PLUGGING IN TO PLANT ROOTS

Marsh grasses can power small fuel cells

Cast-off electrons in a plant's roots can provide electricity, a Dutch team reports. Now, through a spin-off company, it hopes to grow grassy generators on rooftops and promote decentralized electrical production in wetlands in developing countries.

Plants exude a variety of waste products that microbes consume, such as glucose, acetate, butyrate, and propionate. The underground interaction leaves spare electrons in the surrounding soil and water, which researchers—led by Bert Hamelers at Wageningen University, in the Netherlands—began tapping in experiments in 2007. They were already working on using so-called microbial fuel cells (MFCs) to treat wastewater when they realized that plant roots improved the performance of the fuel cells.

In a series of experiments, the team measured the performance of its fuel cells as used in conjunction with plants. When bacteria consume a plant's organic waste, they release electrons, carbon dioxide, and hydrogen ions. The plant-microbial fuel cell passes the ions—but not the electrons—through a membrane to an oxygen-rich cathode, creating a potential difference. Wageningen environmental technologist Marjolein Helder and her colleagues built a pilot plant on the roof of a building at the university that has produced an average of about 0.44 watts per square meter of planted area, which they report in a forthcoming article in *Biotechnology for Biofuels*. "With the power output we've achieved, we don't have an economically practical green electricity technology… but we'll definitely be able to compete soon," Helder says.

She's comparing the plant-microbial fuel cell to other biomass energy technologies, such as growing trees and burning the wood or fermenting waste biomass into a liquid fuel. The amount of energy per unit land area the team has achieved is already the same order of magnitude as that of at least one estimate of old-fashioned wood-burning, of about 0.7 W/m^2. The advantage of plant-MFCs is that although they'll require occasional maintenance, they won't require harvesting or transporting wood.

Helder calculates that the system should be able to approach a maximum power density of around 3.2 W/m^2. The team hopes to get closer to that figure by

> Some soil bacteria build microbial "nanowires" with conductivities comparable to those of synthetic metal nanowires.

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altering the size and shape of the fuel cell electrodes in order to reduce their internal resistance. Its last attempt at such modifications doubled performance from 0.22 to 0.44 W/m². Other possible changes include using a different plant growth medium to direct more of the waste electrons to the electrodes, and improving the substrate on which the microbes feed.

The installation costs are still higher than those of other renewable technologies such as windmills or solar panels, says bioelectrochemist Feng Zhao of the Chinese Academy of Sciences, in Xiamen. He also notes that rooftop systems will work only in places that can count on adequate rainwater and little evaporation, such as the Netherlands. The next necessary step, he says, is to drop the capital costs. Helder says her pilot plant cost around €600 (about US $780) per square meter to install but that most of that cost was labor. She is aiming for under $40 per square meter.

Still, existing plant-MFC technology is probably already good enough to power environmental sensors in remote locations, Zhao says. "The voltage itself can…reflect the plant health or soil microbial activity," he adds, so MFCs could also monitor the very plants that power them. Some companies and laboratories have already begun using tiny forest-monitoring sensors powered by a potential difference between trees and the soil around them.

For now, Helder's spin-off company, Plant-e, is focusing on a tabletop toy: a plant-microbe fuel cell that powers a spinning globe. The toy may raise awareness and a little money, but the real goal is to commercialize larger installations, she says. If the toy market can power the start-up long enough to turn a profit or pick up a bigger investment, Plant-e will expand from its rooftop design to one that could work on an industrial scale in wetlands. "It could be a source of decentralized electricity in developing countries," Helder says. —LUCAS LAURSEN

TIM ROBBERTS/GETTY IMAGES

NEWS

GRAPHENE GOES THE DISTANCE IN SPINTRONICS

Experiments push electron-spin signals to record lengths

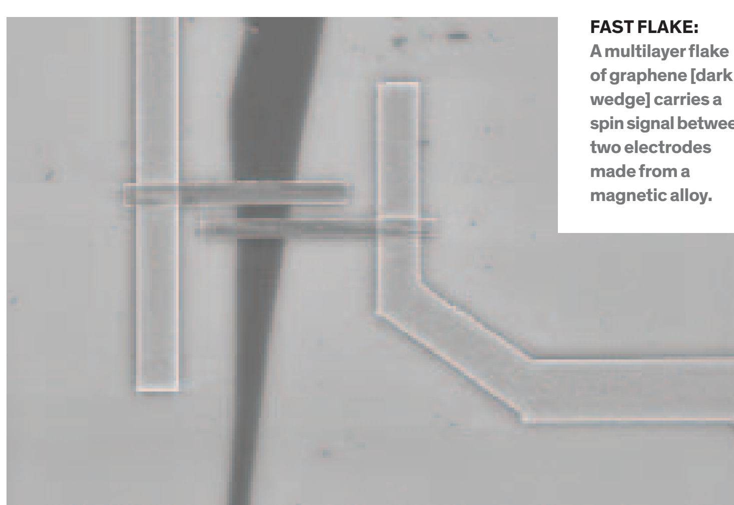
THE FUTURE OF COMPUTING might just come down to the honeycomb. Researchers have pushed graphene's ability to carry information using the spin of electrons to record distances. The results mean that the material—composed of honeycomb-like sheets of carbon atoms—may be ideal for future devices that use spin instead of electrical current to perform computations and carry signals.

Spin is a quantum mechanical property of many particles that responds to magnetic fields and corresponds to an intrinsic angular momentum. It can be a useful binary signal, because in the presence of a magnetic field it can be oriented in either of two ways—either parallel or antiparallel to the magnetic field.

Harnessing spin is nothing new—it is already used over short, vertical distances to store and read data in hard disks. But many researchers hope to find a way to use spin over longer distances. That could pave the way for new kinds of devices that perform computations using much less power than existing CMOS devices.

Such "spintronic" devices would bear some structural similarity to the traditional transistor, with an input and an output—sort of like the transistor's source and drain—connected by an electron-carrying channel. However, the signal involved is carried by the magnetization of the channel rather than the flow of current. In a spintronic device, the input and output areas are magnetic. When a voltage is applied at the input, it skews the distribution of electron-spin orientations in the channel so that they more or less reflect the magnetization of the input. In one recently proposed spintronics device, this spin signal can then be used to alter the magnetization of the device's output.

But the success of any spintronic device hinges in large part on what happens to spins once they make it into the channel. Interactions with »



FAST FLAKE: A multilayer flake of graphene [dark wedge] carries a spin signal between two electrodes made from a magnetic alloy.