Supplemental energy puts humans in charge

Posted on August 2, 2018 by Gail Tverberg

Energy is a subject that is greatly misunderstood. Its role in our lives is truly amazing. We humans are able to live and move because of the energy that we get from food. We count this energy in calories.

Green plants are also energy dependent. In photosynthesis, plants use energy from the sun to convert carbon dioxide and water into the glucose that they need to grow.

Ecosystems are energy dependent as well. The ecologist Howard T. Odum in *Environment, Power, and Society* explains that ecosystems self-organize in a way that maximizes the useful energy obtained by the group of plants and animals.

Economies created by humans are in some respects very similar to ecosystems. They, too, self-organize and seem to be energy dependent. The big difference is that over one million years ago, pre-humans learned to control fire. As a result, they were able to burn biomass and indirectly add the energy this provided to the food energy that they otherwise had available. The energy from burning biomass was an early form of **supplemental energy**. How important was this change?

How Humans Gained Dominion Over Other Animals

James C. Scott, in *Against the Grain,* explains that being able to burn biomass was sufficient to turn around who was in charge: pre-humans or large animals. In one cave in South Africa, he indicates that a lower layer of remains found in the cave did not show any carbon deposits, and hence were created before pre-humans occupying the cave gained control of fire. In this layer, skeletons of big cats were found, along with scattered gnawed bones of pre-humans.

In a higher layer, carbon deposits were found. In this layer, pre-humans were clearly in charge. Their skeletons were much more intact, and the bones of big cats were scattered about and showed signs of gnawing. Who was in charge had changed.

There is other evidence of human domination becoming possible with the controlled use of fire. Studies show a dramatic drop in numbers of large mammals not long after settlement by humans in several areas outside Africa. (Jeremy Lent, *The Patterning Instinct,* based on P. S. Martin's "Prehistoric overkill: A global model" in *Quaternary Extinctions: A Prehistoric Revolution*.)

In recent times, humans have added fossil fuel energy, hydroelectric energy and nuclear energy to their "toolbox." All of these energy sources have allowed humans to stay in charge.

Whether humans' control of energy is good or bad depends on a person's point of view. Without humans being in charge, the human population would likely be similar in size to that of the populations of chimps or gorillas– in other words, tiny in comparison to today's human population. Furthermore, humans would be located only in the warmer parts of the world. As we will see in the next section, humans would not have evolved in the direction they did. Instead, they would have continued with only the abilities they had as pre-humans. They would have continued living in the wild, eating raw food and spending half of the day chewing it.

How the Controlled Burning of Biomass Produced Amazing Results

Pre-humans learned to control the burning of sticks and other biomass over one million years ago. This new-found ability helped our ancestors in many ways:

(1) Pre-humans could cook part of their food. (Richard Wrangham, *Catching Fire: How Cooking Made Us Human*) The ability to cook food increased the variety of food that could be eaten because some foods need to be cooked to be edible. Chewing time could be greatly reduced (Chris Organ et al.), leaving more time for tool making. Moreover, cooking allowed nutrients in food to be better absorbed.

(2) Less of the energy from food was needed for the maintenance of large teeth, jaws, and guts. Instead, more energy could go into building a larger brain. In this way, our ancestors could outsmart their predators, instead of depending on their muscles and teeth.

(3) Pre-humans could use fire as a tool to burn down unwanted trees and brush, making it easier to capture prey and encouraging new plant growth of a type more suitable as human food. Also, the fire itself could be used to frighten predators.

(4) Stone tools could be made sharper using heat.

(5) The heat from fire could be used to enlarge the range where pre-humans were able to live.

(6) Larger brains and frequent gatherings around campfires allowed language to develop.

(7) Humans, with their larger brains, were able to selectively breed different types of plants and animals, choosing characteristics that were better suited to their needs. As humans tamed fire and animals, they themselves became (in some sense) tamer.

The Physics Reason Why Energy Is So Important

We are all familiar with how the energy from food allows humans to grow. We also know how solar energy allows green plants to grow. Most physics instruction focuses on thermodynamically closed systems—that is, systems to which no new energy supply is added. Sometimes isolated systems are discussed—again a situation where no additional energy is available. In these situations, there is no growth—only a gradual depletion of the available energy supply, leading ultimately to "heat death."

More recent analysis has shown that thermodynamically *open systems*, which are characterized by inflows of energy, are very different. They can, and do, change and grow. Hurricanes grow when heat from warm seawater

is available. Stars grow as the result of the chemical reactions taking place within them. All of these structures (known as dissipative structures) are temporary in that they cannot continue to exist when suitable flows of energy are no longer available. They can also be undone in other ways, such as too much pollution or by other forms of "entropy."

On earth, the energy system we experience is an open system. Energy from the sun is constantly being supplied. Energy made available by burning biomass and from burning fossil fuels is also being supplied, as is nuclear energy, in the form of electricity. The energy obtained from burned fossil fuels, in fact, reflects the re-release of ancient solar energy that was once stored in the bodies of small plants and animals. Under the proper temperature and pressure conditions, this stored energy had been slowly transformed into fossil fuels.

The Hidden Nature of Energy Consumption

When humans burn fossil fuels today, they are able to access the use of this stored energy. Some researchers have talked about the ability to utilize fossil fuel energy as being similar to having "energy slaves." In making this analogy, it has been observed that a human adult produces roughly the energy output of an always-on 100 watt light bulb. Even when humans were still hunter-gatherers, they made some use of energy slaves, approximately tripling the amount of energy available to the economy at that time. By the time the industrial period was reached, always-on watts per capita had climbed to 8000, indicating that energy available to industrialized humans was 80 times as high (8000/100 = 80) as the amount expected based on food energy alone. The huge increase represented primarily the use of fossil fuels.

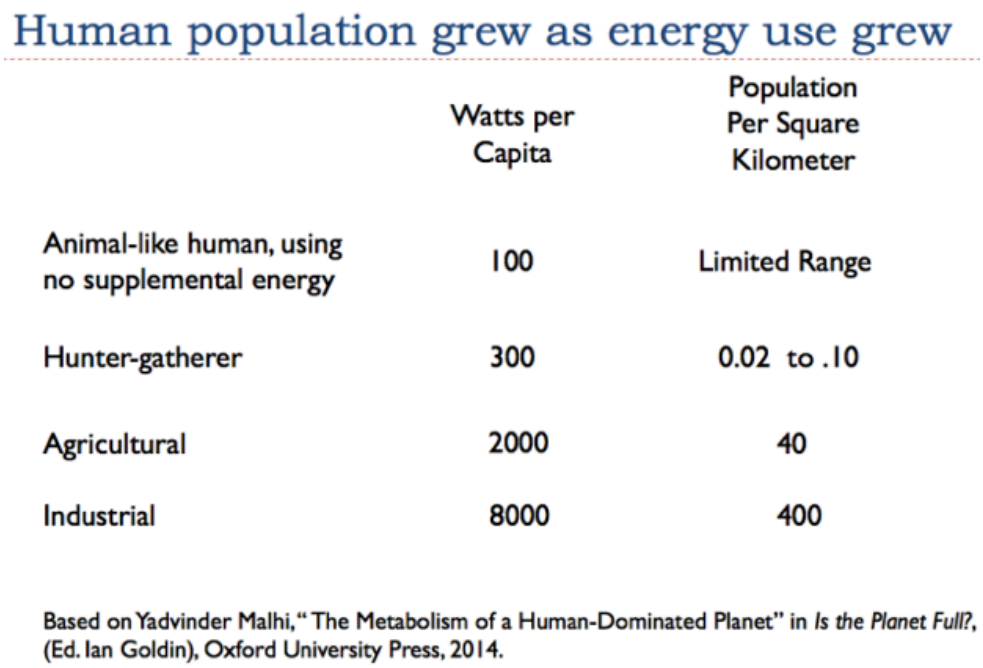

Figure 1. Relationship between human energy use and population.

In *Against the Grain*, Scott finds that slave labor was very widely used in early civilizations. Male slaves were often used for tasks requiring heavy labor, such as mining and building roads. Today's fossil fuel energy slaves can do these things and much more. For example, a truck operated on a road makes liberal use of fossil fuel energy slaves partly to make the road, partly to build the truck and partly as fuel to operate the truck.

Any commercial process requires energy in one or more forms. Part of the energy can be human energy. This human energy can be used in many ways such as typing on a computer, listening, thinking, operating machinery, speaking, digging in the ground, and walking. The rest of the energy is likely to consist partly of electricity and partly of fossil fuels burned for heat. (Some of this heat energy is converted to rotary motion in order to power vehicles.) Constructing a building requires a tremendous amount of energy; manufacturing a car is also energy-intensive. Heating and lighting a building require energy. Even obtaining a potable glass of cold water requires energy.

Figure 2 is a chart showing a breakdown of non-transportation energy consumption in the United States, based on data from the United States Energy Information Administration.

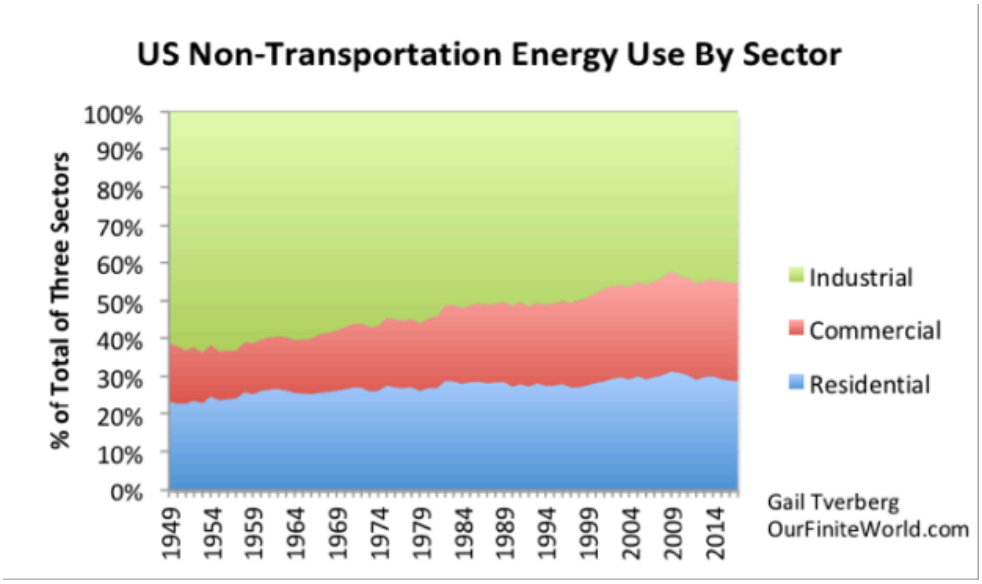

Figure 2. United States non-transportation energy consumption by sector, based on information from the US Energy Information Administration.

The residential percentage of non-transportation energy consumption rose from 23% in 1949 to 29% in 2017. We don't have a world estimate of the breakdown of energy consumption for residential use, but the United States is probably unusually high with its 29% residential share. According to a study by the National Renewable Energy Laboratory, China's energy consumption was only 11% residential in 2014.

If people do not understand how much of our energy consumption is hidden, it is easy for them to overestimate the benefit that can be achieved through energy conservation by individual citizens. A major use of supplemental energy (that is, beyond that available from food consumption) is to provide **finished goods** of all sorts, such as cars, homes, electricity transmission lines and roads. Supplemental energy consumption also provides the gift of *free time*. Without modern agricultural equipment, many more of us would be working long hours in the fields, leaving little time for advanced education and other modern pursuits. Another benefit of supplemental energy consumption is a much longer life expectancy, thanks to such things as clean water and antibiotics. Indirectly, supplemental energy consumption also provides jobs that pay well. Without supplemental energy consumption, there would be few jobs other than digging in the ground with a stick, in an attempt to grow food.

In a very real sense, the availability of inexpensive energy supplies that work to power existing machinery and equipment is what allows today's economy to function.

How Can We Tell If Human Carrying Capacity Has Been Reached?

If we are discussing primates such as chimpanzees, baboons and gorillas, it is fairly easy to tell when the carrying capacity of the environments they inhabit has been reached. These primates depend on local food and water supplies. If there is not enough food to go around, the weakest and the lowest ranking will find themselves without enough high quality food, bringing the population back below the carrying capacity. In some cases, as population density rises, there may be aggression toward immigrants to the territory. Females have even been observed to kill the infant newborns of community members.

Humans have control of various types of energy supplies, in addition to food. These energy supplies make it easier to produce enough food for the overall population. People today are used to having things that wild animals do not have, such as clothing, education, climate controlled homes, transportation, medical care and retirement benefits. It should not be surprising that in our case, the first sign of reaching carrying capacity is something other than *running out of food*. In fact, the laws of physics suggest that reaching human carrying capacity is unlikely to be signaled by *running out of any energy product*, such as oil.

Instead, the issue that tends to arise as humans reach carrying capacity is increasing **wage disparity**. This issue arose in the 1930s, and it seems to be rising again now. Increasing wage disparity is a way, within our economy, of squeezing out some members, if there are not enough energy supplies to go around. Providing climate-controlled homes, automobiles, paved roads and electricity transmission lines for people all over the world would take a huge amount of energy supplies–far more than we have available today. Wage disparity assures that some groups cannot afford these goods and services, thereby effectively holding down *demand* for these goods and services.

Many people believe that oil prices are likely to rise very high, if there is a shortage. However, if wage disparity grows sufficiently large, any spike in prices is likely to be short lived. Instead, the energy limit that we are reaching may be *prices that do not rise high enough to encourage adequate production of energy products*. Without sufficient production of these energy products, there will be a shortfall of finished goods and services.

Physicist François Roddier in *Thermodynamique de l'évolution : Un essai de thermo-bio-sociologie* explains that when there is inadequate energy for an economy, the situation is similar to some members of the economy being "frozen out" through low wages. The same forces allow a rising portion of the wages (and other wealth) to go to the very rich. This situation is like steam rising. These individuals do not use very much of their wages to purchase goods and services made with commodities. Instead, they tend to use their wages for services (such as tax avoidance) that are not very energy intensive. Also, they tend to use their wealth in ways that tends to drive up asset prices, without adding true value. For example, buying previously issued shares of stock can have this effect.

Eventually, the poor are frozen out. In fact, in cases of extreme wage disparity, the problems can spread further as governments find it impossible to collect enough taxes to finance their spending.

What Characteristics Do Energy Supplies Need to Have?

Unless we are willing to give up our dominion over other species, including microbes, humans need to secure a supply of energy products that grows with human population. These energy products must precisely match the needs of current infrastructure. They also need to be inexpensive and non-polluting. They cannot add new problems of their own–new types of entropy.

At this point, we are running into difficulties. Fossil fuels are becoming ever more expensive to extract. They also lead to carbon dioxide and other pollution problems. Nuclear energy seems to be quite dangerous, given the problems with waste disposal and multiple accidents, including the one at Fukushima.

Wind and solar, and indeed hydropower, are not really solutions, either. For one thing, they are not very controllable. If humans expect to control their environment, they need to be in control of their energy resources. Even waterpower can vary by a huge amount, from month to month and from year to year.

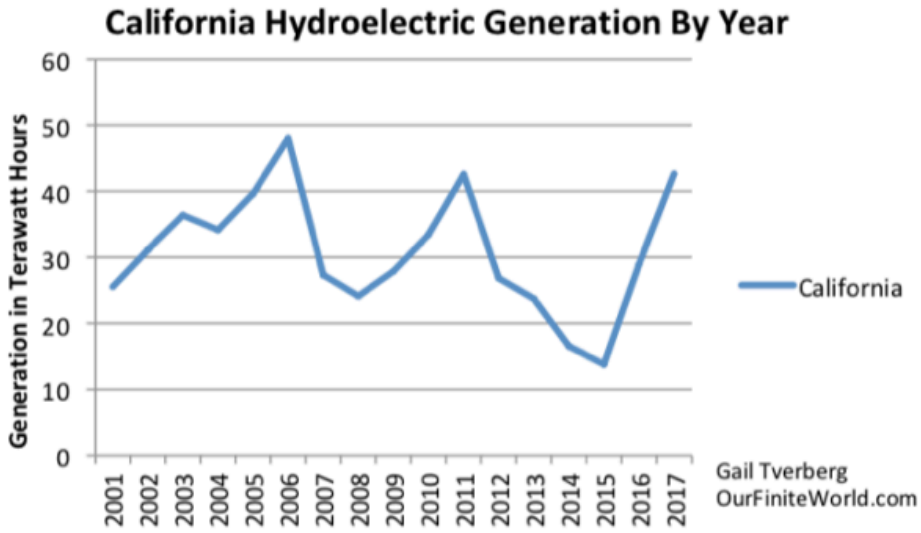

Figure 3. California Hydroelectric Generation by Year, Based on data of the US Energy Information Administration.

Hydroelectric, wind and solar can be used in limited amounts, as part of a portfolio of energy products, but they cannot be used on their own, unless they are hugely overbuilt. In that case, only a very small portion (which can then be controlled) is used. Many people believe that storage can be used as an alternative to backup energy supplies, but the cost of adequate storage seems to be extraordinarily high because of the long-term nature of required storage. (Note also the apparent need for multiple-year storage indicated by the pattern on hydroelectric generation shown in Figure 3.) If humans expect to be in control of other species, humans need to be in control of the supply of energy resources.

Of course, choosing not to be in control is another option. In such a case, we can expect human death rates to rise rapidly. If this happens, women will again be valued for their ability to produce large numbers of children. Men will be valued for their strong muscles. The world will become a very different place.

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About Gail Tverberg

My name is Gail Tverberg. I am an actuary interested in finite world issues - oil depletion, natural gas depletion, water shortages, and climate change. Oil limits look very different from what most expect, with high prices leading to recession, and low prices leading to financial problems for oil producers and for oil exporting countries. We are really dealing with a physics problem that affects many parts of the economy at once, including wages and the financial system. I try to look at the overall problem.

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Ed *says:*

August 5, 2018 at 1:41 pm

I am glad to see the president standing up to the predatory capitalist practices of the Chinese dictatorship.

Reply

Third World person *says:*

August 5, 2018 at 2:20 pm

so i was see this afghan-soviet war documentary