FUELING THE FUTURE

ASU leads the race for clean and sustainable energy

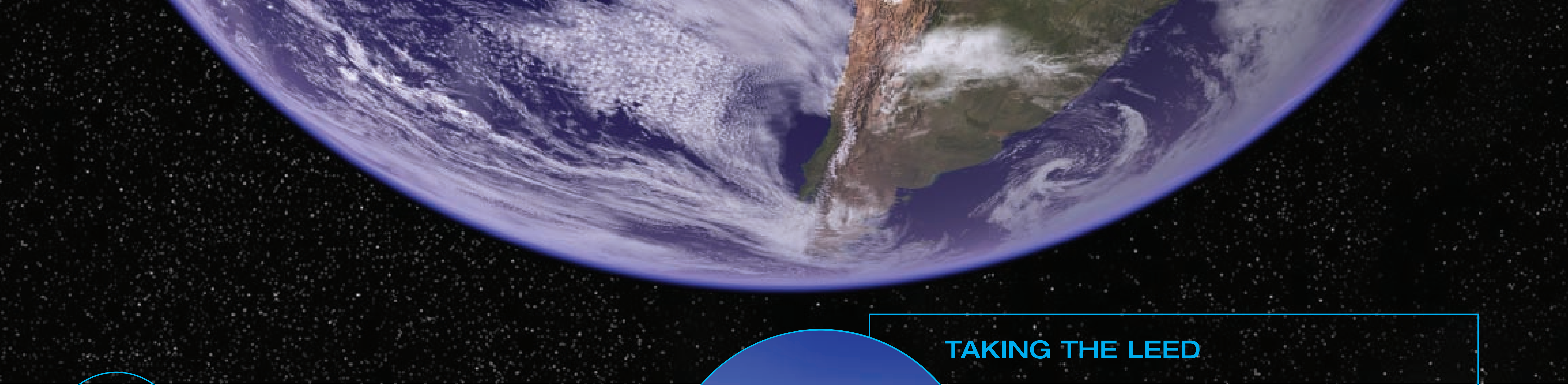
Sticker shock at the gas pump seems to have become less a short-term trend than a permanent reality as Americans continue to shell out $2.50-plus per gallon at the pump. Even a compact car with a 14-gallon tank can expect a price tag of $35 when its belly is full – more than double what it cost a decade ago.

With predictions that global oil production will fail to meet the increasing demand for energy in the next 10 to 20 years, the problem is not going away anytime soon … especially in light of America's addiction to it.

Oil not only heats our homes and fuels our airplanes, cars and trucks, but products made from oil (petroleum) also include medicines and plastics. The next time you purchase new eyeglasses, pick up a crayon, use dishwashing liquid or chew bubble gum, consider that these items, too, are made from petroleum. Even water bottles, cell phone cases and automotive parts contain petroleum as a main ingredient.

By **Melissa Crytzer Fry**

(From left to right) ASU researchers Bruce Rittmann, Michael Salerno, Willem Vermaas and ASU alumna Candy Wood.



“Petroleum is too valuable as a feed stock for these kinds of products for us to be burning most of it for bulk energy,” says Bruce Rittmann, researcher and director of ASU’s Center for Environmental Biotechnology. “It is a crime to deplete such a resource for such low-level use if we have alternative forms for bulk energy.”

The bright light on the horizon, however, is that as oil prices soar, research in alternative fuels also grows. And ASU professors and alumni are at the helm of some of the most groundbreaking alternative energy research in the world.

According to Rittmann, increases at the gas pump have actually opened doors of opportunity for new research. “We need this kind of social force to help us in our research,” he says, indicating that federal and private research funding for many of his projects simply wasn’t available until rising oil costs and fossil fuel depletion statistics became a public concern.

“The energy crisis is not just about the quantity of oil out there,” adds researcher Cody Friesen, a professor with the School of Materials. “It’s a socioeconomic problem, it involves politics, and there are environmental issues.”

Today, most electricity and vehicle fuel is generated from fossil fuels such as coal, oil and natural gas – non-renewable resources that originated from decayed plants and animals.

“Burning fossil fuels, as we all know, creates pollution,” says Slobodan Petrovic, an electronics systems professor whose research encompasses a wide range of topics, from hydrogen production and storage to fuel cells and carbon dioxide sequestration. “And while some pollutants can be toxic, others, like carbon dioxide (CO2), contribute to global warming – or the greenhouse effect. So in addition to having to worry about energy demands, humanity needs to worry about reducing the impact of energy harvesting on the environment.”

“There are two energy options being considered at the government level,” says Govindasamy Tamizhmani, who manages ASU’s Photovoltaic (solar) Testing Laboratory at the Polytechnic campus. “Nuclear is one option. Renewable resources are another. Nuclear energy is a quick fix, but it could be disastrous if not managed properly.”

But perhaps an even bigger concern on the minds of many is the socioeconomic and political impact that oil shortages may have on American society.

“If we rely on fossil fuel from unstable regions abroad, we will have geopolitical problems,” explains Rittmann. “We’ll see a continuing increase in prices for scarce resources and maybe cut-off of oil from certain regions of the world due to political issues. The more we depend on those resources, the more we’re at risk for disruptions to our economy and the foundation of our society.”

Kent Whitfield ’90 B.S., ’92 M.S. couldn’t agree more. Formerly a manager responsible for alternative energy technologies with Underwriters Laboratories, Whitfield now works for Mirasole, a manufacturer of solar cell technology. He seconds the notion that foreign policy will become an economic concern.

TAKING THE LEED

Another aspect of satisfying future energy needs is creating a built environment that conserves the fuel with which it is being powered. A number of new and recently completed buildings at ASU have met the standards established by Leadership in Energy and Environmental Design (LEED) Green Building Rating System™, developed by the U.S. Green Building Council. The LEED system is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings.

LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

The following are some of the buildings that have received LEED certification or who were in the process at press time of qualifying for the system’s various levels of excellence.

- ASU Hassayampa Academic Village, Tempe, Silver (in process)
- ASU Polytechnic Buildings, Mesa, Silver (in process)
- ASU Cronkite School of Journalism, Phoenix, Silver (in process)
- ASU Biodesign Institute, Building A, Tempe, Gold
- ASU Biodesign Institute, Building B, Tempe, Platinum
- ASU Fulton Center, Tempe, Certified (in process)
- ASU Interdisciplinary Science & Techonology I, Tempe, Gold
- ASU Interdisciplinary Science & Techonology II, Tempe, Silver
- ASU Interdisciplinary Science & Techonology III, Mesa, Silver (in process)
- ASU/UofA Biomedical Campus, Phoenix, Certified (in process)

"Undoubtedly, those countries that are right now investing in alternatives will be further along the learning curve once the 'peak oil' point hits the globe," says Whitfield. "Those that have not invested in new industries and infrastructure will have very few options of what to do to maintain their current lifestyles."

"Many people see the need to break away from reliance on foreign oil, albeit mostly for political reasons," says Candy Wood '03 B.S., an electrical power subsystems engineer for General Dynamics. "I believe the greater responsibility is to our future generations. If we cannot figure out how to derive clean energy sources to supply our power needs, we will be leaving a very unhealthy legacy for our children."

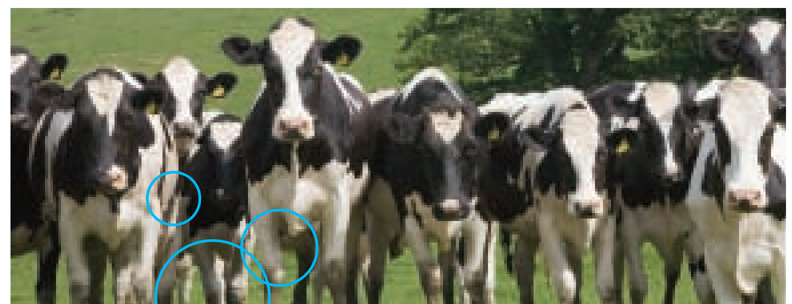
Wood's concerns are shared by ASU researchers who are in a race to more efficiently provide viable energy alternatives such as methane, hydrogen, biodiesel and bioethanol.

Methane: Turning Waste into Energy

When he's not riding his bicycle to work in an effort to conserve fuel, ASU Biodesign Institute postdoctoral research associate Michael Salerno spends his time working with waste (biomass). He focuses on microorganisms that naturally create methane gas.

Methane is a key component of compressed natural gas, and, when combined with other hydrocarbons, offers a cleaner burning fuel already used in today's vehicles. It's also an untapped resource that's widely available in the unused waste streams of various industries.

"My main goal is to improve methane production that occurs in wastewater treatment," says Salerno, who works with water treatment plants to help them recapture energy from their wastewater supplies. In his lab, Salerno runs wastewater through a high-voltage generator, causing the release of simple sugars and the breakdown of complex biomass molecules. "These actions result in more food for the microorganisms and more production of methane," explains Salerno.



With such a system, wastewater treatment plants, instead of flaring their unused methane into the atmosphere, could generate enough methane to meet their own electricity needs. Similarly, farmers, who have high amounts of animal waste, could generate their own energy using manure to feed an onsite reactor.

"Through this process, we are also reducing the amount of solids that we dispose of in landfills," adds Salerno. In the past few months, his lab has begun investigating—successfully—other waste streams and the amount of methane that can be produced or increased by manipulating the microbial ecosystems within them.

"Our society is already set up to use natural gas," says Rittmann. "If we have a good renewable source of methane, society can use it straight away. We're just working to find ways to improve the overall process to do it more efficiently."

Hydrogen: The Ultimate Alternative Fuel

While hydrogen is touted as the best alternative fuel – because the only reaction product from burning hydrogen is clean water—this future energy scenario is likely also the furthest away from real-world application, at least where vehicles are concerned.

Hydrogen does not occur freely in nature and must be produced by another primary energy source. Also, fuel cells, the devices in which hydrogen is converted to electricity by passing it over a Teflon-like plastic membrane coated with a platinum catalyst, still face significant cost and performance challenges.

Friesen, along with ASU Polytechnic professors Tamizhmani, Petrovic and Arunachala Madakannan, are working to decrease the lag time, through their work with hydrogen fuel cells – devices in which hydrogen is converted to electricity as it passes over a Teflon-like plastic membrane coated with platinum catalyst.

Hydrogen can be produced from a number of sources – water electrolysis, biomass, natural gas, coal, oil, solar or nuclear power. The current stumbling blocks to commercial availability of fuel cells in vehicles and other applications, however, are finding more efficient and less expensive ways of producing hydrogen from renewable sources, and the high cost to manufacture it.

Friesen's focus is on finding the best way to store and use hydrogen with materials that can be incorporated without the need for constant refueling, or, in the case of vehicles, disruption of a car's performance.

He is developing nanoscale materials – so tiny that they're less than one-thousandth the width of a strand of hair—for hydrogen storage. He and his student team are developing materials using ASU's High Performance Computer Center, allowing them to examine the surfaces of hydrogen fuel cell catalysts where chemical reactions take place. This bird's-eye view helps them see reactions and develop more efficient catalysts to increase the performance of fuel cells.

The Polytechnic team, by merging together the fields of microelectronics and solar energy, is working to create a completely sustainable energy scenario using a concept called the solar-hydrogen cycle. Their research is two-fold, focused on producing hydrogen by using only the sun and water, and focused on developing smaller fuel cells with more efficient and cost-effective materials.

"The portable fuel cell has a great potential to replace batteries for a variety of applications such as laptops, DVD players, PDAs and other electronic devices," explains Petrovic, who also studies portable fuel cells.

Polytechnic is also testing stationary fuel cells – most notably the 250KW fuel cell station of local power company, SRP. The station currently provides electricity for a portion of ASU's Polytechnic campus.

"For fuel cell to be applied to transportation applications, it might be another 10 to 15 years," says Madakannan, citing the high cost of materials, research and development. "The technology that is nearest – in three years – is portable fuel cells, followed by residential applications."

(Opposite page) Methane is one potential source of clean alternative energy. It can be produced from animal waste and may help reduce the amount of solids in landfills. (This page) Hydrogen is considered the "ultimate" alternative fuel, and can be produced from water electrolysis, natural gas, biomass and other sources.

B Biofuels: Creating Bioenergy without Plants

Open spaces and sunshine are two of the key components behind School of Life Sciences professor Willem Vermaas and his team's alternative energy research.

Unlike traditional biofuels, which are created by converting plant matter (such as corn) to ethanol, the fuel Vermaas envisions would actually be produced in large, flat enclosed systems on open land the size of several football fields. Instead or rows of plants exposed to natural sunlight, the field would include rows of enclosures containing thin layers of water, cyanobacteria and CO2.

"Cyanobacteria are effective in utilizing solar energy, removing CO2 and making it into sugars, which they convert into the key materials for biodiesel," explains Vermaas. "You would have a closed system with nitrate coming from ground water, CO2 waste coming from power facilities, and the energy coming from the sun. Together you convert those cyanobacteria into products, such as ethanol and biodiesel, that you can put in your car."

An added benefit over plants, he says, is that cyanobacteria don't deplete soil nutrients, require fertilizers that often contaminate water sources, or compete with food production.

The concept has generated much enthusiasm. "The then-CEO of BP, John Browne, came to ASU to receive an honorary degree in 2005," explains Jonathan Fink, the Julie Ann Wrigley Director of ASU's Global Institute of Sustainability and ASU's chief sustainability officer. "He was excited enough about the research that he suggested his chief scientist come visit ASU – which he did."

Biologically derived diesel already is among the first alternative energy sources to reach consumers, and Vermaas believes that biotechnology on cyanobacteria may change the landscape of economical biofuel production options. "Ten to 15 percent of fuel at the gas pump is already ethanol, but right now, it all comes from plants," he says. "That has some serious economic and ecological limitations."

A July 2007 study released by J.D. Power and Associates on consumer attitudes toward "alternative powertrain vehicles" revealed that 50 percent of all new-car shoppers are considering a hybrid, and 60 percent of such shoppers aged 16 to 25 years are thinking about going hybrid for

their next vehicle. While these percentages are down from figures in 2006, those holding fast to a desire to drive a hybrid vehicle cite environmental concerns, rising fuel costs and a sense of social responsibility as enduring factors in their interest.

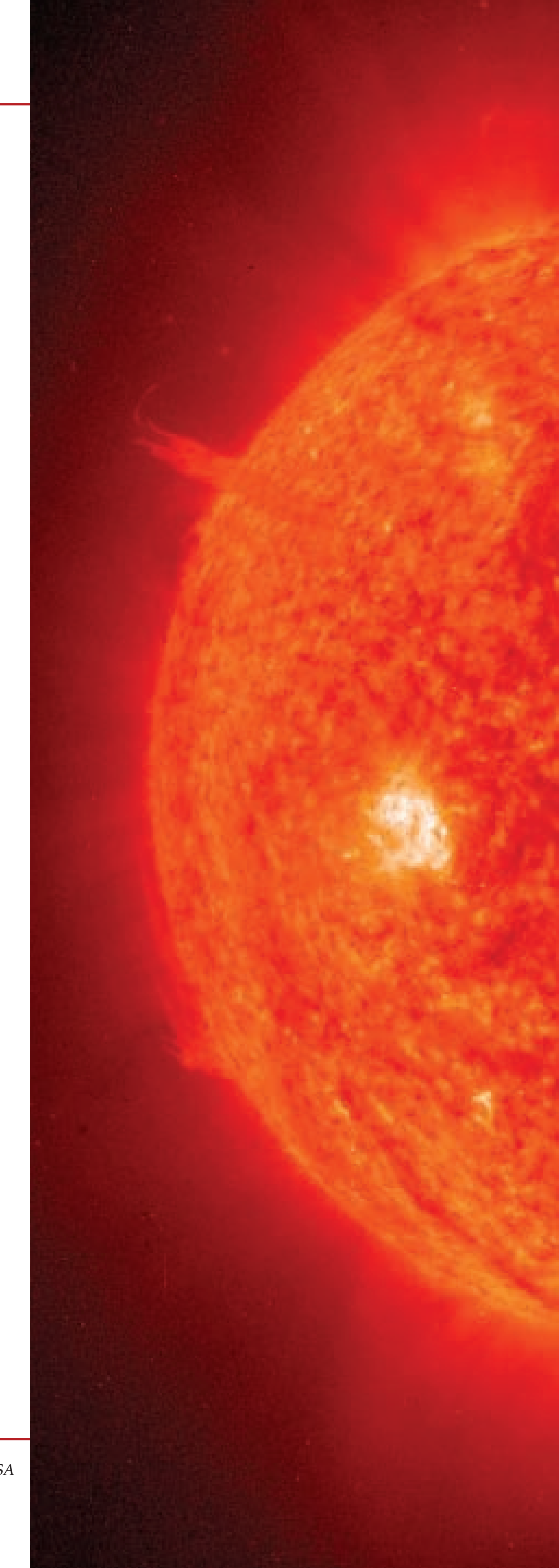
Oil companies are driving hybrid hype not only through higher gas prices, but also through public messaging. Recent Shell Oil advertisements have a prophetic ring to them with the tagline "The era of cheap oil is over." Even so, ASU researchers and alumni are confident they are on the path to success – a path that will ultimately help the wallet, but more importantly, heal the Earth.

Melissa Crytzer Fry is a freelance writer based in Mammoth, Ariz.

TACKLING THE POLLUTION PROBLEM

In addition to providing alternative energy solutions that will fuel tomorrow's vehicles, ASU's researchers are keenly aware of their role in erasing the fingerprints of the past so that humanity does not leave behind a polluted world, void of natural resources. A sampling of their efforts is listed below:

- Photovoltaic Testing Laboratory – ASU Polytechnic is home to one of only three photovoltaic (PV) module testing laboratories in the world, testing and improving the efficiency of solar panels worldwide.
- Sustainable Housing – Researchers in ASU's College of Design and Ira A. Fulton School of Engineering are working to design a "zero net energy home" that produces more energy than it uses, using PV modules, a solar cooling strategy and wall panels with solar thermal and PV technology woven into them.
- Bioplastics and Biofuels – Metabolic engineering is allowing School of Life Sciences researchers to manipulate the genes of photosynthetic bacteria so that they will convert more of their resources (fueled by light energy) into materials that can be turned into biofuels and bioplastics without the use of petroleum.
- Microbial Fuel Cells – ASU Biodesign Institute researchers in the Center for Environmental Biotechnology have developed a microbial fuel cell consisting of microorganisms that "eat" pollutants and transfer that energy into the direct production of electricity.
- Clean Water – Ground water containing perchlorate (a component of solid rocket fuel), which cannot be removed by conventional water treatment processes, is now being cleansed via a new Biodesign Institute technology that utilizes bacteria and hydrogen gas to reduce perchlorate to harmless water and chloride ion.



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