

Running on Sunshine:

CLAS FACULTY PROMOTE RENEWABLE ENERGY

ENERGY ISSUES WEIGH HEAVILY ON AMERICANS' MINDS THESE DAYS. THIS SUMMER, THOUSANDS OF PEOPLE LOST THEIR ELECTRICITY IN AN ENORMOUS BLACKOUT ACROSS THE NORTHEAST. IN ARIZONA, PHOENIX-AREA RESIDENTS IDLED IN LONG LINES AT THE FEW GAS STATIONS THAT OFFERED FUEL AFTER A PIPELINE RUPTURED BETWEEN PHOENIX AND TUCSON. IMMEDIATE CRISES ASIDE, AMERICANS HAVE OTHER REASONS TO WORRY ABOUT ENERGY. ON SEPT. 11, 2001, WE BECAME PAINFULLY AWARE OF OUR VULNERABILITY TO TERRORIST ATTACKS. AND SINCE THE U.S. WENT TO WAR AGAINST IRAQ EARLIER THIS YEAR, IT SEEMS WISE TO REDUCE OUR DEPENDENCY ON FUEL FROM THE MIDDLE EAST. THE NATION'S PREDOMINANT FORM OF ENERGY—FOSSIL FUELS—ALSO IS WREAKING HAVOC ON THE ENVIRONMENT, PRODUCING ENOUGH CARBON DIOXIDE TO CAUSE MASSIVE GLOBAL CLIMATE CHANGES WITH UNKNOWN CONSEQUENCES. AMERICA NEEDS AN ENERGY SOURCE THAT IS CLEAN, SECURE AND UNLIMITED. IF ALL THOSE REQUIREMENTS SOUND A LITTLE DAUNTING, TAKE HEART. ARIZONA IS RICH BEYOND COMPARE WITH AN EXCELLENT ENERGY SOURCE. AND A NUMBER OF CLAS FACULTY MEMBERS ARE DOING THEIR BEST TO PROMOTE IT.



Martin Pasqualetti



Neal Woodbury



Thomas Moore



Michael Kuby

“What do we have here in more abundance than any other state?” asks geography Professor Martin Pasqualetti. “The sun. People come here for the sun, yet curiously we don’t really use it.”

Pasqualetti plans to change that. In addition to his ASU faculty role, he also chairs the governor’s Solar Energy Advisory Council. The council promotes research, development and use of renewable energy sources, particularly solar.

The benefits of solar power are clear. First, sunlight is limitless, and Arizona receives almost year-round sunshine. Second, solar generators can operate independently of a large electrical grid, making them good choices for people in remote areas, and providing a measure of security.

“One central facility is an easy target,” says Pasqualetti. “If there are 10,000 solar sites out there, terrorists aren’t as attracted to them.”

Of course, solar energy is also environmentally sound, producing no pollutants, no noise and needing no transmission lines. And it can play a major role in developing the “hydrogen economy” that President Bush is promoting.

Hydrogen fuel cells may replace combustion engines in the cars of the future. These cells combine hydrogen with oxygen to produce energy. Their only waste product is water. Because 75 percent of U.S. oil consumption now goes to transportation, a move to hydrogen-powered cars could have a huge environmental and social impact.

Unfortunately, hydrogen deposits don’t lie in wait underground like coal or oil. Hydrogen can be obtained from fossil fuels, particularly natural gas, but doing that neu-

tralizes much of its environmental benefits. The better way to get hydrogen is to break apart other molecules, namely water. This process requires energy. The ideal source of this energy would be solar or another renewable resource, not fossil fuels. But the current technology for obtaining hydrogen is extremely inefficient.

“Any high school class can stick two electrodes in water and make hydrogen,” explains biochemistry Professor Neal Woodbury. “But it’s an inefficient process, and a lot of energy—about half—is wasted as heat.”

Woodbury is looking for a way to extract hydrogen more efficiently. He knows it’s possible, because it happens all the time.

“It turns out photosynthesis solved this problem some three billion years ago,” he explains.

Photosynthesis is the process plants use to get energy from sunlight. They use light to split water into oxygen and hydrogen ions. The oxygen is released into the air, while the hydrogen ions are involved in storing energy for sugar production.

A hydrogen fuel cell basically reverses this process, combining hydrogen with oxygen to produce water, releasing energy as it does. With current technology, however, that process is inefficient. Once again, part of the energy produced is wasted as heat.

THE HOLY GRAIL

As a researcher with the college’s Center for the Study of Early Events in Photosynthesis, Woodbury is trying to mimic nature’s process. The key to the problem lies in finding the right catalyst.

“There are a number of holy grails in chemistry,” notes Thomas Moore, another biochemistry professor. “Some are in medicine, some are in food production, others are in energy production. But there’s one sort of cross-cutting holy grail, and that is catalysis. A catalyst allows a process to occur that naturally wants to occur. To produce hydrogen, Moore continues, “some kind of molecule has to absorb light to make a chemical species energetic enough to rip electrons out of water.”

In plants, this event occurs through the “oxygen-evolving complex.” The biochemists are working to create a simpler version of it. They plan to use light—this time from a laser beam—to build pieces of proteins on electrodes. Because they don’t know the exact chemistry used in photosynthesis, they will create a few thousand “best guesses,” then measure how much en-

ergy it takes to produce hydrogen with each one. They will take the most efficient candidates and continue refining from there.

“We will ‘evolve’ some molecules that will have properties similar to the oxygen-evolving complex,” says Woodbury.

Modeling hydrogen power on photosynthesis will make the technology cheaper and more convenient. Even so, transitioning the world, or even the state, to renewable energy sources will be a monumental task.

“The land space required for solar cells to supply the whole world’s energy requirements doesn’t take that much room,” says Moore. “But the global energy infrastructure is built around fossil fuels.”



According to Pasqualetti, the liberal arts will have to lead the way in this transition. “Energy is often considered a technical issue with a social component,” he says. “But it’s actually the other way around.”

A CHICKEN-AND-EGG PROBLEM

Michael Kuby, an associate professor of geography, is addressing one aspect of the issue from a social-science perspective. With a National Science Foundation grant, he is studying the optimal location of refueling stations for alternative fuel vehicles.

“There’s a chicken-and-egg problem,” Kuby says. “Manufacturers don’t want to produce cars until a refueling structure exists, but no one wants to put up refueling stations until there are cars to use them. Our motivation for doing this study is to break that cycle by showing how to optimally locate the stations so you don’t need as many of them.”

Kuby approaches the problem using a branch of mathematics called “combinatorial optimization.”

“If you have hundreds of sites but you have a budget for 50 stations, there are zillions of possible combinations,” says Kuby.

“Combinatorial optimization is a technique for solving these kinds of problems.”

Currently Kuby is developing the algorithms that will help solve the problem. Planners only need to plug in some pieces of information, such as the network structure, number of stations and how far the vehicles can travel on a single tank of fuel, to get the best layout for refueling stations.

Once he has developed the methodology, Kuby plans to apply his tool to the U.S. railway system. That is a good place to start because the rail system is smaller than the highway network, and fewer customers are involved.

“The national railway system could be served with a pretty small number of stations,” says Kuby. “If they start to use it, that would ratchet up the hydrogen production infrastructure. That might get hydrogen production over that initial hurdle.”

Ultimately, all of the scientists hope to get over that first hump. Then ASU could lead the way toward energy independence for the entire United States.

“ASU should lead by example to Phoenix. Phoenix should lead by example to the state. The state should lead by example to the nation,” says Moore.

“I think we’re at a tipping point as a state, and also as a university,” notes Pasqualetti. “The economic opportunity is in the multi-billions,” he adds, pointing out that Arizona sends several billion dollars out of state each year to buy energy.

“The sun here can provide 2,500 megawatts per square mile,” notes the geographer. “If you used six square miles of incident radiation you could supply all the electricity this state needs.”

Pasqualetti points out that a local firm, Kyocera, is the third biggest solar-cell manufacturer in the world.

“There are firms out there that need expertise from the college—from sociology, psychology, geology, everyone,” says Pasqualetti. “We have 35,000 new housing starts per year in Phoenix. Imagine if all of them used solar.”

The technology already exists. However, Pasqualetti says life scientists are needed to determine environmental impacts, sociologists and psychologists to promote public acceptance, geographers to address land-use issues, and political scientists to manage public policy, among others.

“You’re facing an impossible uphill battle if you try to do it without the liberal arts,” he says. ■