The rising need for clean, renewable forms of energy. The lack of adequate sanitation in many developing countries. These are two global problems that may not seem to go together. But what if a wastewater treatment plant could actually generate power, instead of using it? That’s the promise of microbial fuel cells (MFCs).

As Bruce Logan, Kappe professor of environmental engineering at Penn State, explains it, MFCs represent a completely new method of renewable energy recovery: the direct conversion of organic matter to electricity using bacteria.

It has been known for many years that bacteria could be used to generate electricity, Logan explains. But the organic material was always glucose, or some other high-energy carbohydrate. “We showed that you can do it with any biodegradable material,” he says. Even the wastewater that’s flushed down drains and toilets.

To make a microbial fuel cell, Logan continues, “you take bacteria, give it food but no oxygen, and add two conductive electrodes, an anode and a cathode. The bacteria oxidize the organic material, and transfer electrons to the anode,” or negative electrode. Then the electrons flow from the anode through a wire to the cathode, “and you have current,” he says. (On the cathode side, the electrons recombine with the protons and with oxygen to form water.)

The real beauty of Logan’s MFC, however, is that while it produces electricity, it also cleans the wastewater it uses. As Logan explains it, the air flow into the cathode tube reduces oxygen, providing the same cleaning effect normally accomplished by aeration. Since four to five percent of all U.S. electricity is used to treat wastewater, the potential savings are huge.

And there’s yet another twist. By applying a small electrical current to boost the action of the bacteria in a microbial fuel cell, Logan can reconfigure the cell to produce not electricity from wastewater, but hydrogen. Call it a microbial electrolysis cell, or MEC.

Not surprisingly, these parallel technologies have attracted a lot of attention, both at home and abroad. In March 2008, Logan was one of 12 scientists worldwide to receive a Global Research Partnership Investigator award from Saudi Arabia’s fledgling King Abdullah University of Science and Technology (KAUST). Logan will receive up to $10 million over the next five years to further his bioenergy research program.

“[Saudi Arabia] uses a tremendous amount of energy for desalination, and of course it’s all supported by fossil fuels,” Logan says. “The idea is to try and use wastes and waste waters and agricultural residues as a renewable energy source, and also to provide additional energy for desalination. But mostly our focus will remain on providing a global solution for energy sustainability of the water infrastructure. The heart of the whole thing is to come up with a way to allow for water and wastewater treatment which doesn’t suck up energy.”

To learn more, see: www.engr.psu.edu/ce/enve/logan/default.htm

Rachel Wagner found out about Bruce Logan’s research while she was serving in the Peace Corps. After she graduated from Virginia Tech with a master’s in biological systems engineering, she and her husband had taken off for a two-year hitch in Belize.

“We didn’t have Internet in our village,” Wagner says, “but we would ride the bus to the big city once a week, to shop for groceries and to get online. I knew I wanted to get into alternative energy. A few places sparked my interest, but—working for Dr. Logan—you don’t turn down an opportunity like that.”

After a year in Logan’s lab, Wagner was awarded a graduate research fellowship by the National Science Foundation. For her Ph.D., she’s zeroed in on learning exactly how the bacteria within microbial fuel cells do their work.

“That’s what research is really all about,” Wagner says. “You generate a big idea, and then you figure out all the little details to make it happen.”