AN

ENERGY PRIMER:

How We Consume Our Ancient Sunlight

BY JAN STEINMAN
Think about someone in your community whom you would describe as “energetic.” You might say they are forceful (in the nicest possible manner)—or that they can bring pressure to bear on situations (again, in the nicest possible manner) which allows them to accomplish work, and that they are empowered to keep things flowing over long periods of time.

If so, you’ve unwittingly made a link between personal energy and the physics of energy. The essential characteristics of an energetic person are similar to those of a physical energy source, such as a gallon of biodiesel, sunlight on a solar panel, or the water coursing through a micro-hydro turbine.

Stand that same box of fireplace matches on its small end, and you’ve got an energy use that has a tremendous force, but only a small amount of flow for a very brief time. This might represent, for example, an electronic flash for a camera. Yet, both “boxes” contain the same amount of energy!

In both these lighting examples, the specific force was voltage (also called “electromotive force”), and the flow was amperage, which is a count of the number of electrons that flow over time, and when multiplied together, they consume power in watts, which when used over a period of time, consume energy in the form of watt-hours.

(The firing of a small camera flash will consume about the same energy as a neon or electroluminescent night-light glowing for perhaps a month, but an incandescent night-light that uses a Christmas tree light bulb uses the same amount of energy in well under a minute!)

Energy exists in many forms, but always has the three components of force, flow, and time. Energy can be converted between various forms, but can never be created or destroyed—this is the First Law of Thermodynamics, pioneered by Sir Isaac Newton in the late 18th century.

That’s the theory—wouldn’t that be nice in practice! If we could convert energy between sunlight and mechanical motion, without any losses, all our energy problems could be solved. But in reality, the Second Law of Thermodynamics states that when making energy conversions, a certain amount is always non-recoverable—it isn’t destroyed, but it is converted to an unusable form or unusable quantity of energy. This is called entropy, and I think it has a clear parallel in community social situations, as well! (Think of the old game of “telephone” and the energy spent in repeating misinterpreted communications.)

So although we talk about energy “production” and “consumption,” we are really simply converting energy to and from various forms, losing energy through entropy.

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Physical energy can be defined as the application of power to perform work over a period of time.

But what is “power”? It can be defined as a force that causes a flow. For example, when you push against a latched door, you are applying a force to that door, but until the door is unlatched and actually moves, no flow results, so no power is actually transmitted to the door until it moves, when mechanical work is performed. (Likewise, a powerful person applies force of will, influence, or money, to entice ideas, labor, or goods and services to flow.)

It takes a finite amount of time to open the door—no matter how fast you move it, it doesn’t happen instantaneously. This time component is the third dimension of energy.

Think of a cardboard box. It has height, depth, and width. These might correspond to force, flow, and time, respectively. Together, the volume of the box (in liters, gallons, cubic inches, whatever) would represent a quantity of energy.

You could imagine a short, narrow, long box—like a box of fireplace matches. If such a box were lying on its side, it might represent an energy use that had relatively little force or flow, but one that continued for a long time, such as a night-light.
in the process. When making such conversions, the ratio of the energy you start with to the energy you end up with is called the efficiency of the energy conversion process.

For example, let's get away from lighting and drive a car. (If you don't drive a car, imagine driving a semi-truck that is delivering goods to you instead.) In fact, let's start millions of years ago: the sun shone onto the surface of the Earth for millions of years, at a strength of about 1,000 watts per square yard. Plants converted this solar energy into chemical energy through photosynthesis, but at an efficiency of only a few percent. So now we're down to a few tens of watts per square meter that is actually harvested by the plants.

But think of our night-light example. You can collect tremendous amounts of energy over long periods of time, even if the power is relatively low at any given instant. These few tens of watts were collected into chemical energy by millions of generations of plant life, and that chemical energy was preserved after the plants died and became transformed by heat and pressure into coal, petroleum, and natural gas.

Now, let's pump out some of those long-dead plants, and refine them a bit to take out the most useful bits for automotive transportation. This process also has eutrophy, measured by extraction efficiency, (also called "Energy Returned over Energy Invested", or "EoE") and today we use about one unit of energy to recover five units of petroleum energy. So before these long-dead plants even make it to our gas tank, we've lost about 20 percent of them.

Next, the petroleum's chemical energy is transformed via spark (gasoline) or heat and pressure (diesel) into thermal energy. This is actually quite an efficient process,
and nearly all the chemical energy is transformed into thermal energy. But this is where things start to break down!

For most gasoline engines, only about 25 percent of the heat energy is transformed into mechanical energy to make the car move. (Diesel engines can transform about 40 percent.) So now, we’re down to under 1

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percent of the energy that the sun initially put into those long-dead plants. And then the transmission and tires eat up another 10 percent (manual) to 20 percent (automatic). This is why your radiator gets hot and your tires get warm—it’s “waste” energy that could not be utilized to move the vehicle.

Now consider the tremendous rate at which we are using this ancient sunlight. A 200 horsepower gasoline engine—not unusual in an SUV or larger car—consumes about 60 million watts of ancient sunlight when it is running. This is the sunlight falling on an area of about 150 square miles! We are using energy at the rate of a flash bulb that accumulated at the rate of a night-light. We have this long, thin box of energy—the gift of ancient sunlight—that we are literally using in a flash, in geological terms.

Perhaps my clumsy attempt to tie physical energy with social energy made a bit of sense to you, or not. But I find it a useful analogy when dealing with fellow communitarians. Is he a slow-burning night-light? Is she a flash bulb? Energy conservation and wise use can be applied to organizations, as well!

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Jan Steinman has been a ski instructor, electrical design engineer, software engineer, and fine-art photographer, among many other pursuits. He drives with biofuels, strives to be an alternative lifestyle pioneer, and is a founding member of Eco-Reality: www.EcoReality.org. Jan is co-author of this issue’s editorial, “Community Survival During the Coming Energy Decline,” pg. 24.

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www.campaugusta.org
17530 Lake Vera Road, Nevada City, CA 95959
randall@campaugusta.org 530-265-3702