Water to make power, power to purify water: Engineer aims to limit waste

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Research for many water scientists involves a frustrating paradox: Water purification requires prodigious amounts of electricity, while utilities guzzle huge volumes of water to generate electricity.

That's why Zhen He, a newly hired engineering professor at the University of Wisconsin-Milwaukee, is hopeful that his prototypes for energy-producing water-treatment reactors bear fruit. Just as hopeful are his business partners at Gannett Fleming Inc., an international engineering firm that's helping finance He's research.

Together, He and his partners hope to develop commercial applications in the growing global market for water systems that operate with a small carbon footprint.

The bioreactors that crowd He's labs are built around a phenomenon that was established 100 years ago in Britain, but that scientists all but ignored until recent years. As bacteria break down organic materials, such as wastewater contaminants, the process emits a stream of electrons that can be captured with a pair of simple electrodes to generate electricity.

If all goes well, He's systems will perform three functions at once:

• Purify wastewater using bacteria.

• Produce electricity.

• Desalinate a separate supply of seawater in the same three-chamber bioreactors.

"This is not a perpetual motion machine. The science is proven. It's just taking energy that's untapped and using it," said David Drew, an engineer in the Madison, Wis., office of Gannett Fleming.

He, who left a post at the University of Southern California last summer to join UW-Milwaukee, said the work is in its "initial stage."

He and Drew are looking for new allies to help them win federal grants so they can develop and test larger reactors.

He wrote his doctoral thesis on microbial fuel cells, the technology underlying his reactor.

Classic microbial fuel cells have two chambers. And like a battery, one side has a positive electrode and the other a negative. One side is filled with bacteria and wastewater, which triggers the circuit.

The big innovation for He and Drew was the addition of a third chamber that holds salty seawater. Salt molecules, or sodium chloride, dissolve naturally in water. Permeable membranes separate the third chamber from the other two, allowing positively charged sodium atoms to migrate toward the electrode in one chamber while negatively charged chloride particles seep into the second. That removes the salt, molecule by molecule -- at least in the lab.

So far, it appears unlikely that the system can remove every last trace of salt from water. But at the very least, He said his system could create a pre-desalination process that removes most of the salt and reduces the energy needed to strip out the rest.

He was hired at UW-Milwaukee to help fill one of the most glaring deficiencies in the region: While the area has dozens of water-technology companies, the Water Council says the region's weakest link is the virtual absence of university-driven water-tech programs. He joined UW-Milwaukee after the engineering school won approval to bring in 22 new faculty members over the past year from other schools, part of UW-Milwaukee's strategy to play a bigger role in the regional economy.

It wasn't until energy prices rose in recent years that scientists revived an interest in energy-producing bacteria, He said. Some two dozen research groups are at work on similar technologies in the U.S., but more are researching parallel applications in Chinese universities, said the Chinese-born He.

"I'm hardly the first," He said.

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