Schooner Bay, Point Reyes National Seashore, California

ENERGY

It's Electric—With the Right Mix

Freshwater-saltwater ecosystems could provide bountiful renewable energy

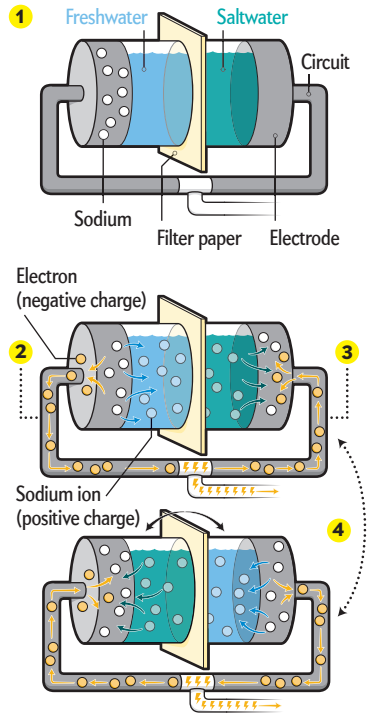
There is great opportunity where rivers and oceans meet: the salinity gradient that forms at these freshwater-saltwater boundaries holds a substantial amount of potential energy. Estuaries, for instance, could cover an estimated 40 percent of global electricity generation.

Scientists have been working for decades to turn this potential into a usable power source and have developed a number of techniques. One of the latest comes from Pennsylvania State University, where Chris Gorski, an assistant professor of civil engineering, and his colleagues say they have come up with a way to generate electricity from freshwater-saltwater ecosystems that is potentially more efficient and cheaper than previous attempts. The system, a variation on a process called capacitive mixing, works a little like a battery. It employs battery electrodes and relies on an electrochemical gradient—but unlike a battery, it is an open system (*graphic at above right*).

So far Gorski and his team have tested only a cell-phone-sized prototype in the laboratory. As reported in *Environmental Science & Technology*, it produced 0.4 watt per square meter—twice the power density achieved in previous capacitive mixing studies. The researchers still need to boost output and determine if the system is cost-effective and scalable (the power plant would be the size of a small warehouse in a real-world setting). They also need to investigate the potential for ecosystem disruption because the "river battery" requires the passage of large amounts of estuary water.

Yale University chemical and environmental engineering researcher Anthony Straub and other scientists are skeptical about the possibility of building an efficient system on a river-ocean junction—and say technologies like Gorski's may ultimately only work in places with relatively extreme salt gradients, such as hypersaline lakes, geothermal wells or wastewater facilities. But if it proves viable and safe, such a system may one day join solar and wind power as a form of renewable energy. —*Annie Sneed*

How It Works



1. Saltwater and freshwater are pumped into opposite sides of a cell, immersing battery electrodes composed of copper hexacyanoferrate. Filter paper keeps mixing between the two sides to a minimum.
2. On the freshwater side, the electrode is primed with sodium. In the presence of freshwater, the iron in the electrode reacts with sodium to release sodium ions into the water. The iron simultaneously releases electrons, which travel through a circuit.
3. On the saltwater side, the iron in the electrode absorbs sodium ions from the water and pulls in electrons coming from the freshwater side. These two reactions are coupled, and electricity is generated as electrons flow through the circuit from one side of the cell to the other.
4. Every 60 seconds, the liquids are switched (the saltwater side of the cell now receives freshwater, and vice versa) so that the current is maintained.

ROLF SCHULTEN *Getty images (estuary)*; SOURCE: "HARVESTING ENERGY FROM SALINITY DIFFERENCES USING BATTERY ELECTRODES IN A CONCENTRATION FLOW CELL," BY TAEYOUNG KIM ET AL., IN *ENVIRONMENTAL SCIENCE & TECHNOLOGY*, VOL. 50, NO. 17, SEPTEMBER 6, 2016

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