Battery harvesting versus energy harvesting

M. Simon, Technical Contributor

 Should you use primary batteries or energy harvesting for your low power isolated from the grid application? Are primary batteries better or worse than energy harvesting? Can you use one or the other or do you need both? Neither? It is an interesting question depending on the application, the power required, and the costs involved. So let us explore the field and see if we can determine a set of rules that will help us come up with a final answer. Stored energy (batteries)? Harvested energy? Neither? Both?

Power and energy

Two things must be considered from the very beginning: power required and energy required. They are not the same thing. For power, look at the peak power required or “Volts” times “Amps”. For energy, which is mainly a concern for batteries, you need to know the average power for the required length of time or “Volts” times “Amps” times “Time”. You can't meet just the power requirements or energy requirements; Both requirements must be satisfied. Energy harvesters only need to be able to deliver the power (average and peak) required. A harvester will deliver that power throughout its lifetime. The energy stored in a battery no longer limits the lifetime of a harvester powered device. That is a very powerful advantage.

Harvesting advantages

If harvesting can be your sole source of energy, you can save the cost of a battery. Alternatively, you can use the energy harvested to charge a rechargeable battery (i.e. keeping a cell phone charged from mechanical energy produced by the human body at an outdoor rock concert.) Logistics and labor can be a significant cost for a battery-powered device, especially if your device is at the bottom of the ocean or in space. Batteries work until they run out of energy. Harvesting works until it fails and everything fails eventually. A battery backup for your harvester is a good idea if the device is mission critical.

Temporary storage

The energy harvester has temporary storage in the form of capacitors, if its collection is intermittent, or if it must store small amounts of energy in order to deliver pulses of power. Batteries often need the same kind of storage in tandem

with the batteries in order to deliver pulses of power. Ceramic capacitors are preferred for storing small amounts of energy. When you need more energy, electrolytic capacitors can be used, but be aware of life specifications. For maximum energy storage use super capacitors. Check the life specification on those too. You may need to use several types of capacitor to meet your requirements.

Harvesters

Here are some of the different types of harvesters available. The granddaddy of harvesters in the consumer market is the solar cell. It harvests light. You can harvest vibration, temperature difference, air motion, water motion, radio waves, humidity change and chemical and biochemical reactions (fuel cells).

Light harvester

Light harvesters, commonly referred to as "solar cells", have been around for a very long time. The first widespread commercial use was solar powered calculators, which were really mostly powered by building lighting. Garden lights have become quite common as costs have come down for solar cells, white LEDs, and small rechargeable batteries. Because of its intermittent nature, harvesting solar energy requires storage, if its load needs to be serviced around the clock and in cloudy weather. Some applications require three days of storage to get the power delivery reliability required. That will vary with the application, climate, and latitude.

Air motion

A wind turbine collects energy from air motion. For megawatt power devices, the grid makes up for peaks and dips. For off grid and some on grid applications, batteries are used to get the energy delivered by the generator to match the power required by the load. For low power, you can use small turbines and generators or create devices that vibrate in the wind and then collect the energy from the vibrations.

Vibration

Vibration energy can be collected by a magnet and coil generator or with a piezoelectric charge generator. Most vibration collectors are tuned, which greatly amplifies the vibrations thus requiring less material for the collection mechanism. Tesla used the principle of resonance (Q multiplication) to greatly "amplify" the high voltages his transformers produced, but resonance comes with a downside. The source needs to be a fairly constant frequency because collection efficiency is greatly reduced outside the resonance band.

Temperature differences

Thermocouples, normally used as temperature sensors, can also be used to capture energy from temperature differences. They have the advantage of being able to handle high temperatures but they are not very good when it comes to capturing large amounts of energy. At lower temperatures thermoelectric heaters and coolers can be operated in reverse allowing you to collect a current flow from a temperature difference rather than using a current flow to create a temperature difference. Radioisotope thermoelectric generators use thermoelectrics to develop continuous power on the order of watts to hundreds of watts for decades. With the heat source built in, such generators are more like batteries than harvesters. But

the same principle can be used for harvesting. Pyroelectric generators are another possibility.

Radio wave harvesting

When I was a kid, diode detector AM radios with a one transistor (bipolar) amplifier powered by radio waves picked by the antenna were popular among experimenters. The more advanced radios had two tuned circuits. One for the radio and one for the power supply. The principle of Q multiplication (Tesla) at work again. Now a days with rectennas collecting microwave energy the idea has gone mainstream. Generally this is not a harvesting method because the microwaves are beamed to the receiver, but it could be if you are collecting AM broadcast station energy. Depending on your distance from the station, station power, and the power that you need a long wire antenna and a good ground may be required. Don't forget your lightning protection if you use such a set up.

Applications

The application area I find most interesting is using energy harvesting for biomedical applications. This is especially good for internal medicine applications such as heart pacemakers that can get enough energy from a beating heart to keep the heart beating with out requiring battery replacement surgery every few years. Some other application areas are sensor networks, energy control (light switches that communicate by radio and that are powered by the flip of the switch is one neat application), machinery monitoring, structural monitoring, surveillance, and no doubt more will the thought out as the technology becomes more pervasive. Which brings us back to the original question. Batteries or harvesters? It depends.