The materials that make an energy company: BP chief scientist Ellen Williams discusses sustainable energy

Interviewed by **Martin Green** and **Prachi Patel**

After over three decades in academia, Ellen Williams left her position as a Distinguished University Professor of physics at the University of Maryland to take on the role of Chief Scientist at BP in January 2010. Williams is responsible for keeping a pulse on science and technology developments that could advance BP's energy portfolio and serves as a liaison to the company's university partners. She provides assurance for research and development spending and strategic scientific advice to BP senior executives. She has been instrumental in developing the BP International Center for Advanced Materials (ICAM) that will initially fund research at three UK-based universities and one US university. The center's research foci encompass materials integrity to advance corrosion protection during operations as well as the development of stronger, lighter materials for use in the challenging environments of hydrocarbon production and processing.

***MRS BULLETIN*: How does BP define sustainability?**
ELLEN WILLIAMS: We think about it in terms of a balance of meeting the world's energy needs, which are immutably growing, while reducing energy risks including climate change. For example, we are looking at cleaner, more efficient ways for extracting hydrocarbons and processing them.

Let's touch on the ramifications of sustainable development. Water is a good example. BP produces lots of wastewater. What do you do with this water?
The big issue is being able to clean up the water to the point where it's possible to release it into the environment, and then to figure out what to do with the concentrated contaminants that remain: heavy metals for example. Dealing with wastewater is the biggest part of our water cost, larger than the cost of getting water to use in our operations.

A major aspect of what we do in terms of water sustainability is figuring out ways to minimize our overall water use. Right now, of all the freshwater used in the world, about 2% is used to extract fossil fuels. One approach BP has used in water-stressed areas is developing ways to run our operations with the maximum amount of water recycling.

How do you view photovoltaics and why did you get out of it? Do you think there are still some meaningful research challenges in photovoltaics?
When you look at photovoltaics or any other power generation, you have to look at availability and the cost to the consumer. Hydropower is low-cost, but not available everywhere. Coal and natural gas are more generally available and are neck and neck in price in terms of use for power generation. Of course gas is in many ways a cleaner power generation source than coal. Wind price is coming down so it's getting very close to coal and gas, but it has an intermittency issue.

We were not in the solar power production business. We manufactured solar panels and had a great product. At the time we sold BP Solar, we had produced around 4% of all the installed solar panel capacity in the world. What caused us to exit the business was that manufacturers from China started driving the costs down tremendously and quickly. That's been great for the world because it has brought the cost of power delivery down from, say, three times that of coal to maybe two or less, but it made us uncompetitive.

Right now, the real issue in PV is capital costs: how much does it cost to install per unit of capacity? That's where short-term, big materials issues continue to need work. Of course I would still want to see materials researchers working on pushing up the efficiency of silicon solar cells, because that ultimately limits what you're going to be able to achieve.

Do you think wind power is going to come up faster than solar in terms of filling the energy portfolio?
Yes. Wind power is growing incred-

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ibly fast, and there's a big opportunity there, especially as the world is getting to offshore wind where you have much steadier winds. BP has wind farms all over the United States. In this case, our business is power generation. We buy the wind turbines; we're not in manufacturing.

What are BP's most important materials concerns and priorities?
As an energy company, BP is not primarily a materials development company. We buy most of our equipment and materials toolkit. Nevertheless, some materials research issues are very important for us.

We've identified three top priority areas for investment to drive our operations and activities. The first area is materials integrity under corrosive environments. In oil and gas exploration and production, we often deal with hot hydrocarbons coming up from below the earth under pressure along with sand, a mix that is hugely corrosive and destructive. Then there are saline environments. Along with oil and gas, we often produce water that is much saltier than seawater. As a result, one major focus for the BP-ICAM will be developing alloys that are intrinsically strong and resistant to embrittlement.

Then, we have materials integrity concerns that involve the ability to respond in damaging environments. One is structural integrity: for instance, we're very interested in lightweight nanostructured materials and how we can make them self-healing. And the other is protective coatings, which are tremendously important under these difficult environments.

Another important materials-related area in petrochemicals and refining as well as in oil and gas production is separations. An energy-effective way to do separation is using membranes, so designing membranes is important for us. In production, there are separation issues in the water that come up with the oil and gas, which can be quite dirty and we have to treat it. We also have separations issues in our refineries' out-streams. Then there is our biofuels business, where we usually need to separate the biofuel from water. We're actively looking at new nanotechnology developments for better designing membranes. We need the best selectivity and throughput and, of course, cost because everything we do is on an enormous scale.

The Gulf oil spill demonstrated that the petroleum industry in general was not prepared to deal with a serious event like a rupture. Did materials play a role in the disaster or in its mitigation, or was this an engineering problem?
It was primarily a series of engineering events. But as with everything in life, materials are always present. One issue in the aftermath of the accident was the corrosive environments I mentioned before. As a result, the blowout preventer was tremendously eroded when it was finally brought to the surface.

In stopping the well, again materials issues cropped up, even though they weren't the primary issue. An interesting materials-related concern came up in early attempts to capture oil by putting a big dome over the broken riser. We were going to have the oil flow up into that dome and then take it out at the top, and knew in advance that the move would be difficult because of a problem with methane hydrates. At the pressures and temperatures a mile below the ocean's surface, methane forms a methane ice. In fact, methane hydrates clogging pipelines and impairing production is a classic materials problem the oil and gas industry deals with all the time.

I think the oil and gas industry learned the importance of having relief equipment fabricated and on hand. BP developed response technology in real time, and we've committed to make what we learned about responding effectively to such accidents available to the entire oil and gas industry.

As a former academic, how well are you faring in the industrial world? What advice do you have for the next academic who vies for a high position in industry?
I've found people in industry more diplomatic than academics are in general. I had to learn to be careful with my outspoken opinions. Taking a little bit more time to think about what you're going to say and saying it in a constructive fashion is very important in industry. In that same context, in industry, unlike a pure research environment, the world does not revolve around science. Science is part of an overall technology context, and it is an interesting challenge to develop ways that fundamental approaches can help advance practical problems. The experience of moving to industry has been very energizing and tremendously interesting. I've learned a lot both technically and about the way the world works. □

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