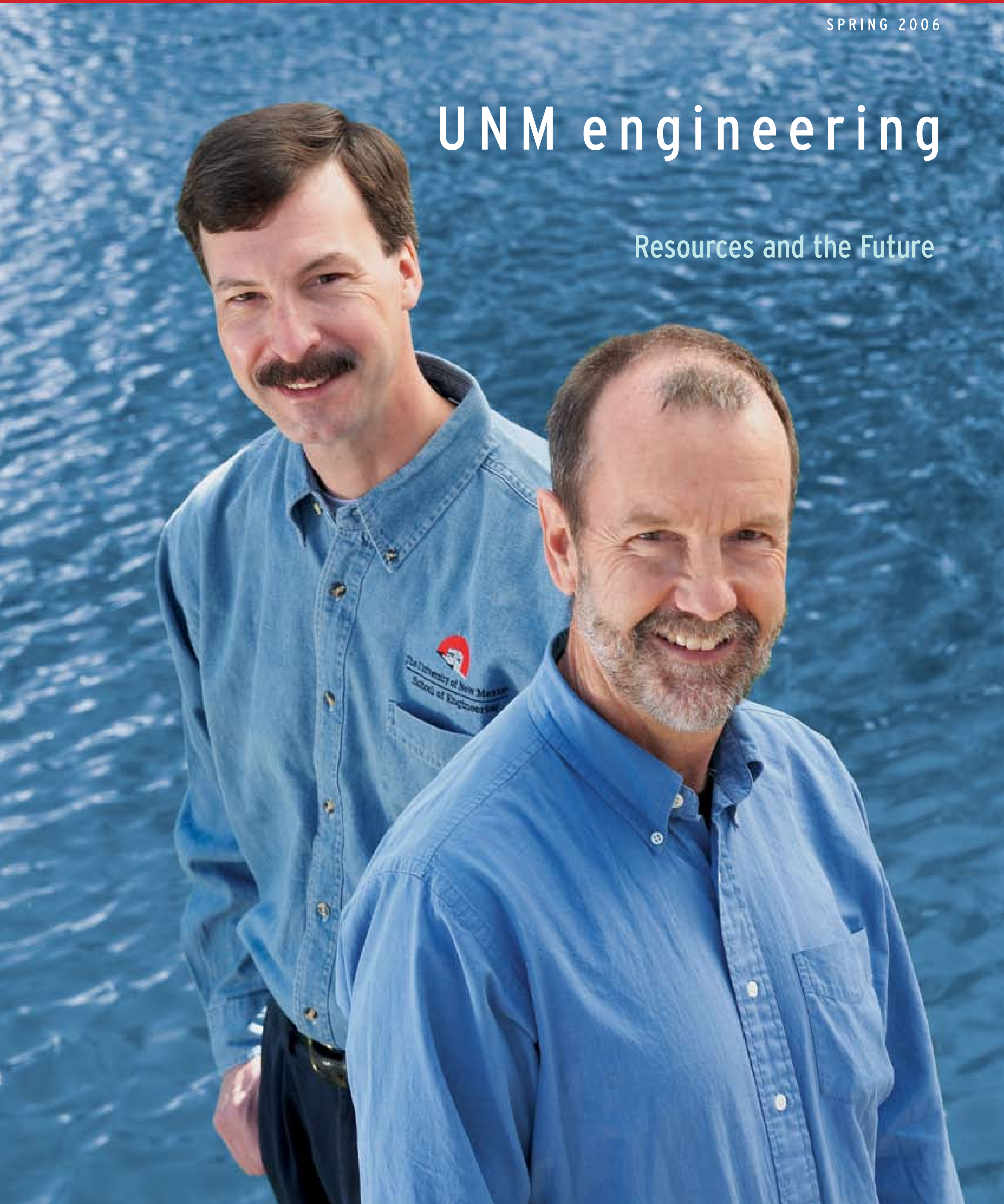
THE UNIVERSITY OF NEW MEXICO SCHOOL OF ENGINEERING

SPRING 2006

UNM engineering

Resources and the Future



POWERING THE FUTURE

UNM RESEARCH IMPROVES FUEL CELL TECHNOLOGY

WHICH IS THE MORE COST-EFFICIENT POWER SOURCE: THE LITHIUM BATTERY POWERING YOUR CELL PHONE, THE TINY BATTERY THAT MAKES YOUR TIMEX TICK, OR THE POWER FROM THE GRID THAT MAKES YOUR ELECTRIC STOVE WORK?

Ph.D. student Madhusudhana Dowlapalli is researching how to create an electrochemically resistant material that would inhibit the corrosion process of fuel cells.

"We're using nanotechnology approaches to design materials to address key issues in fuel cell development."

Assistant Professor Plamen Atanassov

When you run the numbers and factor in, among other things, the cost of the power source and its expected life span, you'll find that based on price per kilowatt, electricity from the grid is the best bargain of the three. In fact, we readily pay up to a thousand times more for some energy sources, like telephone batteries, than we do others.

From those examples, it's clear that society will pay different prices for energy based on the need for the specific circumstances of its use. "Introduction of a new power source or new energy conversion device is a question of winning the price game with the existing sources that address the same need," says Plamen Atanassov, assistant professor of chemical and nuclear engineering.

If you replaced any of those conventional power sources or energy carriers—batteries, oil, or electricity from the grid—with a fuel cell, you'd pay somewhere between $1–$10 per kilowatt. It's a reasonable price for some applications, but not cheap compared to electrical power derived from gas or coal. However, with new materials and better engineering, a fuel cell's price per kilowatt is dropping. As it does, these lightweight, efficient, and almost emission-free devices will replace conventional energy conversion devices and power our future.

What's Old Is New Again

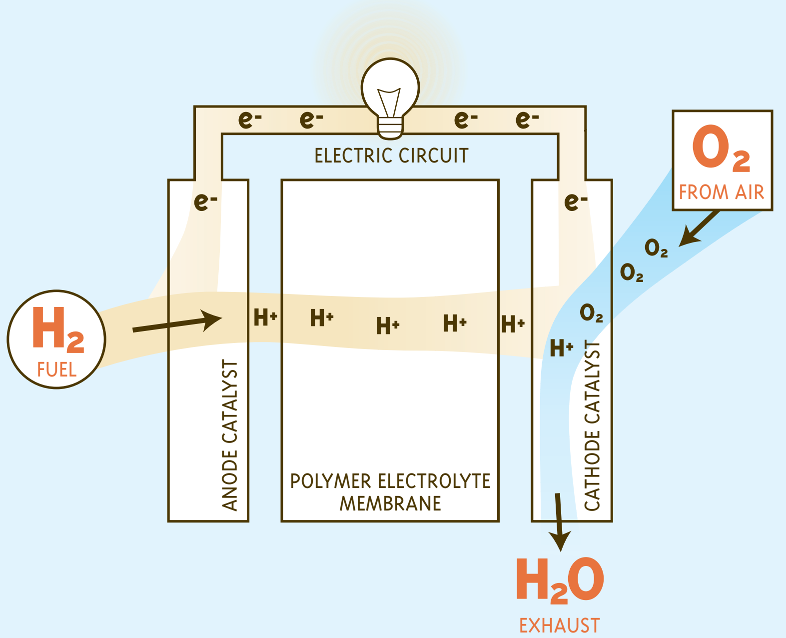
Actually, the power source of the future isn't new at all. Fuel cells, which use electrochemical processes to turn chemical energy in hydrogen gas and oxygen into electricity, were invented in 1838. In the 1960's, the U.S space program used fuel cells to power spacecraft electrical devices. Today they keep the lights on in offices and hospitals, and even power some cars. Still, fuel cells haven't gained traction as a primary power source because of the lack of necessary infrastructure, engineering challenges, and cost drawbacks. But considering all their potential—and with growing pressure on conventional energy sources—researchers and companies around the world are racing to improve fuel cell technology.

Atanassov is deeply involved in fuel cell research and in teaching the next generation of engineers to develop better fuel cell technology. A charismatic and popular instructor, Atanassov is leading several student teams in researching novel materials for fuel cells, bio sensors, and bio fuel cells. "We're using nanotechnology approaches to design materials to address key issues in fuel cell development," explains Atanassov.

Two of those key issues are the durability and affordability of fuel cell materials. A team of Ph.D. students working with Atanassov is addressing both factors. The students are trying to lower the cost and improve the performance of the catalytic layer in the cathode side of the fuel cell. "Our group is among many in this country that are making a very serious contribution in this research," says Atanassov. "Most of the teams, however, are from industry or the national labs. We're among the few well-recognized academic groups in the area." The team, Madhusudhana Dowlapalli, Tim Olson, and Elise Switzer, collaborates in a lab in Farris Engineering Center, where they analyze processes, create new materials, and then run tests on a fuel cell test station that measures their success in an actual fuel cell environment.

Three Researchers, Three Approaches

The catalyst, which reduces oxygen in the fuel cell, is made of carbon black, a type of carbon powder. The carbon black structure serves as a support for platinum nanoparticles. Platinum's price—well over $1000 an ounce—is a limiting factor in manufacturing more affordable fuel cells. The supply of platinum is also limited, which could make it a strategically important metal



Schematic representation of the basic fuel cell design: the fuel, hydrogen, flows into a porous anode where it is oxidized, producing a charge that is passed through an external circuit; oxygen from the air is reduced on the cathode, where it forms water while reacting with the protons migrating through the polymer electrolyte membrane.

if fuel cells are generally adopted as an energy conversion device. That's why Switzer is focusing on how to use the platinum more efficiently. She's developing ways to enhance the catalytic efficiency by applying smaller, dispersed patterns of platinum particles on nanostructured carbon black supports. At the same time, she hopes her approach will result in more effective transport of reactants and products through the catalytic layer.

Olson is trying to get around the cost of platinum by replacing it altogether. He's researching alternative catalyst coatings called pyrolyzed metallo-porphyrins, a group of chemicals that can be heat-treated to enhance their catalytic activity in reducing oxygen. Pound for pound, porphyrins aren't as effective as platinum, but they are much less expensive, so more of them can be loaded onto the catalyst to achieve results similar to platinum coating. "I'm studying the mechanism as to why these materials work the way they do, and why they work as well as they do," explains Olson. So far, he's focused on one type of porphyrin — pyrolyzed cobalt porphyrin — that has good potential for better oxygen reduction.

While Olson and Switzer are optimizing the catalyst materials, Dowlapalli is studying the interface between the materials; specifically the chemical reaction that occurs where the platinum and carbon black connect. That interface causes corrosion which, over time, reduces the fuel cell's efficiency. Dowlapalli is changing the types of carbon black used to make the catalyst structure and varying the load of platinum on the catalyst to better understand the reaction. His ultimate goal is to create an electrochemically resistant material that would inhibit the corrosion process.

It's a step-by-step process for Switzer, Olson, and Dowlapalli, but they all see the bigger picture. "I think if I'm successful in my research, it will lead to an increase in the life of whatever the fuel cell is in and that's really important," says Dowlapalli. Indeed. Their nanoscale changes have big implications for a better, more sustainable way to power the future. ✦

Atanassov and Ph.D. student Elise Switzer are improving the durability and affordability of fuel cell materials.

UNM AWARDED $3.5 MILLION FOR FUEL CELL RESEARCH

A new $3.5 million grant will allow Plamen Atanassov the opportunity to study the use of natural substances, such as glucose and ethanol, as electrical power sources for smaller devices. These bio-fuels will then be used to power small surveillance devices. Atanassov will serve as principal investigator on a research project titled "Fundamentals and Bioengineering of Enzymatic Fuel Cells" for a grant awarded to the University of New Mexico and its collaborators by the Department of Defense through the Multidisciplinary University Research Initiative.

U.S. Senator Pete Domenici announced the grant, saying, "I commend UNM for being the recipient of this competitive research money. Studying and developing natural sources of power has become an emerging priority. This is a tremendous opportunity for UNM to advance communication mechanisms for our men and women in uniform."

Based at UNM, the project will include collaborators from Sandia National Laboratories as well as Columbia University, Michigan State University, St. Louis University, Northeastern University, and the University of Hawaii-Manoa.