Renewable Energy Terms

Charge—Fundamental Property of Matter

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Derivation: From French charger, *and Latin* carricare, *to load a wagon, from Latin* carrus, *a car or wagon.*

Electrical charge is a fundamental property of matter, and understanding it is fundamental to grasping electrical concepts accurately.

In my column in *HP90,* I said that a flow of electrons is an electrical current. This is a useful way to think about current, but the description breaks down a bit in places. It is true that *in wires,* electron flow relative to the protons contained within atoms is an electrical current. But in a few cases, such as in batteries, it's not electron flow, but the flow of ions—atoms that carry a charge because they have lost or gained electrons.

In both cases, it is "charge," or charged particles, that flow. Charge is a difficult thing to define. It's rather like defining time or space. Charge is a component or property of atoms, but it is also, in a sense, a "thing." Everyone has felt a "charge" at one time or another, but you can't really hold one in your hand. It's like the wetness in water—we can talk about it separately, but I've never been able to separate the two myself.

Matter can be broken down into atoms, and atoms into charged particles, or "particles of charge" if you will. Electrons are negatively charged, while protons are positively charged. In most matter, these charges are equal in number, and balance each other out. So even though matter is full of charge, it generally has an overall electric charge of zero. The positive and negative charges are attracted to each other, which is what holds matter together.

Through a variety of means (heat, light, motion, magnetism, etc.), charges can become unbalanced in matter. This causes the charges to flow. In a PV module, photons of light bump charges along in a circuit. Light doesn't create the charges that it moves. The charges are already there—they are part of the material. But there's an energy input (via light in the case of a PV) at one end of the circuit, and an energy output at the other end where the load does work.

The origin of the word "charge" actually might confuse people about how electrical circuits function. In fact, there's a schoolroom analogy that says electrons are like train cars in the wire, where each carries a little bit of charge and dumps it one car at a time to be used by your appliances. This is misleading. The electrons have the same charge throughout the circuit, and flow in a circle. Energy makes a one-way trip, and actually flows in a field around the wire. Charges flow very slowly, while energy—the stuff that does the work—flows almost instantaneously.

When we say that we "charge" a battery, you might think that we're building up electrical charges in the battery. But in fact, we're storing energy via a chemical process, while the charges continue their slow trip through the whole circuit.

So charges flow through batteries, lightbulbs, and other loads. It is their movement that allows energy to flow from one place to another, but the charges are not "used up." In DC, the charges move in one direction. In AC, the charges wiggle back and forth. In both cases, the energy in the circuit is transferred in a one-way trip from source to load.

When we say "electrical current," we are talking about the rate of charge flow. Current isn't stuff that flows. Current is the rate of flow of the charges. A current is not energy, and a charge flow is not an energy flow.

In technical terminology, the charge flow rate is called amperes or amps—coulombs of charge per second. We measure the total charge that has passed a single point in amp-hours or coulombs—these are quantities of charge. When we multiply amp-hours by the voltage (system "pressure"), we get watt-hours, which is the energy generated or used.

Energy and charge are not at all the same thing. Energy is like sound, while charge is like air. Sound travels through air, but fortunately you don't feel a wind blowing in your face every time someone talks to you. The air is the vehicle that allows sound to travel, just as charges in a circuit are the vehicle that allows energy to travel.

So while you can put a charge in your musket, we actually put charge *through* our batteries and loads, and we don't get a charge out of them—we get energy.

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