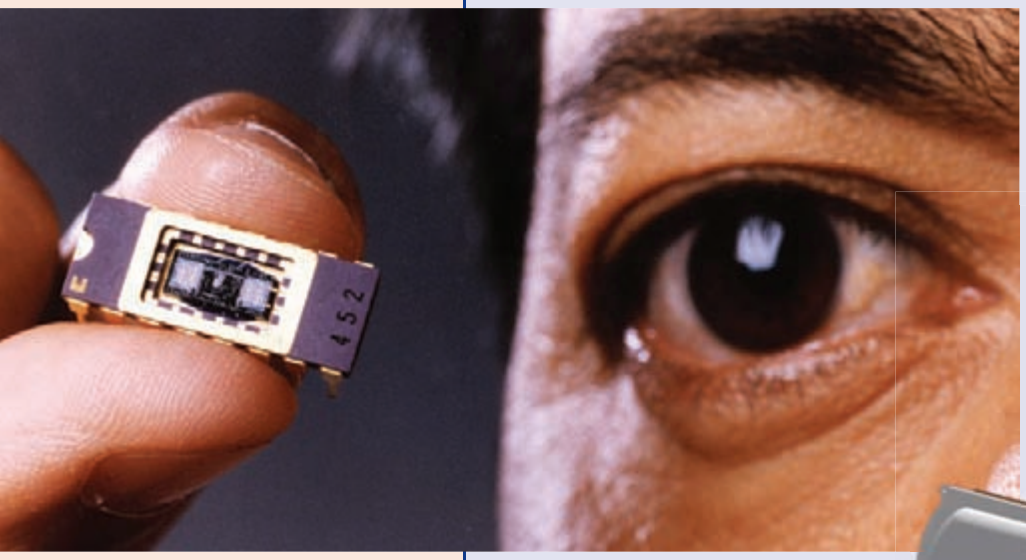
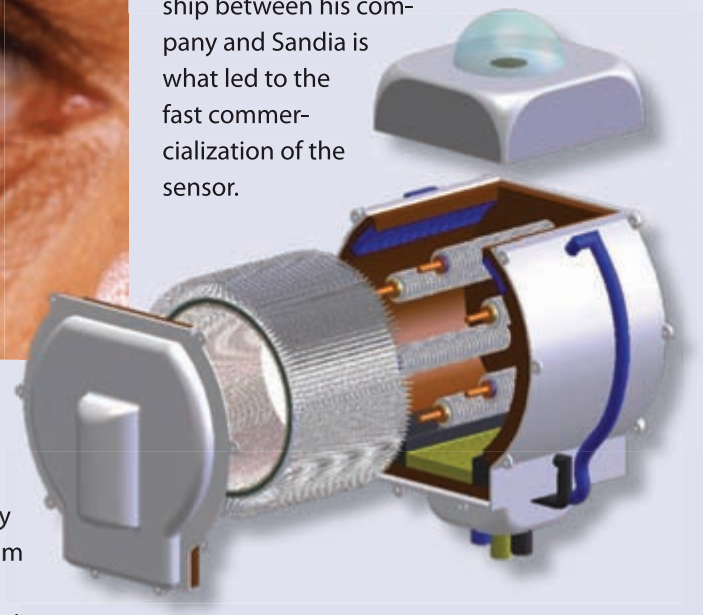
NEWS NOTE

Wide-Range Sensor to help hydrogen economy



Above: Wide-Range Hydrogen Sensor
(Photo by Randy Montoya)

Right: Hydrogen fuel cell



After more than a decade of research and development, a hydrogen sensor invented by Sandia researchers will find its way into applications such as petroleum refining, hydrogen production, chemical production, chlorine production, nuclear waste monitoring, and fuel cells.

The Wide-Range Hydrogen Sensor, developed by Sandia and commercialized by H2scan, is smaller, faster, sturdier, more user-friendly, and less expensive to manufacture than other hydrogen sensors available on the market, says retired Sandia developer Bob Hughes.

The Wide-Range Hydrogen Sensor is currently being used for petroleum refining and hydrogen and chlorine production, but its real contribution will be to the hydrogen economy, once it gets rolling, says Hughes.

"It will have many applications to the hydrogen transportation and automotive industry. It can monitor hydrogen levels in fueling stations and in cars and trucks burning hydrogen," Hughes says.

H2scan president, CEO, and founder Dennis Reid says his company is already working with automobile companies so cars could use these sensors to monitor hydrogen levels in hydrogen vehicles. Reid says the partnership between his company and Sandia is what led to the fast commercialization of the sensor.

H2scan has delivered sensors to more than 200 government and industry customers, including numerous oil companies, Air Products, PraxAir, Air Liquide, UOP, Total, General Electric, Boeing, Bechtel, NASA, Lockheed Martin, Merck, Nissan, Toyota, GM, Honda, Ballard, UTC, Northrop Grumman, Shell Hydrogen, Ball Aerospace, Westinghouse, and others. Reid expects to release the product soon for refineries and is working closely with the world's largest provider of systems for refiners worldwide.

Reid says that H2scan has grown from seven employees to 22 since the initial cooperative research and development agreement was signed with Sandia. "As our sensor becomes known and our client list expands, I expect we will triple in size over the next two to three years, thanks to Sandia's involvement," Reid says.

Researchers Mike Thomas and Bob Hughes with the sensor.
(Photo by Randy Montoya)

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The links between water and energy

Story by Chris Burroughs

Water and energy are inextricably linked. It takes large volumes of water to produce energy and lots of low-cost energy to treat and distribute water. But the planning and management of these fundamental resources have historically been done in isolation. Such lack of coordination could lead to inefficiencies, conflict, and unnecessary stress on natural resources and the environment.

With power demands in the U.S. expected to increase 30 percent by 2025, researchers question how existing water supplies could accommodate new power generation. Future U.S. growth will likely also occur in the Southwest, a region with an already limited water supply.

Sandia's computer modeling initiative — drawn on the Labs' expertise in energy, water, and optimization — might provide some answers to these types of complex issues.

Vince Tidwell, Sandia principal investigator, says researchers face three problems — the coupling of complex systems, the integration of processes over disparate time and length scales, and the analysis and optimization of these models.

Tidwell also says electrical power generation nation wide requires about 140 billion gallons of water per day. Power generation accounts for more than 40 percent of all freshwater withdrawals in the United States. Although only a small fraction of the water withdrawn for power production is actually consumed (3.3 billion gallons per day), withdrawals taken from waterways and aquifers can lead to overdraft conditions while return flows introduce unwanted heat to the watershed that can pose problems.

Sandia's model demonstrates possible energy and water shortfall scenarios for particular regions. Such shortfalls lead to tough and sometimes complex choices among future needs for energy, water, and environmental balance.

"Our model allows energy and water producers, resource managers, regulators,

Sandia researchers are developing an energy-water model for integrated management of water and energy resources.

and decision makers to look at the different tradeoffs of water use and energy production caused by uncertainties in population, energy demand, climate, and the economy," says Tidwell.

The research is in its second year of three-year funding through Sandia's internal Laboratory Directed Research and Development LDRD program.

The model, which will run on a standard PC, uses readily available software and provides rapid feedback.

Energy modeler Len Malczynski says the model will allow users to tailor their investigations to examine specific concerns. For example, they can get results on energy and water scenarios at the national, state, or local levels and will be able to look at specific watersheds. Such models would help determine water-energy trends in states like New Mexico where most of the power it generates leaves the state.

Water cools the inside of a nuclear reactor

Researchers will also create models and tools to assist in siting power plants and balancing the energy portfolio (e.g., fossil, nuclear, renewables). Decisions might be based on concerns such as cost, availability of water, availability of fuels, access to transmission lines, and greenhouse gas emissions.

"Users will be able to run hundreds of scenarios and see the effects in graphs and tables of their water and energy choices a year from now or decades away," Tidwell says.

When the project is completed, researchers hope to make the model available to water and energy utilities, regulators, and decision makers.

Power plants such as this one can withdraw large amounts of water to generate energy.

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Nanotubes hold promise for sensor systems, semiconductors

In his upcoming book, Sandia researcher François Léonard examines the physics of carbon nanotubes and investigates their future in semiconductor electronics, flat-panel displays, and chemical and biological sensors.

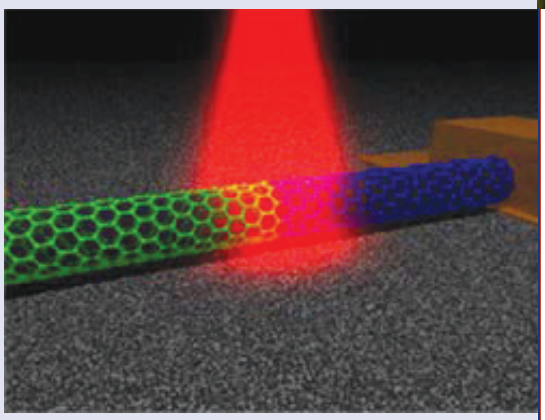
Carbon nanotubes are long thin cylinders composed entirely of carbon atoms. While nanotube diameters are in the nanometer range (1-10), they can be up to centimeters in length. The strong carbon-carbon bond makes carbon nanotubes resistant to any kind of deformation. Carbon nanotubes are unique because they can be either metallic or semiconducting.

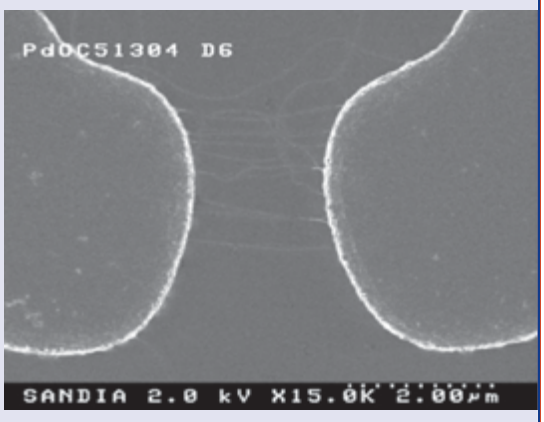
Nanotubes may someday have application in energy-related research and products such as solar cells, fuel cells, batteries, and capacitors, Léonard says.

He says carbon nanotubes also hold promise as a material for semiconductor electronics, which could lead to the development of new nanoelectronic devices. "Carbon nanotubes create transistors that are only one nanometer wide," says Léonard. "This makes it possible, in principle, to achieve high device densities compared with the current state of the art."

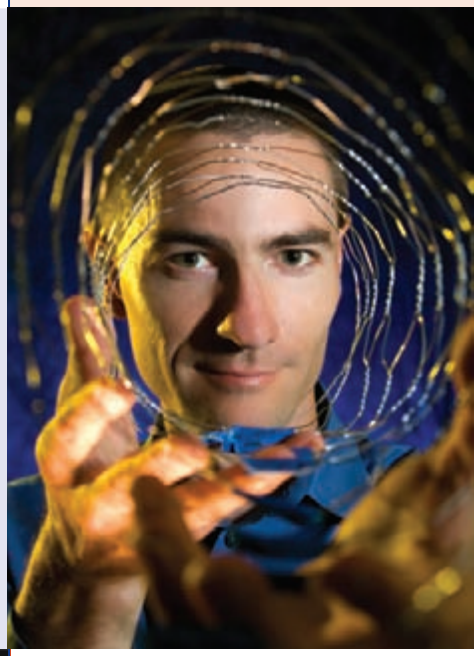
Currently, Léonard is investigating optical detection using carbon nanotubes. Nanotubes' electronic properties favor light absorption, which can be controlled with nanotubes of different diameters. The fabrication process for a semiconducting optical nanotube detector would be compatible with fabrication processes used by the semiconductor industry.

Nanotubes also hold promise in flat-panel devices. Flat panel displays are typically made from a high density of sharp tips, to which high voltage is applied to extract electrons. These electrons strike and activate the pixels in the screen. Carbon nanotubes can serve as the emitters because they are sharp, long, and can sustain high fields and high temperatures.





Another potential use is in chemical and biological sensors. Carbon nanotubes are small and can serve as sensitive detectors, able to detect a single molecule of a target substance. Nanotubes can also be used for DNA detection.



François Léonard holds a cylinder of wire mesh similar in design to a carbon nanotube.
(Photo by Randy Wong)

Illustration of a carbon nanotube illuminated with monochromatic light. Work at Sandia is exploring the properties of such carbon nanotubes for photocurrent generation.

Scanning electron micrograph of several carbon nanotubes between two electrodes. At Sandia, such assemblies are utilized to explore electronic, opto-electronic, and sensing devices.
(*Images from Alec Talin*)

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Stirling Energy Systems' solar-to-grid system
(Photo by Randy Montoya)

Greater efficiency means more affordable solar power.

Record-setting solar power

Story by Chris Burroughs

On a perfect New Mexico day Sandia and Stirling Energy Systems (SES) set a new solar-to-grid system conversion efficiency record by achieving a 31.25 percent net efficiency rate.

"This advances our dish engine systems well beyond the capacities of any other solar dish collectors," says Bruce Osborn, SES president and CEO, "and moves it one step closer to commercializing an affordable system."

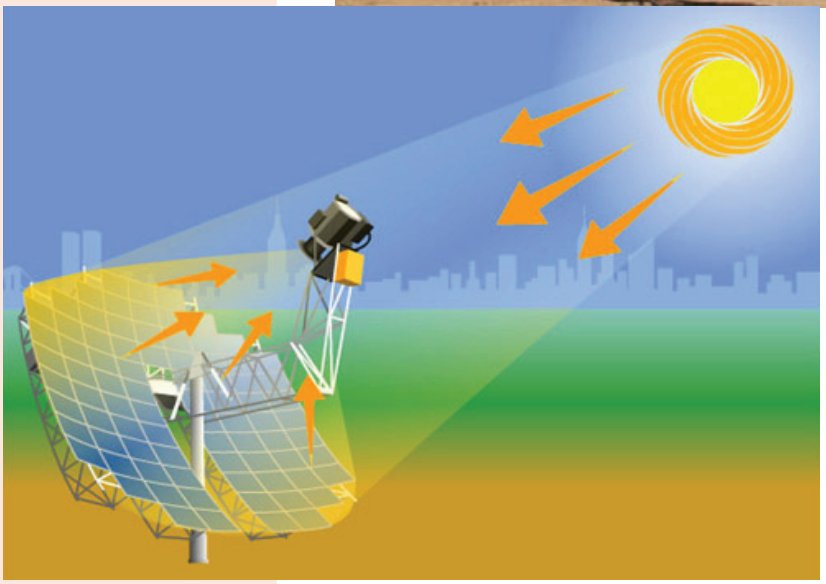
An SES dish unit consists of 82 mirrors formed in a parabolic dish shape to focus the light to an intense beam. The solar dish generates electricity by focusing the sun's rays onto a receiver, which transmits the heat energy to a Stirling engine, which is a sealed system filled with hydrogen. As the gas heats and cools, its pressure rises and falls. The change in pressure drives the pistons inside the engine, producing mechanical power, which drives a generator and makes electricity.

Sandia provides technical and analytical support to SES in a relationship that dates back more than 10 years. Dishes at the six-dish Model Power Plant at Sandia's Solar Thermal Test Facility produce up to 150 kilowatts (kW) of grid-ready electrical power each day.

The record-setting test ran for two and a half hours. During the testing phase, the system produced 26.75 kW net electrical power.

Stirling dishes at Sandia
(Photo by Randy Montoya)

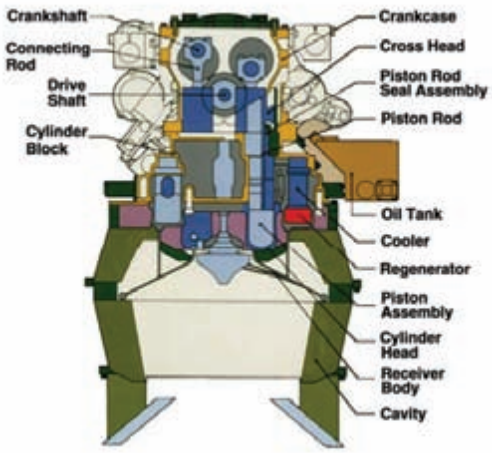
The Stirling engine automatically tracks the sun and focuses solar onto a power conversion unit (PCU). This in turn converts the intense heat to grid-quality electricity.
(Courtesy of SES)



Lead Sandia project engineer Chuck Andraka says several technical advancements to the systems made jointly by SES and Sandia led to the record-breaking solar-to-grid conversion efficiency. SES owns the dishes and all the hardware.

Osborn says SES has signed power purchase agreements with two major Southern California utilities (Southern California Edison and San Diego Gas & Electric) for up to 1,750 megawatts (MW) of power, two of the largest solar power contracts ever granted. Collectively, these contracts require up to 70,000 solar dish engine units.

"This exciting record shows that using these dishes will be a cost-effective and environmentally friendly way of producing power," Osborn says. "SES is actively engaged in the commercialization of a system called the 'SunCatcher.' The demonstrated high efficiency means more energy is generated for the given investment, lowering the cost of the energy delivered."



Model of Stirling engine
(Courtesy of SES)

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Green jet fuel

Story by Michael Padilla

Researchers are evaluating promising oil crops that will not directly compete with food and feed markets.

A Sandia team is investigating how to produce military Jet Propellant 8 (JP-8) fuel using renewable biomass oil feedstocks, including oil crops, unconventional sources like algae, and various forms of waste vegetable and animal oils.

The 18-month effort, backed by a $6.7 million DARPA project award, aims to develop, demonstrate, and commercialize a process by October to produce the JP-8 fuel used by U.S. and NATO militaries.

According to Sandia project leader Ron Pate, researchers are evaluating promising oil crops that will not directly compete with food and feed markets, can avoid the use of higher-quality agricultural land, and may also allow for reduced demand for energy, fresh water, and other inputs.

"National scale-up of oil crop-based aviation fuel production at the volumes, supply availability, reliability, and competitive costs desired is a complex and dynamic 'system of systems' challenge," says Pate. "We are leveraging our capabilities and expertise in systems dynamics modeling, simulation, and assessment to help provide insight and decision support to the project."

Several key problems for bio-oil projects include land use, water demand and availability, soil and climate conditions, energy, and other critical inputs.

The conversion processes under development are expected to yield high fractions of liquid biofuel product in the form of JP-8 and green diesel, along with other useful coproducts. Pate says oils derived from plants like soy, oil

Ron Pate with a vial of biomass and a vial of biomass-derived oil *(Photo by Randy Montoya)*

Several projects at Sandia are examining renewable options for biofuel. *(Photo by Randy Montoya)*

palm, sunflower, and numerous others provide an easy-to-handle material with high energy density and chemical structures that can more easily be converted into high-performance liquid fuels than other forms of biomass.

Production of conventional oil crops for biofuel will face limits due to competing markets for oil crop products and competing uses for the land and water required to grow the crops, Pate says.

Algae can be grown using land not otherwise suitable for agriculture, and can use lower-quality water sources such as inland brackish ground water, various waste waters, desalination concentrate, by-product water from oil, gas, and coal-bed-methane energy mineral extraction, and coastal sea water.

Despite the high productivity potential of algae, Sandia's preliminary techno-economic assessment reveals several major areas where innovation will be required before affordable algal biofuel production is possible.

These include less energy-intense processes associated with algal biomass harvesting, dewatering, and neutral lipid extraction. Currently, Sandia has several internally funded projects underway to address issues associated with algae for biofuel.

Fuel produced using the new processes will have to meet stringent military specifications. The military needs high-energy efficiency in the conversion of renewable bio-oil feedstock to JP-8 fuel and other valuable coproducts that can include green diesel fuel and other industrial chemicals, Pate says.

Researchers expect the technology will also be viable for future use in the production of fuel for commercial jets.

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With Sandia's help Hawaii will soon be greener than ever

The Hawaii Clean Energy Initiative (HCEI) will transform Hawaii's energy system to utilize renewable energy and energy-efficient technologies for a significant portion of its energy needs.

DOE and Sandia will help Hawaii supply 70 percent of its energy needs using clean energy by 2030, which could reduce Hawaii's current crude oil consumption by 72 percent. This type of clean energy transformation will continue to help sharply reduce greenhouse gas emissions.

Sandia project lead Juan Torres says Sandia is providing technical advisement, analysis, and engineering support for clean energy projects, policy, and regulations.

Hawaii currently meets about 90 percent of its energy needs through imported oil refined into gasoline for transportation and diesel for electricity, says Torres. "Because of its location," he says, "Hawaii's gasoline and electricity prices are typically the highest in the nation."

In the near term, Sandia will help the island of Lanai achieve its goal of using 100 percent renewables for all of its energy needs, he says.

In the future, Sandia plans to help the island of Kauai incorporate renewables as part of its generation portfolio. In addition, Sandia will assist privatized military housing communities implement renewables to reduce their energy costs.

Alexander Karsner, DOE assistant secretary for energy efficiency and renewable energy, says, "Hawaii's success will serve as an integrated model and demonstration test bed for the United States and other island communities globally, many of which are just beginning the transition to a clean energy economy."

Sandia will help Hawaii incorporate renewable energy into its generation portfolio.
(Photo by Randy Montoya)

Left: Gov. Linda Lingle signs the HCEI

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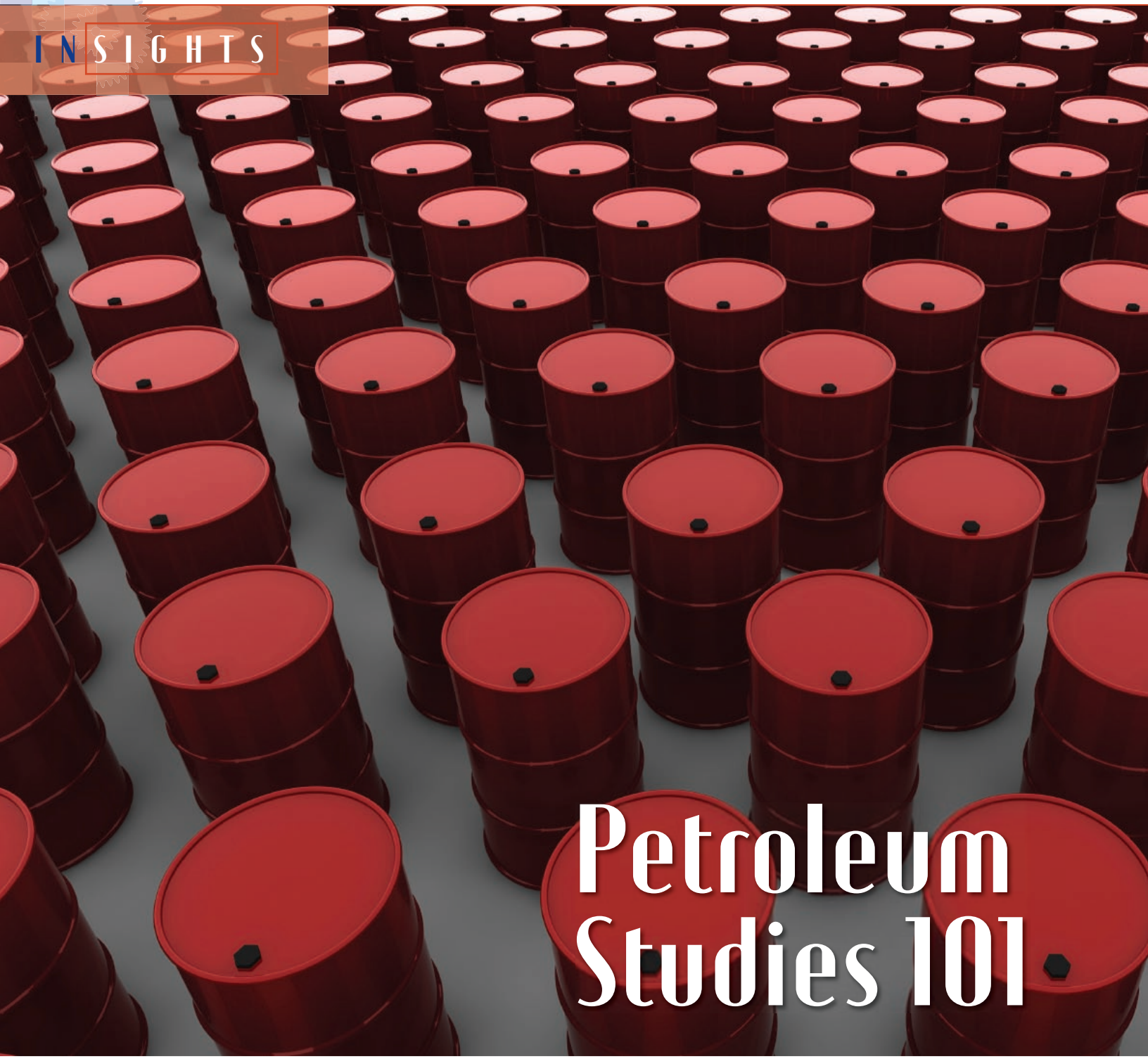


Petroleum Studies 101

By Arnie Baker
Sandia Chief Economist

$4 a Gallon Gasoline this summer—How did we get here where are we headed?

Getting to $4 for a gallon of gasoline, as we did this summer, took some doing. Only last July we paid $3, and back in July 2004 we paid $2. Many factors combine to drive oil prices.

Strong economic growth, especially in developing countries

Since 2004 developing countries have grown 6 percent per year, with China growing at 10 to 11 percent per year. Strong economic growth, coupled with domestic oil price controls in many developing countries, including China and the Middle East, boosted world oil demand by some four million barrels per day.

Weak supply

OPEC (Organization of Petroleum Exporting Countries), though mostly Saudi Arabia, uses surplus oil capacity to balance the market. That surplus capacity began to decline in 2003. By 2005 it was down to one million barrels a day. With little surplus capacity, any disturbances in the market can cause prices to rise.

Most OPEC members have not been increasing their oil production because rising oil prices have poured billions of dollars into their economies and reduced their need to produce more oil.

Other oil producers are reducing production for a variety of reasons. Russia and Venezuela have asserted control over their oil production. Mexican oil production (PEMEX is government owned and prohibits foreign ownership) is down 22 percent since January 2004. Instability in Iraq has kept its oil production low.

Falling U.S. dollar value

Since oil is priced in U.S. dollars, a weaker dollar inflates the oil price and encourages oil exporters to seek higher-dollar oil prices. Since July 2004 the dollar has fallen 22 percent against the Euro, 14 percent against the Japanese yen, and 10 percent against the Chinese renminbi.

A weak dollar means that non-U.S. oil consumers pay less for oil because their currency has more purchasing power.

Flight to higher returns

As the dollar falls, investors tend to move money out of stocks, seeking higher returns in commodities such as oil, metals, livestock, corn, and soybeans. This reinforces a boom in oil and other commodities. If markets believe this will continue over the long term, this pulls up short-term prices as well.

So where are we headed?

Changes are underway, but many will take time to soften prices.

Saudi Arabia has agreed to increase its oil production.

Oil demand in the U.S. and some other developed countries is beginning to fall. U.S. consumers are purchasing more fuel-efficient vehicles. Most automobile manufacturers have some type of plug-in electric/hybrid or electric vehicle scheduled for the marketplace in 2010 or 2011.

Liquid fuel alternatives from coal, oil shale, and cellulose are being explored, and high oil prices will stimulate additional oil production as well.

The U.S. may find itself having to raise interest rates before the end of the year to help curb inflation, which might slow the economy but also strengthen the dollar.

Many developing countries are trying to cope with both sharply rising food and energy prices, which seem to be fueling broader-based inflation.

Developing countries like China have begun to raise their subsidized domestic oil prices, which could slow down oil demand growth. China's economic growth and growth in oil demand also may slow now that the Olympics have ended. If oil markets see an economic slowdown, believe that changes in consumer behavior will bring down demand, and/or believe supplies of oil and other liquids will ratchet up, oil and gasoline prices could turn down quite rapidly.

Arnie Baker is Sandia's Chief Economist of Sandia National Laboratories, Albuquerque, New Mexico.

He is a Senior Associate with the Center for Strategic and International Studies (CSIS) Energy Program in Washington, D.C., a former President (2005) of the International Association for Energy Economics, and former President of the United States Association (2002).

He holds a BA in History and MA and PhD degrees in Economics from Virginia Polytechnic Institute and State University.

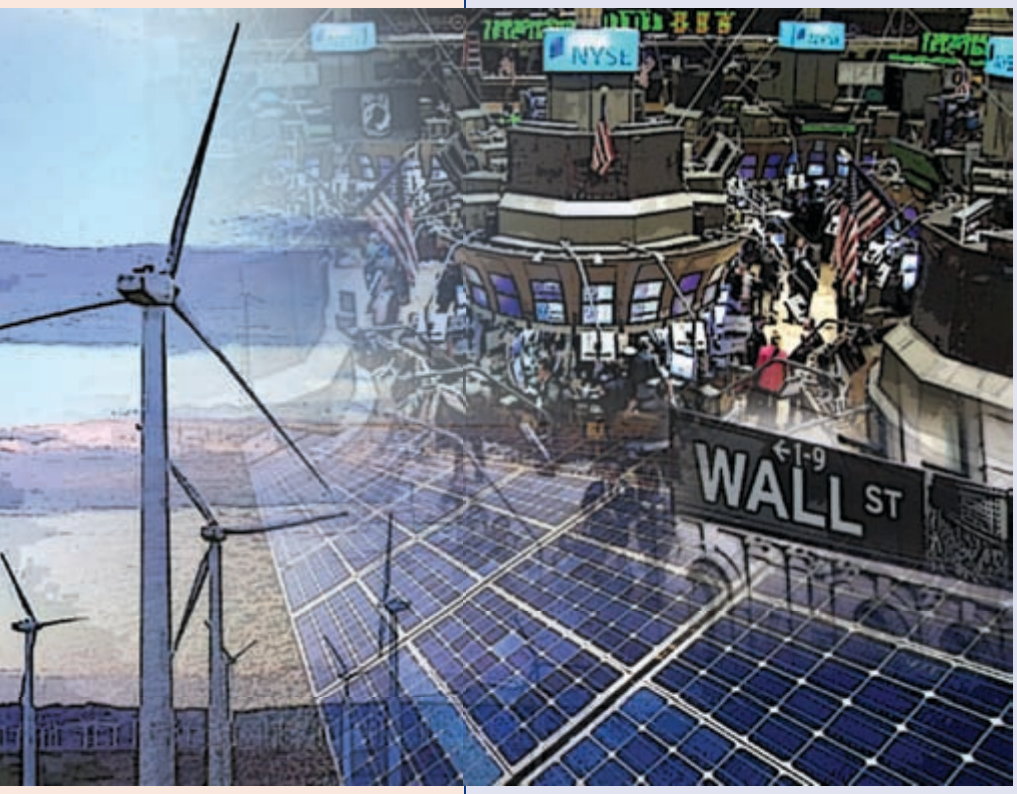
Prior to joining Sandia in 1996 he served for 17 years at Atlantic Richfield Company (ARCO).

Prior to joining ARCO he served at the U.S. Department of the Treasury as Special Assistant to the Undersecretary for Monetary Affairs, and as a staff economist at the U.S. Federal Trade Commission.

Baker has written book chapters and articles on energy, economic policy, and global change.

NEWSNOTE

Sandia, Milken Institute educate Wall Street on key energy issues



MILKEN INSTITUTE
Changing the world in innovative ways

In collaboration with the Milken Institute, Sandia recently conducted a workshop in New York City designed to provide attendees insight into technologies that will reduce greenhouse gas emissions and increase energy security. Some 50 attendees, representing Wall Street's largest and most prestigious investment firms, participated.

"Wall Street often doesn't get the complete picture," says Ron Stoltz, head of Sandia's California Energy Liaison Office. Stoltz helped develop the workshop to provide answers about energy technologies to key capital market leaders. Workshop attendees included representatives from Goldman Sachs & Co., Allstate, GM, and Lehman Brothers, among others.

"Sandia's energy programs often focus on startup companies and traditional venture capitalists," says Les Shephard, Sandia VP for Energy, Security, and Defense Technologies. "The event attracted top-level financiers and long-term investors whose future decisions may very well mobilize capital and markets at a sufficient scale for real changes in energy security and emissions reductions."

Once known as the "junk bond king" for his role in developing the junk bond market, financier and philanthropist Michael Milken today devotes his time to a number of philanthropic ventures designed to achieve positive societal outcomes.

Joel Kurtzman, a senior fellow at the Milken Institute, says he was overjoyed yet not surprised at the positive response from the workshop's attendees, whose organizations were collectively worth upwards of $200 billion in assets.

"They were impressed," he says. "Market leaders usually get a lot of biased information from organizations that are seeking funding. Sandia delivered speakers who were able to cut through all the hype, which cemented its already stellar reputation among the attendees."

A follow-up workshop, says Stoltz, is planned on nuclear energy and the issue of water in the energy sector.

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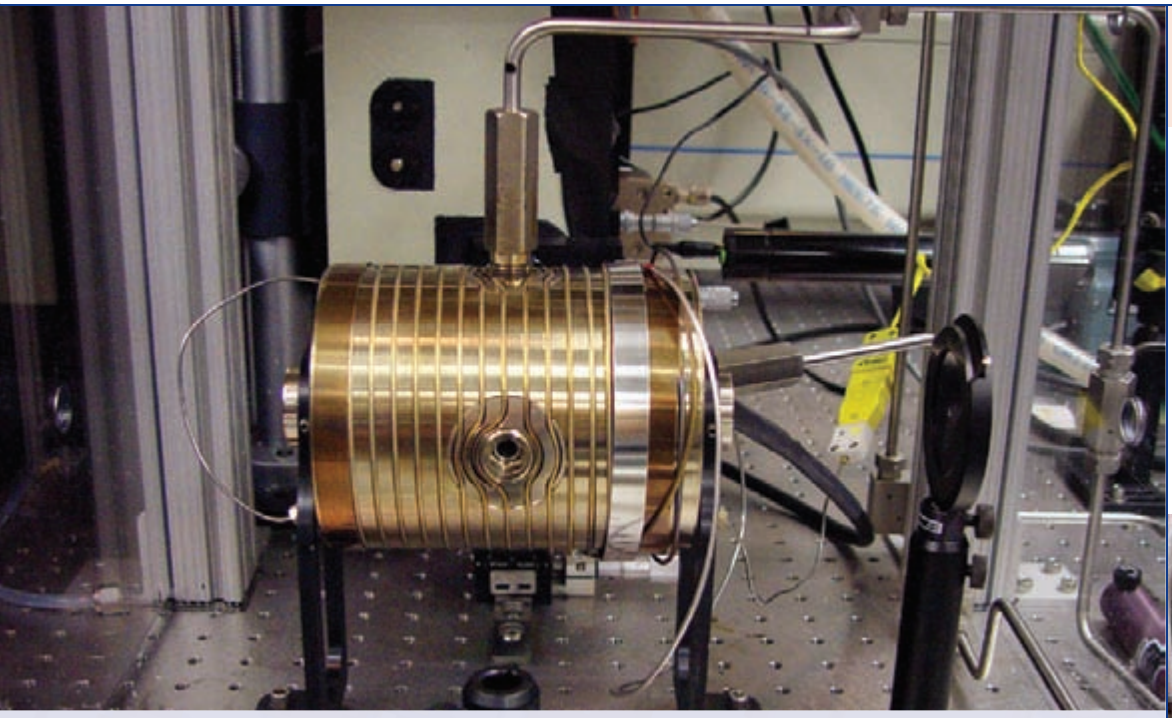


Reactor for optical probing of high-pressure chemistry

Advanced fuel chemistry for advanced engines

TNewer engine designs require that engine designers know more about the details of a car's combustion reactions. New cars will require more precise engineering, which means that engine designers need to understand how combustion works in the engine at a deeper level.

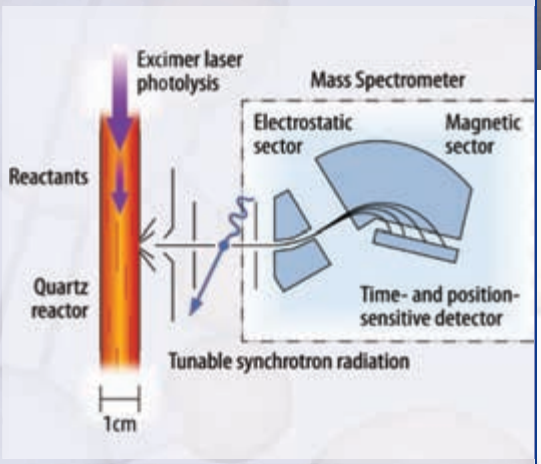
In a standard gasoline engine, the fuel-air mixture is compressed and the spark starts combustion at the correct time in the engine cycle. In a diesel engine, fuel injection initiates combustion.

Researcher Craig Taatjes says many new high-efficiency and low-emission engine designs rely on much higher compression to ignite the fuel-air mixture. In these new engines, high compression heats the mixture to a point where it ignites on its own.

New engines must control this compression more precisely because no spark or fuel injection event sets the timing. Fuel for new engines, Taatjes says, must have a specific chemistry in order to ignite the combustion process.

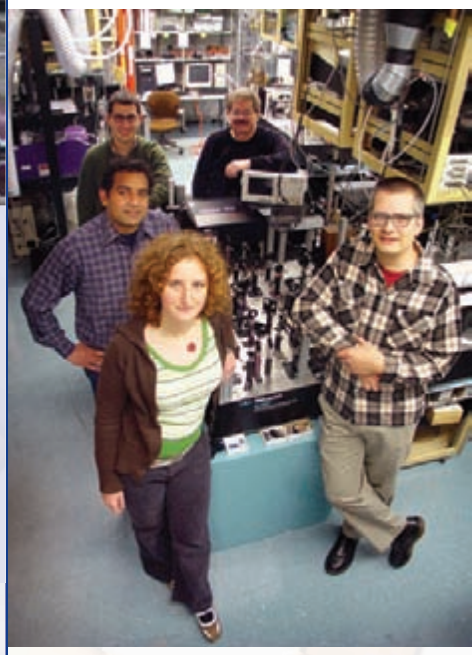
The project studies the effects of high pressure on ignition reactions.

Few previous elementary kinetics measurements of these reactions have been at actual engine pressures, and most ignition models neglect their pressure dependence.



Schematic of mass spectrometric detection

The LDRD is rounding out its second year. The findings may have broad implications for modeling compression ignition, and researchers hope that it will improve the ability to control combustion timing in advanced engines.



Advanced Fuel Chemistry team: (clockwise Judit Zádor, Ravi Fernandes, Giovanni Meloni, Leonard Jusinski, and Craig Taatjes

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"Since oil is priced in U.S. dollars, a weaker dollar inflates the oil price and encourages oil exporters to seek higher dollar oil prices."

Arnie Baker

Sandia Chief Economist

Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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