Hatching Innovation in the Labs

Don Hammerstrom

MAKING APPLIANCES SMARTER

Donald J. Hammerstrom envisions a day when every electrical appliance is wise to what's happening on the far side of the wall socket. The inexpensive device he and his Pacific Northwest National Laboratory colleagues in Richland, Wash., have developed, dubbed the Grid Friendly Appliance Controller, is designed to reduce reliance on backup generators and prevent power outages that can occur when the electrical grid suffers momentary capacity problems.

The controller, which he says could be built into a water heater, clothes dryer, or other energy-hungry appliance for $5 or less, recognizes when telltale fluctuations in the current flowing through the socket indicate that the grid is straining to meet demand. The controller's response: briefly scale back the appliance's electricity use. That move, if multiplied by many appliances in thousands of homes and buildings, would be enough to relieve the strain on the grid, potentially averting a blackout. The grid would also need less 24-7 standby capacity (read, wastefully idling generators) to buffer the occasional unexpected fluctuation in electrical supply or demand.

The appliance owner, meanwhile, wouldn't need to do a thing. In a recent real-world trial, most consumers didn't even observe a difference in how well their retrofitted appliances performed when the grid was strained. "It's essentially unnoticed," Hammerstrom says.

The next big step will be enticing manufacturers to build, and consumers to buy, smart appliances. Because each purchase would make energy cheaper and more reliable for all, utilities, appliance makers, and other groups would have to work together to persuade everyone to upgrade. *–Ben Harder*

Lisa Alvarez-Cohen

REMOVING HAZARD FROM WASTE

There are two kinds of storage tanks for hazardous waste, says Lisa Alvarez-Cohen, chair of the civil and environmental engineering department at the University of California–Berkeley: Those that leak and those that will leak.

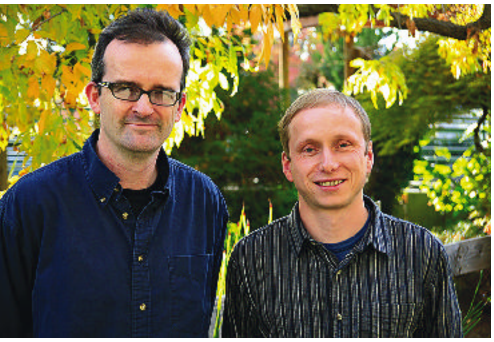
The challenge, for scientists, is finding a way to clean up the mess. For decades, though, cleanup efforts at the hundreds of industrial sites where toxic waste from, say, Big Pharma plants is slowly seeping into the groundwater have been stymied by high costs and ineffective tools.

Alvarez-Cohen may have a tidy solution: making the toxins literally disappear. Using a technique called bioremediation, she is studying ways to manipulate naturally occurring microorganisms living in the soil so that they organically degrade toxins building up in aquifers and other water supplies. When prompted with the right stimulus, she has found, certain bacteria will "breathe in" toxic chemicals and breathe out nontoxic gases. "It's really cool," she says, "and it's cost effective."

One of the first researchers to study how bacteria could be used to break down MTBEs, the now banned gasoline additive, Alvarez-Cohen is testing ways to biodegrade a range of what she calls "emerging contaminants," from flame retardants to the byproducts of wastewater disinfection.

In the future, thicker tanks may keep these new toxins, many of them known carcinogens, in their storage sites. But it's only a matter of time, Alvarez-Cohen says, before a gasket fails or a pipe bursts: "It's important for us to understand whether any chemical we're going to release into the environment has the potential for biodegrading or not. And if it does, we need to know how." *–Justin Ewers*

FROM LEFT: PACIFIC NORTHWEST NATIONAL LABORATORY; DAVID BUTOW / REDUX FOR *USN&WR*



Phil Hugenholtz and Falk Warnecke

FROM TERMITES TO BIOFUELS

The concept is appealingly simple: Termites have specialized enzymes in their guts that digest wood and grass. Advanced biofuels, made from wood and grass, require enzymes to break down the starting material. At the moment, such enzymes are costly and, despite improvements, somewhat inefficient. Natural enzymes—termite enzymes—may offer a path to more efficient biofuels.

In 2007, Phil Hugenholtz (at left in photo) and Falk Warnecke of the Energy Department's Joint Genome Institute in Walnut Creek, Calif., took a step in that direction with a paper in the journal *Nature* identifying more than 500 genes in termite guts associated with enzymes that break down wood's main structural component, cellulose.

That effort, says Hugenholtz, who heads the institute's Microbial Ecology Program, "was just the tip of the iceberg. It was just one species in one part of the gut." The focus has since turned to grass-feeding termites, where discoveries might be even more applicable to commercial biofuel production, given the interest in cellulosic ethanol made from switch grass. "One of the goals is to find these novel enzymes, enzymes that haven't been found before in other places," says Warnecke.

These findings, in turn, are being compared with data from other animals that break down cellulose, including cows, wallabies, and birds. The DNA sequencing itself, Warnecke notes, offers only "a few clues" about which enzyme would be most efficient. "That would be the next step of the analysis," he says. *–Kent Garber*

Daniel Nocera

STORING SOLAR ENERGY

Harnessing the sun's power requires, first, capturing solar energy. That's what solar panels do. But capture isn't the only hurdle, says Daniel Nocera, director of the Solar Revolution Project at MIT. Finding an affordable way to store the energy for later use is crucial. "If you can only use the sun when it's shining, you're in trouble," he says.

That's why the inexpensive catalyst that Nocera has created, using cobalt and phosphate, is such a breakthrough. It efficiently splits water molecules into oxygen and hydrogen, elements that serve as fuel for energy generation. When the catalyst receives electricity from a solar panel's photovoltaic cell, "it rips water apart to make oxygen," he says. That process previously required an expensive catalyst or extreme heat, pressure, and low acidity; the new catalyst does the trick under standard conditions. "The hard part of water-splitting was getting the oxygen out," he says. What's left can be readily stored as hydrogen.

Using solar energy, the average American household would need to split a bit more than a gallon of water a day to provide it with ample fuel for its electricity needs. Homes with energy-storage capacity wouldn't even need to be on the electrical grid, Nocera says.

The next challenge, he adds, will be making more affordable photovoltaics and fuel cells. Fuel cells, which use stored oxygen and hydrogen to make electricity, are pricey in part because they depend on a platinum catalyst. Nocera hopes he can replace it with a version of his. That's just one more way his material could help catalyze a revolution in renewable energy. *–B.H.*

Harry Atwater

REINVENTING PHOTOVOLTAICS

When Harry Atwater was a student in Pennsylvania during the oil shocks of the 1970s, his elementary school had to close for weeks at a time during the winter because of a fuel shortage.

"That made a powerful impression," says Atwater, now the director of the center for sustainable energy research at the California Institute of Technology, where he has devoted his career to finding a more reliable source of energy. Long an evangelist for photovoltaic solar cells and next-generation thin-film PV materials, Atwater has spent the past few years testing a technology that could reinvent photovoltaics altogether. Instead of cutting silicon into thinner and thinner wafers, as many scientists are doing, Atwater is researching ways to make arrays of silicon nanorods, small clusters of wires a hundredth the size of a human hair, convert sunlight into electricity.

Because the wires, bunched together like bristles on a brush, can absorb light along the entire length of each wire—while also "trapping" the sunlight on the semiconductor—a pack of nanorods is much more efficient than a conventional, flat wafer, even though it requires much less silicon. In recent tests, Atwater has found that the wires concentrate light at an intensity five to 10 times greater than traditional solar panels. "It's one of those things that's so obvious in retrospect, but it works unexpectedly well," he says.

Atwater may not be able to get schools through the winter yet. But he's getting closer. *–J.E.*

CLOCKWISE FROM TOP LEFT: DAVID GILBERT—DOE JOINT GENOME INSTITUTE; DONNA COVENEY—MIT; CALTECH