Satisfying our global energy appetite: Former DOE Under Secretary Raymond Orbach looks ahead

Few people in the United States have the global energy perspective that Raymond L. Orbach can bring to the table. After a 40-year research and administrative career in the University of California system, Orbach joined the U.S. Department of Energy, where he was director of the Office of Science, making him the highest-ranking science policy administrator within DOE. The Office of Science is the third largest federal sponsor of basic research and the primary supporter of the physical sciences in the United States. In mid-2006, after the position was created by the Energy Policy Act of 2005, President George W. Bush nominated him as the first DOE Under Secretary for Science. As Under Secretary, his primary responsibility was to serve as Chief Scientist for DOE and to advise the Secretary of Energy. In addition, he was responsible for leading the Department's implementation of the American Competitiveness Initiative and served as chair of the Technology Transfer Policy Board. In 2009, Orbach became the founding director of the Energy Institute at the University of Texas at Austin. The institute's goal—expressed in its mission "good policy based on good science"—is to promote sustainable energy security and continued economic vitality for Texas and the country.

***MRS BULLETIN:* You have had a distinguished career in energy with influential positions at the U.S. Department of Energy and now at the Energy Institute at the University of Texas at Austin, but you began your professional life in the University of California system. At what point did your interest in energy take off and how did that occur?**
RAYMOND L. ORBACH: I've always been interested in energy. When oil was really cheap, no one ever talked about energy, but one of the issues where I grew up in southern California was energy efficiency, and in particular automobiles, so smog was a major issue. When I was at the University of California, Riverside, I was very much involved with a program where we worked with automobile manufacturers to improve performance and reduce emissions. Then when I moved to the U.S. Department of Energy and was in charge of energy-related basic research, my familiarity with global energy issues really blossomed.

As we speak, the 2012 U.S. budget is still being debated. Preliminary indications are that science and energy will contain little or no growth relative to previous years. If funding for science and energy ends up suffering cuts, what should we keep and what is secondary?
Owing to the budget deficit, you will see draconian cuts across the board, except in science! If you look at the markups from the House and Senate for DOE, the National Science Foundation, and the National Institute of Standards and Technology, they've been cut by 0.5% to 1%. But that's nothing compared to the reductions that other elements in the government are going to receive. People who want to see huge increases ought to recognize the relative support that Congress is giving to basic research in the current budget climate.

Sustainable energy that is affordable, environmentally green, and readily available is the long-term goal, but the economy and national security loom large in the near future. How do you balance these sometimes conflicting priorities?
I frankly don't see them in conflict. My view is that current energy sources are going to be around a long time, and they are critical to energy security. There's no reason why we can't make them green with modern technology. A timely example is the Canadian tar sands. I've been to Fort McMurray, Alberta, where oil is produced from the sands. And while the tar sands have gotten a bad rap, I've got to tell you that something like over 90% of the water—and they use a lot—goes back into rivers and streams at the appropriate purity. In addition, a separate organization monitors air quality from all of the production sites along the rivers and streams in Alberta. Finally, when they're finished with a site, it has to be returned to its original condition. I think the Canadians have done a very good job at showing that you don't have to despoil the environment when you work with oil and gas.

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You have been quoted as saying that there is no magic bullet for solving the energy problem. Given that diversity is probably essential, how do you see the road to achieving sustainable energy? And what role do you think materials research fits in?
Because there is no single source that will satisfy the energy needs on a global scale, we need a broad spectrum of energy sources: photovoltaics, solar-to-fuels, nuclear, wind, coal (whether we like it or not), natural gas, and geothermal. Each of these areas has not one but many associated materials challenges. No matter where you look across the energy spectrum, materials issues are dominant.

For me, two areas that stand out are radiation damage and gas storage. Our nuclear reactors are 40 years old, and the neutron fluences on the reactor materials are extreme. There are major questions like, "How can you make materials stronger and less brittle?" that I think we've now got a chance of addressing because of the high-end computational simulation powers coming online.

For gas storage, researchers have developed new materials, such as the metal organic frameworks (MOFs) that are essentially all surface. The consequences of these new materials are enormous: We may be able to use natural gas instead of gasoline for transportation, which would reduce CO_2, NO_x, and sulfur emissions substantially; if we could figure out a way to use MOFs to store hydrogen at room temperature, we'd have another major transportation advance; and MOFs may be able to provide cost-effective capture of CO_2 from coal-fired or natural gas power plants.

Success stories are sometimes useful for building support for scientific research outside of the scientific community. Can you summarize one or two examples of materials advances that moved from the laboratory into the marketplace?
I think the announcement that Dan Shechtman received this year's Nobel Prize in Chemistry is about as good an example as you can find. Quasicrystals were originally found in complex metallic alloys and are now used in razors because they are very hard, as well as in other applications. Most people think their use will become even more widespread. Another example is the rechargeable Li-ion battery in your portable electronic device. The transition to an oxide cathode was pioneered by Professor John Goodenough here at The University of Texas at Austin. He optimized the voltage and capacity to get the energy density up to the requirements of mobile devices. These are just two examples of materials research that have changed the way we do things.

You are founding Director at the Energy Institute at the University of Texas at Austin whose mission is to provide the state and the country guidance for sustainable energy security. What is your vision for implementing this mission?
What I've been doing in the institute is to take the most vexing energy problems that society faces, not just in the United States but globally, and look for scientific research that the campus and our colleagues can carry out that address them. An energy-production example is shale gas, which has transformed energy security in the United States and elsewhere, but it also raises environmental challenges. How can you deal with those? On the energy-storage side, can we store at base-load levels electricity from wind? And the emerging answer is new electrolyte materials for flow batteries that could operate at base-load levels safely at room temperature.

Obtaining energy directly from the sun is also part of the Energy Institute's research portfolio. What are the challenges for this path?
We get a huge amount of sunlight falling on the earth. The difficulty is that it's diffuse; it's not very intense at any particular point. We need materials that can capture and convert sunlight to energy or fuels at least as high as 10%. Even with this efficiency, to actually make a dent in our energy needs, we need to cover very large areas. So the real challenge is to absorb sunlight efficiently over large areas in a cost-competitive way. This is basically a materials problem.

We want to thank you very much for your perspective on energy and materials. Can you give any final words of encouragement or advice that materials researchers should follow?
To young people, I can say this is an opportunity to make a difference. The inventions are still to be made that will deal with the energy needs of our globe. And we're talking about the lives of billions of people. Getting into materials is the best and the most effective way I know to make a difference while feeling a deep personal satisfaction. Even for policy-oriented students, a career of substantial scientific investigation and accomplishment is essential—good policy must be based on good science.

Raymond L. Orbach was interviewed by *MRS Bulletin* representatives **Russell R. Chianelli** and **Arthur L. Robinson**

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