electricity using a method that goes back at least as far as the Ancient Greeks, namely rubbing together two so-called triboelectric materials (amber, the Greek word for which is electron, and wool were once popular) to create a static charge. TENGs turn this party trick into a useful resource by conducting the charge so generated away as a current.

TENGs, invented a mere decade ago, might plausibly involve sensors attached to human bodies or clothing. Bodies are continuous generators of motion, whether from breathing, gesticulating or running for a bus. The flexibility of many triboelectric materials makes them ideal for sewing into fabrics, where they could harvest the body's movement in order to power sensors that monitored vital statistics such as breathing and pulse rate during exercise. Such sensors might also do well in the hands of clever marketing types, with the phrase "batteries not included" being not a warning but a boast.

Conclusion

All these different types of sensors and switches gain their power from their outside environment in so many different ways to increase efficiency in manufacturing, transit, switching, quality control and many other activities. This energy saved makes the general environment a better place for all of us.

Sources:

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Environmentally Powered Sensors and Switches

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Introduction

There are new sensors and switches being developed and currently in use which get all of their power from their outside environment. This can be from either light, heat, kinetic motion or even vibration. They have a built in battery for backup, but will never need recharging or replacement. They are used to efficiently monitor and control indoor temperature, humidity, air circulation, increase manufacturing productivity, monitor building structures, railroad car efficiency, mining, and even human body and clothes positioning.

Light Power of Any Kind

Light sensors get their power similarly to solar cells, but are adjusted to cope with artificial interior lighting which is both weaker than sunlight and of a different color. Such photovoltaic sensors are used to measure levels of illumination, temperature, air pollution and even (of particular interest at the moment) airborne pathogens. Automatic systems can then

adjust lighting, heating, ventilation and air-conditioning levels appropriately. Photovoltaic sensors can also track products on assembly lines and monitor quality during manufacture. They offer eyes and ears in sterile chambers and provide early warning of shortages or leaks. They generate vast quantities of data as well, which can be used to maximize efficiency — though firms that employ them in this way tend to be secretive about the details. A study published in 2019 on the industrial applications of all sensor types in Germany, Switzerland and Austria by EY, a consultancy, estimated the combined boost to revenue from their extensive deployment could be as high as 34%, depending on the sector involved.

Powerless Switches Use Motion To Run Them A German company, EnOcean, has developed switches which are wireless and self-powered. They run simply from the kinetic energy flipping them. These switches are battery free and maintenance free.

Power from Temperature Difference

In the dark, a more useful source of scavenged energy is heat. The trick of turning this into electricity was discovered two centuries ago, and has been improving ever since. It usually involves a device called a thermocouple, made of sheets of two appropriate materials laid face to face. When one side is hotter than the other, electrons move between the sheets, generating a current.

Some of these devices are designed for inaccessible locations where battery replacement would be impractical. These sensors have been installed on wells in the freezing conditions of Alaska and the desert heat of California, to measure the pressure at the well heads. They have, as well, been fitted to steam-flow gauges under the streets of New York, to make sure customers are billed correctly for their use of the city's district-heating system.

Temperature sensors also rely on thermoelectric harvesting. Customers in the food industry use it to ensure ovens are sufficiently hot, while owners of industrial plants can check their cooling systems are working properly. And thermal harvesters can even be embedded in the concrete foundations of buildings, or affixed to internal beams, to flag structural weaknesses and mechanical problems.

Vibrations for Transit

Another field in which energy-scavenging sensors are being deployed is transport. It is here that vibrations and movement come into their own. A firm, Hitachi Rail, designs sensors powered by piezoelectricity. This is a phenomenon whereby certain materials generate current when stressed or deformed. Perpetuum's products monitor the condition of railway rolling stock—an abundant source of vibration. Sensors in wheels, gearboxes and motors are able to assess those components' health by looking for thermal and vibrational telltales of defects. They can also monitor the condition of the track. Several countries' railway networks make use of them to varying degrees, including those of America, Australia and India.

ReVibe Energy, a Swedish firm, has similar aims. Its sensors, which rely on electromagnetic induction rather than piezoelectricity to convert vibrations into energy, can be fixed to carriage wheels to monitor their position as well as the stresses on their bearings. This technology is being applied to mining as well, to look out for unusual patterns of movement in machines involved in the crushing and transport of aggregates.

Human Body Movement

There is also one further source of movement, which might be exploited to run sensors. This is the human body itself, which is becoming increasingly fashionable to adorn with sensors. A plausible way to convert body-movement into electricity is to employ devices called triboelectric nanogenerators (TENGs). These convert friction into