Flushing the toilet may someday help keep the lights burning, thanks to a device developed at Penn State University that uses sewage-eating bacteria to generate electricity even as they cleanse wastewater.

"I don't imagine we'll be powering Pittsburgh," said Bruce Logan, the environmental engineer who has led development of the device. But the sewage flowing into the Allegheny County Sanitary Authority could be the source of enough power to help run the Alcosan treatment plant, he said.

The device, called a microbial fuel cell, captures electrons that are naturally released by bacteria as they digest wastes and converts the electrons into electrical current.

The fuel cell in Logan's laboratory is only about the size of a soda bottle and doesn't produce enough current to power a mini-Christmas tree light. But the experiment, reported online this week by the journal Environmental Science and Technology, shows for the first time that the device can generate electricity from wastewater while removing 78 percent of its organic matter.

Logan and his co-workers, post-doctoral researcher Hong Liu and graduate student Ramanathan Ramnarayanan, have since improved its efficiency by a factor of 10. Boosting the efficiency by at least another factor of 10 will be needed if a bioreactor is to produce a meaningful amount of power "without being the size of Nevada," he added.

"Proving it can be done is the big step," said Thomas Waite, a program officer for the National Science Foundation's environmental engineering/environmental technology office.

The agency sponsored Logan's experiments under a program intended to help risky ideas that nevertheless could have a high payoff, he noted.

"He has a very good track record," Waite said of Logan. "The idea that you could generate a large amount of electricity just from the bioprocessing of waste was very promising."

Interest in microbial fuel cells, an idea that has kicked around for a couple of decades, has grown in recent years, with researchers at a number of institutions now pursuing them, said Derek Lovley, a microbiologist at the University of Massachusetts at Amherst.

Some have proposed using the fuel cells for powering electronic devices in remote locations, such as the bottom of the ocean, where it is difficult or impossible to change batteries. Others have eyed using them in some Third World countries, where domestic wastes already are used to produce methane; the same wastes could be used to produce electricity instead.

At least one researcher has proposed "gastrobots" ---- robots that power themselves by eating food.

But Lovley, who does extensive research on microbial fuel cells, doubts that fuel cells that feed on wastewater will be practical any time in the next 10 years. "The technology isn't there," he maintained.

"When we eat something, we oxidize it," he explained. "And oxidation means we remove electrons." In humans, those electrons get transferred to oxygen molecules, which are then exhaled. In the bacteria in his fuel cell, normal respiration involves transferring the electrons to iron-bearing rocks.
Logan's fuel cell is able to capture these electrons by getting the bacteria to attach themselves to a positively charged electrode, or anode, made of graphite or carbon-filled cloth.

As the bacteria eat the sewage in the wastewater, they release positively charged hydrogen ions into the water and release negatively charged electrons to the anode. The electrons flow through a wire to a negatively charged electrode, or cathode, that is exposed to air; the hydrogen ions, meanwhile, pass through a special membrane to reach the cathode, where they recombine with the electrons and with oxygen to form water.

Some researchers have devised experimental fuel cells that digest sugar water; others use special populations of bacteria that seem especially suited to power production.

But the Penn State researchers use wastewater filled with particulate matter, "the kind of material that you and I produce and flush down the toilet every day," Logan said. And the bacteria are just those that are normally found in wastewater.

"You don't really need to go out of your way to find these bacteria," he added.

At UMass-Amherst, Lovley is trying to determine exactly how bacteria transfer electrons. With that knowledge, it may be possible to design better electrodes or even genetically engineer bacteria to more efficiently transfer electrons.