Microbes Sweet on Making Power

Alternative energy is already a big business. Power plants that turn agricultural waste into electrical power, for example, produce 37 billion kilowatt-hours of electricity in the United States each year, enough to supply the entire state of Colorado. Even so, the process used in most “biomass” power plants—burning wastes to produce steam, which drives electricity-generating turbines—converts only 20% to 40% of the energy in plant debris to electricity. Now a pair of Massachusetts-based researchers say that a radical different approach may do better.

In the September issue of Nature Biotechnology, microbiologist Derek Lovley of the University of Massachusetts, Amherst, and his postdoc Swades Chaudhuri report that they’ve created a microbe-based fuel cell that harvests up to 83% of the available electrons in sugar molecules without burning the fuel. That makes the cells clean and efficient. But past microbe-based systems have been either too inefficient or too finicky to have a shot at producing power on a large scale anytime soon. In 2001, for example, a team led by Byung Hong Kim of the Korea Advanced Institute of Science and Technology in Seoul reported that a species of Clostridium bacteria could siphon electricity directly from sugars, but the microbes converted a meager 0.04% of the available electrons in glucose to electricity.

Lovley and Chaudhuri discovered their latest electron-shuttling bacteria by accident. While probing an aquifer in southeastern Virginia for bugs that might help remove uranium from groundwater below old nuclear weapons labs, researchers in Lovley’s lab stumbled on a bacterium called Rhodoferax ferrireducens that passed electrons to iron, a uranium stand-in. The organism’s DNA appeared to be considerably different from that of previously known electron-shuttling microbes. So the team members decided to see what types of substrates it would eat and were surprised to find that it happily downed a variety of sugars. “From there, it was an easy decision to see if we could feed it sugars and generate electricity,” Lovley says.

Lovley and Chaudhuri placed a culture of Rhodoferax in one side of a two-chambered water tank. In each chamber they placed a solid graphite electrode connected by a wire. When fed glucose and other sugars, the Rhodoferax grew and multiplied, completely coating the positively charged anode to which they passed the electrons liberated from the sugars. Although the Rhodoferax proved remarkably efficient at reaping electrons, “there is plenty of room for improvement,” Lovley says. The team has already shown that simply replacing the solid graphite electrodes with electrodes made from either porous graphite or graphite felt—both of which have far more surface area—can boost power output as much as threefold.

Lovley hopes to use Rhodoferax to make more-efficient marine batteries for powering remote instruments. But in the long run, Tender says, the real potential is replacing biomass-burning with bugs. Says Tender: “It really simplifies the prospects of using waste streams and biomass as a fuel source.”

—ROBERT F. SERVICE