Human gait could soon power portable electronics

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In a paper appearing in the journal *Nature Communications*, Krupenkin and Taylor, both engineering researchers at the University of Wisconsin-Madison, describe a new energy-harvesting technology that promises to dramatically reduce our dependence on batteries and instead capture the energy of human motion to power portable electronics.

"Humans, generally speaking, are very powerful energy-producing machines," explains Krupenkin, a UW-Madison professor of mechanical engineering. "While sprinting, a person can produce as much as a kilowatt of power."

Grabbing even a small fraction of that energy, Krupenkin points out, is enough to power a host of mobile electronic devices -- everything from laptop computers to cell phones to flashlights. "What has been lacking is a mechanical-to-electrical energy conversion technology that would work well for this type of application," he says.

Current energy harvesting technologies are aimed at either high-power applications such as wind or solar power, or very low-power applications such as calculators, watches or sensors. "What's been missing," says Taylor, "is the power in the watts range. That's the power range needed for portable electronics."

Solar power, the researchers explain, can also be used to power portable electronics, but, unlike human motion, direct sunlight is usually not a readily available source of energy for mobile electronics users.

In their *Nature Communications* report, Krupenkin and Taylor describe a novel energy-harvesting technology known as "reverse electrowetting," a phenomenon discovered by the Wisconsin researchers. The mechanical energy is converted to electrical energy by using a micro-fluidic device consisting of thousands of liquid micro-droplets interacting with a novel nano-structured substrate.

This technology could enable a novel footwear-embedded energy harvester that captures energy produced by humans during walking, which is normally lost as heat, and converts it into up to 20 watts of electrical power that can be used to power mobile electronic devices. Unlike a traditional battery, the energy harvester never needs to be recharged, as the new energy is constantly generated during the normal walking process.

The initial development of this technology was funded by a National Science Foundation Small Business Innovation Research grant. Now Krupenkin and Taylor are seeking to commercialize the technology through a company they've

established, InStep NanoPower.

In their work, Taylor and Krupenkin were inspired by severe limitations that current battery technology imposes on mobile electronics users. As any cellphone or laptop user knows, heavy reliance on batteries greatly restricts the utility of mobile electronic devices in many situations. What's more, many mobile electronics are used in remote areas of the world where electrical grids for recharging batteries are often not available. Cellphone users in developing countries often have to pay high fees to have cellphones charged. Similar problems face military and law enforcement personnel. Modern soldiers, for example, head into the field carrying as much as 20 pounds of batteries to power communications equipment, laptop computers and night-vision goggles.

The energy generated by the footwear-embedded harvester can be used in one of two ways. It can be used directly to power a broad range of devices, from smartphones and laptops to radios, GPS units, night-vision goggles and flashlights.

Alternatively, the energy harvester can be integrated with a Wi-Fi hot spot that acts as a "middleman" between mobile devices and a wireless network. This allows users to seamlessly utilize the energy generated by the harvester without having to physically connect their mobile devices to the footwear. Such a configuration dramatically reduces power consumption of wireless mobile devices and allows them to operate for much longer time without battery recharge, the Wisconsin researchers say.

"You cut the power requirements of your cellphone dramatically by doing this," says Krupenkin. "Your cellphone battery will last 10 times longer."

Even though energy harvesting is unlikely to completely replace batteries in the majority of mobile applications, the UW-Madison researchers believe it can play a key role in reducing cost, pollution and other problems associated with battery use. The hope, they say, is that the novel mechanical to electrical energy conversion process they pioneered can go a long way toward achieving that goal.

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