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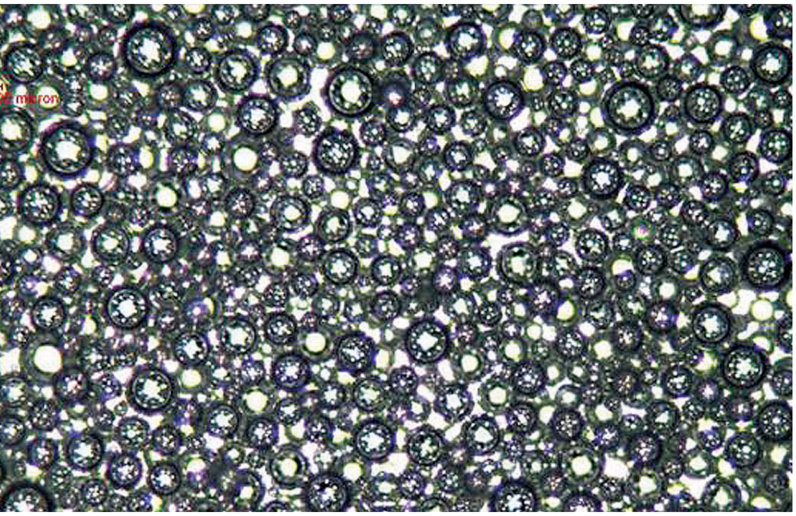
NEWS FROM THE UNIVERSITY OF CALIFORNIA ENERGY INSTITUTE

Aluminum Microfoams:

LIGHTWEIGHT MATERIALS FOR ENERGY SAVINGS

UCLA Assistant Professor Laurent Pilon



Aqueous microfoam generated by stirring water and surfactants (soap) at high speed in a baffled beaker. The objective of Pilon's study is to reproduce this morphology with liquid metals.

For the last few decades, polystyrene foam has reigned as a popular packaging material because it is lightweight, shock resistant, and has low thermal conductivity. Foams made of different materials, such as light metals, are attracting significant research attention today because of their energy-saving and insulating potential, among other characteristics.

Metal and polystyrene foams are solid "closed-cell" foams; their bubbles are completely surrounded by solid walls. Solid closed-cell microfoams – foams with tiny bubbles – are structurally strong, with a remarkable strength-to-weight ratio and resistance to impacts. The presence of bubbles reduces thermal conductivity, so they act as good insulators and tend to better resist thermal shock. They are also good acoustic insulators.

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Berkeley Lab Launches Demand Response Research Center

When electricity demand peaks on hot summer days, or when a power plant goes down unexpectedly, the entire electrical system is challenged to supply enough power where and when it's needed to meet demand. To address the challenge, researchers in academia, government and industry are working together to evaluate a range of demand response strategies and technologies that can facilitate the quick, automatic reduction of energy use in commercial and residential buildings, and in industry.

The U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has established a new Demand Response Research Center (DRRC) funded by an $8 million grant from the California Energy Commission's (CEC) Public Interest Energy Research program. The DRRC will conduct and disseminate research that provides the necessary knowledge base to facilitate near-term adoption of demand response technologies, policies, programs, strategies, and practices.

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Profile:

Bert Willems, Visiting Research Associate

Bert Willems arrived at the UC Energy Institute in January, just days after completing his Ph.D. in Economics at Katholieke Universiteit, in Leuven, Belgium. During his eight-month stay at UCEI, he studied the impact of long-term contracts on market power, and prepared his dissertation papers for publication.

Willems' dissertation research, based on the Belgian electricity market, examines the relationships between generators and transmission networks, including market factors and physical constraints, such as generation and transmission capacity, that affect the ability to foster competition. Prevailing practice in electricity restructuring has been to separate the sectors – to regulate transmission and deregulate generation – as a means to encourage competition in generation. Willems notes, however, that the links between the sectors complicate deregulation efforts.

In one study, he created a numerical model that examines different ways to set the transmission price for a network when three factors are present. These factors are congestion due to limited transmission capacity, fixed costs associated with network construction and operation, and market power. The model calculates optimal transmission prices for each time period and location in the network.

"My model simulates the markets, how the different players are going to produce or consume," he says.

The study shows that the standard method of transmission pricing has to be adapted when there is market power in generation and when the network operator has to collect revenues. A trade-off has to be made; transmission prices should be high enough to pay for transmission investments, but low enough to stimulate competition.

Willems also is studying the mechanism of options and forward contracts in electricity markets, and how these long-term contracts affect market power.

Willems, whose master's degrees are in economics and in mechanical engineering from K.U. Leuven, studied contract theory and industrial organization at Université Toulouse in France. While working on his Ph.D., he was a research assistant in the Energy, Transport and Environment program at the Center for Economic Studies at K.U. Leuven. His introduction to energy economics came when he was studying thermodynamics as a master's student.

"I had the advantage of having an engineering and environment background, but I wanted to know more about the economics side. It's a good combination."

"When I started, I thought economics might solve all the questions I had. But I realized that economics teaches you how to ask new questions. Economics, as a study … allows us to ask what we really want in this society and shows us which trade-offs we need to make."

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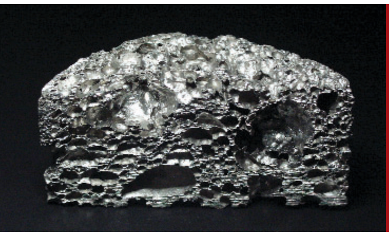
Willems left UCEI in August, returning to Belgium for one year to teach a course in Energy Economics at K.U. Leuven, and is seeking an academic position in a research environment. He appreciates the contacts he made with electricity researchers around the world while at UCEI. He also appreciates Berkeley's approach to economics, which he says extends beyond modeling to applied research with empirical results.

"I'm still the more abstract modeler, but I have learned to include more intuition in my work. It's a different approach to looking at markets, and it's nice to see there's another way of tackling a problem."

Aluminum Microfoams *continued from page 1*



Sample of metal foams obtained by stirring low melting temperature alloys at high speed in a baffled beaker. The foam is stabilized by direct oxidation of the cell walls and no addition of oxide particles is required.

"My goal is to work on a multiple scale system, to start with nanomaterials, generate microbubbles, and to finally make metal sheets of several millimeters in thickness."

For these reasons, closed-cell metallic foams are now being considered for a variety of transportation and aerospace applications. Some auto manufacturers are testing aluminum foams in vehicle chassis and frames in an attempt to make lighter structures. If the entire automotive fleet were lightened, even by just a fraction, world fuel consumption could be significantly reduced. For airplanes, reducing takeoff weight, likewise, could result in significant fuel savings. Aluminum foams also could improve passenger comfort in vehicles by reducing road noise. Similar applications exist in space flight and satellites.

For all their potential, metallic foams face several barriers, primarily in production. UCLA Assistant Professor Laurent Pilon, who teaches in the Mechanical and Aerospace Engineering Department, is studying new ways to produce aluminum microfoam. "I'm trying to look at the process, to make these foams in a newer, cheaper, and scalable way."

The procedures vary, depending upon the materials being used. For aluminum foams, the most common processes are gas injection and the use of blowing agents in conjunction with oxide particles. In gas injection foaming, bubbles are injected into molten aluminum creating liquid foam that is quickly cooled to form a solid foam slab. When a blowing agent is used, solid chemical particles are introduced into the molten metal. When the metal is heated the particles decompose into gas, generating bubbles.

Gas injection is more cost-effective, Pilon explains, but it tends to result in larger bubbles. Use of a blowing agent results in smaller, more desirable bubbles, but controlling the gas release due to particle decomposition is difficult. Bubble size and porosity are important. For structural uses in transportation or space applications, where a high strength-to-weight ratio is desired, the ideal foam has tiny, closely packed and uniformly distributed bubbles, resulting in a more homogenous material.

Stabilizing the bubble walls so that bubbles don't coalesce is another challenge, Pilon explains. "How to get stable foam out of metal is not an easy thing. People are still working on it," he says.

Pilon and his student, Samuel Prim, have adopted a unique process that produces aluminum microfoam that meets many of the desired properties but does not use particle injection. Instead, the team injects varying amounts of an oxygen-inert gas mixture into liquid metal. The oxygen oxidizes the walls of the bubbles, stabilizing them. Then the researchers spin the mixture at high speed (more than 6,000 rpm). They also use a specially designed beaker with baffles that obstruct the flow and create waves during stirring. The waves strike the baffles, breaking the bubbles into smaller bubbles.

"There is still fine-tuning to do," Pilon notes, because the bubbles average 1 millimeter in diameter, and he wants to create much smaller bubbles – less than 100 microns. (A micron is one-thousandth of a millimeter.)

Pilon developed this unique process – the combination of an oxygen-based gas mixture, high spin rate, and baffled beaker – with UC Energy Institute support. He is now seeking funds from the National Science Foundation and NASA to continue his research to create smaller bubbles.

One way he proposes to create smaller bubbles is to nanoengineer non-organic surfactants. Surfactants are substances that reduce the surface tension of the liquid to maintain foam stability. A common organic surfactant, a soap molecule, is about 2 nanometers long, but such surfactants decompose at high temperature and have no effect on liquid metals. Pilon hopes to develop non-organic surfactants that behave like soap in water, and that can withstand high temperatures when injected into molten metals.

He also plans to inject Janus particles into molten metal. Named after the two-faced Roman God, Janus particles have anisotropic properties created by their different surface coatings. One "face" of the particle is repelled by liquid, while the other face has an affinity for liquid. The logical place for these Janus particles and artificial nanoengineered surfactants is at the bubble surface.

"My goal is to work on a multiple scale system, to start with nanomaterials, generate microbubbles, and to finally make metal sheets of several millimeters in thickness."

Incorporating these particles into metal remains a challenge, Pilon adds. "Ideally, we would blow these artificial surfactants in as gases and hope they stabilize the surface the same way particles do."

Ultimately, he seeks to contribute in some way to the improvement of energy use in vehicles. "The objective is making safer cars thanks to better shock absorbers, and lighter transportation systems which would be more energy-efficient. It's a good combination in these times of high oil prices."

Wholesale Markets Need an Electron Superhighway

BY FRANK A. WOLAK

Since the Summer of 2001 over 8,000 Megawatts of new power plants have come on line in California, a close to 20 percent increase in the amount of in-state generation capacity. Over this same period, there has been a substantially smaller percentage increase in the capacity of the state's transmission network. This mismatch between transmission and generation investment makes it increasingly difficult to deliver the electricity produced by both new and existing power plants to final consumers and increases the likelihood of power supply interruptions. A similar mismatch between new generation and transmission investment has occurred in the other wholesale electricity markets currently operating in the United States.

The current structure of the United States electricity industry has created an urgent need for additional transmission capacity. An increasing share of the electricity consumed is purchased from a wholesale market, instead of being provided by a utility from its own power plants. The existing U.S. transmission network was designed to serve a vertically integrated industry that no longer exists. A robust transmission infrastructure is needed to get the power from where it is generated to where the customers live and work.

Investing in the transmission network expands the size of the electricity market any supplier sells into and can bring California utilities additional opportunities to buy electricity at more attractive prices throughout the year. If the transmission system is robust enough to carry electricity produced by a number of suppliers to all customers, wholesale electricity prices should decline because of vigorous competition.

Building up the nation's transmission grid to increase the competitiveness of wholesale electricity markets is comparable to the building of the transcontinental rail network in the early 20th Century. For example, the transcontinental rail network dramatically expanded the size of the market for California fruits and vegetables, benefiting not only farmers here, but also consumers throughout the U.S. The same is true for electricity. A transmission network with plenty of capacity can bring electricity to consumers from far away.

Another benefit of a more extensive transmission network is that the vast majority of the new power plants produce electricity at a substantially lower cost than the existing fossil-fuel facilities. These less-expensive units can be operated more frequently and at a higher level of output if the transmission network has enough capacity to allow them to supply power throughout the entire wholesale market, rather than only to a portion of it.

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Berkeley Lab *continued from page 1*

Demand response has multiple benefits, explains Berkeley Lab scientist and DRRC Director Mary Ann Piette. It can be implemented to reduce energy costs, to help maintain the electric grid or to serve the broader public good. "Demand response is important because it helps lower costs by reducing consumption on high priced days. It also improves reliability and can minimize blackouts, brownouts, and other problems such as voltage sags. The system is better maintained if we can reduce the 'peakiness' of the demand."

"Demand response will prove to be a boon to the electricity-supply picture in California in times of distress."

— CEC Commissioner Arthur Rosenfeld

A government building in Santa Rosa where researchers tested the feasibility of using thermal mass to shift demand.

CEC Commissioner Arthur Rosenfeld, a former researcher at Berkeley Lab, concurs. "Demand response will prove to be a boon to the electricity-supply picture in California in times of distress," he said in a release.

Over the next three years, the DRRC will manage a comprehensive program of research, which will include funding for both in-house and external, collaborative research. Upon completion of a major scoping study at the end of this year, the Center will define its primary research areas and then seek proposals for research projects, Piette says. The Center encourages interested researchers to join its mailing list for future solicitations and RFPs by visiting its Web site at http://drrc.lbl.gov. Several dozen researchers and graduate students are already affiliated with the Center. Roger Levy is the new program development and outreach manager.

While the Center develops its new plan, three demand response projects, funded previously by the CEC, are continuing. The first is a study of real-time pricing as a demand response strategy in the Niagara Mohawk service territory in New York. "What we found was that the educational and government sectors were the most responsive" to real-time pricing, Piette says.

The second project is examining the feasibility of fully automated demand response through a system of Internet-based controls and communications in large commercial buildings. The study, which began last summer in five different buildings, tests the building systems' response when a high price signal is sent over the Web. Each building has a different predetermined strategy for cutting energy use. "Our experiment builds on technologies implemented during the energy crisis," says Piette, who adds that the trials have successfully reduced electricity demand at the test sites by 10 percent. The study is now expanding to over a dozen buildings across California.

A library at UC Santa Barbara, one of five buildings statewide to test fully automated demand response.

A third project is studying the feasibility and economics of using a building's thermal mass to shift demand. Under this test at a government building in Santa Rosa, the chiller runs overnight or in the morning when rates are low to "charge the mass" and cool the building. During the afternoon, the building retains its lower temperature and requires less or no direct cooling during peak demand hours. Researchers hope to expand this trial to buildings with different uses and energy needs, Piette says. "We're reaching out to banks and drugstore chains, and larger commercial operations, all with the goal of reducing afternoon peak time demands."

Piette credits the CEC for demonstrating leadership by creating a center to focus attention on demand response. "It's timely now given the recent energy crisis," she notes. "But DR tends to have varying attention depending upon excess capacity in the market. It really needs to have consistent attention to develop a long term strategy."

Short Takes

CSEM Executive Education Course September 28 and 29

A few spots remain for the popular course, "Economic Fundamentals of Electricity Regulation and Markets." Professor Severin Borenstein and Dr. Jim Bushnell will teach the course September 28 and 29 at the California Independent System Operator's Board Room in Folsom, Calif. For more information and to register, please visit our Web site at www.ucei.org.

UCEI Grant Solicitation Approaching

In early November, UCEI will make available its grant proposal application package for the 2005-2006 cycle. Eligible UC faculty and researchers can either check the UCEI Web site for information as it becomes available or ask to be put on the e-mail notification list for the application package. Just send an e-mail to knotsund@berkeley.edu and the package will be sent to you electronically.

CSEM Fall Policy Conference

Clear your calendar for the afternoon of November 15! The CSEM Fall Policy Conference will feature two sessions: the first led by Professor Severin Borenstein on renewable energy and policies that encourage investment in it, and the second by Dr. Jim Bushnell on the pros and cons of capacity markets. The conference will be interactive and allow time for questions. The conference will be at the Secretary of State Building at 1500 11th Street in Sacramento. It is offered through a grant from the California Energy Commission and open to the public at no charge. Watch the UCEI Web site for more details as the date draws near!

Wholesale Markets *continued from page 4*

More output from these new power plants will lower the average cost of supplying electricity to consumers.

The cost of upgrading the U.S. transmission network should be more than paid for by the economic benefits to consumers produced by more competitive wholesale electricity markets. Unfortunately, electricity industry restructuring has effectively severed the incentive to undertake transmission upgrades from the ability to do so. Generation owners profiting from congestion have no incentive to support the upgrade. Electricity retailers bundle congestion charges into their cost of purchasing wholesale electricity. Transmission owners receive a regulated rate of return on their network investments. Only consumers would like economically beneficial upgrades to occur, but individually they have little incentive to participate in the process.

Like the interstate highway system, an improved transmission system begins with the federal government. Only a concerted national policy can ensure sufficient transmission capacity across state boundaries to establish competitive interstate markets for electricity. States also have a major role to play by ensuring that the networks in their boundaries are adequate to ensure effective competition among suppliers.

Taking the example of California, approximately 0.4 cents of the 12 cents per kilowatt-hour residential consumers pay for electricity goes to cover the cost of the state's transmission network. The revenues that would result from a 0.2 cent increase in this transmission charge could easily fund enough transmission upgrades to produce a far more competitive wholesale market throughout the West. For a typical household consuming 800 kilowatt-hours per month, this would raise their monthly transmission cost by $1.60. However, it is very likely that average retail prices could ultimately fall as a result of these upgrades because of the increased competition and greater output from lower cost power plants would lead to lower wholesale electricity prices.

This sort of cost/benefit calculation should be taking place throughout the United States in order to deliver the full benefits of electricity re-structuring to consumers.

Frank Wolak is a professor of economics at Stanford University and has been a visiting researcher at the UC Energy Institute, most recently in spring 2004

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