Humans Seem to Need External Energy

Strange as it may seem, humans seem to have evolved in a way that we have a *need* for external energy, such as energy from burning wood or fossil fuels. While the evidence is not 100% certain, it appears that we learned to use fire long enough ago that it is now necessary for our food to be cooked. Otherwise, in many climates, we would need to spend half the day chewing our food, and we would not be able to do much besides gather food and eat it. (People on raw food diets get around this issue by using a blender, which also uses external energy.)

There are other evolutionary deficiencies as well: How do we deal with our lack of fur? How do we deal with our evolutionary dental problems? How do we deal with "survival of the fittest"? If we want our children to live, we continually need more food for our growing families. Cooked food gives more choice of food supply. We don't think of humans as having instincts, but like dogs, we have a tendency toward hierarchical behavior, and this affects our need for (or at least "want for") external energy.

An additional issue, now, of course, is that the world's population is over 7 billion people. Even if we had not evolved to require using external energy, cooking our food makes many more types of food available, and is from this point of view much more practical than raw food. Cooking food does not in itself take a huge amount of external energy, but once we had learned the skill of using external energy, it opened new doors for other applications.

In this post, I will explain how these and other evolutionary issues relate to mankind's need for external energy, such as wood, or gasoline, or electricity.

Humans' Need for an Outside Energy Source

According to Todar's Online Textbook of Bacteriology, energy is important for all living organisms. Plants and animals literally can't live without a source of energy. Except for humans, plants and animals get all the energy they require from natural sources: from the food that they eat, or from sunshine through photosynthesis. Some organisms derive the energy they need through oxidation of inorganic compounds. Because of these natural mechanisms, these species have everything they need for survival, without requiring clothing or shelter, or other types of goods.

We can see how different humans are from other animals by comparing ourselves to large primates such as chimpanzees. Large primates spend much of their day gathering and eating raw food. They are not as intelligent as humans, and they mostly live in trees, so as to be able to avoid predators. This limits their choice of food supply. Their total number is far smaller than humans, because they need to stay in habitats to which they are adapted. The number of large primates varies by species (100,000 to 200,000 chimpanzees, about 130,000 gorillas, and fewer than 250,000 Gelada baboons according to the National Primate Research Center), but is always far fewer than the 7 billion humans in the world.

The shift away from behavior similar to that of other primates seems to have started after humans learned to control fire and learned to cook food. Chris Organ and others have shown that for a primate the size of humans, cooking food decreases the amount of time that must be spent chewing food from 48% of daily activity to 4.7% of daily activity. With so much more free time, the way an animal spends its time can change dramatically. Those changing to cooked food could do more hunting, and because of this change, include more meat in the diets. This would improve diets in another way.

It is well-known that cooking makes grains much easier to digest. Grains are a major agricultural crop, so cooking helped enable the transition to agriculture, around 10,000 BCE. With the transition to agriculture came the possibility of much higher world population.

Harvard biological anthropologist Richard Wrangham in "Catching Fire: How Cooking Made Us Human" sees evidence of evolution of adaptation to a cooked food diet as early as 1.9 million years ago. When *Homo Erectus* appeared at that time, teeth and guts were smaller than in predecessor species, and brains got larger. He speculates that the energy that had previously gone into digestion might have gone into brain development.[1]

With the evolution to smaller teeth, smaller gut, and bigger brains, humans have a real *need* to cook at least part of the food they eat. So outside energy for cooking food is one real *need* for the 7 billion people on our planet today.

Other Reasons Outside Energy Is Desired

Humans evolved without fur. Richard Wrangham in *Catching Fire* argues that fire allowed humans to evolve without fur, because a hairless animal can warm itself by a fire. A hairless animal is at an advantage chasing animals because it can dissipate heat much more quickly, allowing a hairless animal to catch one with fur by chasing it until it drops of heat exhaustion. The down-side of having no fur is that humans need at least some type of protection from the outside elements, especially if humans move to locations outside the tropics. Such protection might come in the form of clothing or shelter, or both. Outside energy would be helpful in creating food and shelter, but not as essential as for cooking food. Here again, being able to cook was helpful, because the reduced chewing time permitted more time for creating clothing and shelter.

Humans evolved with little defense against predators, except their intelligence. While other primates could climb trees, humans could not. They couldn't fly or swim either. Here too, outside energy sources were helpful. According to Wrangham, if early humans were gathered around a campfire, and a predator approached, one means of defense was to swing a fiery log at the predator. A group of humans could be protected from predators overnight by having a watchman with access to burning logs stay up all night. Eventually, humans learned how to use outside energy sources to build transportation of many types: automobiles, trucks, boats, and airplanes, to make up for deficiencies in the area of self-transportation.

Humans gradually found other ways that energy could be used to help overcome their evolutionary deficiencies. About 75,000 years ago, humans discovered that by heating rocks before they made tools from them, tools could be made more efficiently, and with a sharper edge (KS Brown et al, 2009). They later discovered that metals could be created with the use of external heat, expanding the type of tool that could be made. Humans evolved with hands that were more dextrous than those of other animals, so being able to produce good tools gave humans an advantage over other animals.

One deficiency of human evolution is that our tooth enamel has not evolved to withstand a diet high in starches. (PS Unger, 2012) Dentistry, which uses energy in many forms, including metal for tools and electrically operated X-ray equipment, helps provide solutions to these evolutionary deficiencies.

Humans, with their upright posture and large head sizes (because of large brains) have tended to have difficulty in childbirth, resulting in many deaths. Modern medicine helps overcome the problem of excessive mortality in childbirth. It, too, uses a lot of external energy, including metal tools (created using heat), sterilization, and medicines made from petroleum products.

Humans Outwitted Survival of the Fittest

In the natural order, each mother gives birth to more offspring than are needed to survive to maturity. This tends to work very well, because the offspring that are best adapted to the environment tend to survive to adulthood. As changes occur, such as a change in climate, or an increase in a particular type of predator, the offspring that are most able to handle the new environment are the ones who survive.

Humans, because of their intelligence, have found ways to defeat survival of the fittest. As areas get overpopulated, humans have moved to areas where they have a better chance of survival. Humans have found ways to increase food supply, through the use of fertilizers, pesticides, irrigation, and refrigeration, all of which require fossil fuels. They have developed trade, so that so areas with shortfalls can benefit from surpluses elsewhere. Humans have developed a world financial system, which has helped enable world-wide trade. The financial system has also allowed investors to pay for goods after they are put into service, so that the cash flow resulting from an investment can be used (after the fact) to pay for the cost of the investment. This enables investment, and faster use of resources, including energy resources.

One of the reasons for continued upward population pressure is the fact that humans have evolved to live beyond their reproductive years. In their declining years, humans often need assistance, either from their offspring or from a public pension program, or both. Because of concern for their own old-age, people without pensions tend to have enough children so that there is a significant chance that a child of the right sex will survive to adulthood. With improving medical care, this tends to lead to ever-rising population.

As an actuary (but not a pension actuary), I am aware that even when there are public pension programs, fewer children can cause funding problems. Public pension programs are typically transfer programs, where today's taxes on working citizens pay for today's benefits to retirees. If the number of retirees becomes too high relative to the number of workers, it becomes very difficult to pay a reasonable level of pension benefits to retirees. The use of "pay-as-you go" funding reflects a reality of life: whatever goods and services are available in a given year will have to be split between retirees and the current working population. If there are fewer workers relative to retirees, funding becomes very cumbersome for the workers.

The pressure of continuing population growth is a major reason for the need for supplemental external energy. The additional population needs to be fed, housed, and clothed. The additional people also needs jobs, and in today's world, these jobs require external energy inputs.

Controls Built Into the Population System

Nature builds a number of controls into the system, so that overpopulation will not occur. The most obvious one is limited food supply. We have found ways around this problem, thanks to the use of fossil fuels for fertilizer, pesticides, herbicides, irrigation, cultivation, and fast transport to market.

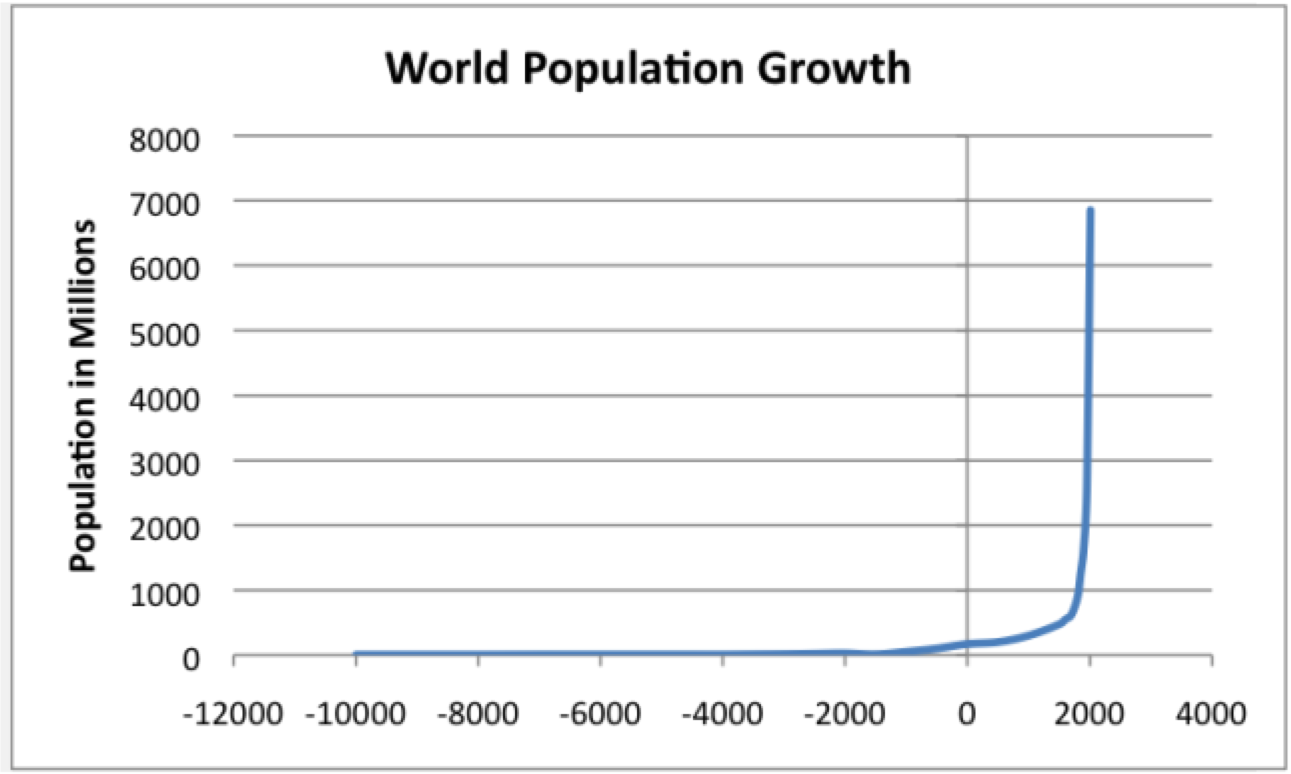

Figure 1. World population was able to increase greatly, once fossil fuels started adding to food supply about 1800.

Thanks to the wonders of fossil fuels, world population has been able to rise to 7 billion.

Besides limited food supply, there are a number of other controls in the system. One is infectious diseases. If humans live in close proximity to each other without adequate sanitary precautions, infectious diseases become a problem. In today's world, these are not much of a problem, because we have built water and sewer systems, and have developed antibiotics. Doing these things required external energy sources, generally oil and other fossil fuels.

Craig Dilworth in "Too Smart for Our Own Good" says that there are instinctual behaviors that would normally act to prevent overpopulation. One of these is **territoriality.** Primates and most mammals are what are called K-selected species.
In K-selected species, territoriality tends to hold down population size by restraining the number of breeding pairs. We have all seen territoriality, if we have male cats or dogs. They mark out their territories, and defend them.

The territories chosen by instinct by K-selected species are large enough to ensure that populations do not grow to such a size that they undermine their own resource base. Thus, if territoriality is working properly, there is no problem with tragedy of the commons (excessive use of shared resources), because the territory selected by the male for his family group is large enough to feed the family, with much available food left over.

There are a number of related mechanisms for keeping K-selected populations in balance with the rest of the ecological system. For example,

- Too high population tends to cause stress and leads to violence against neighboring groups. The winner gets more territory; the losers typically are killed.
- Infants may be killed, to keep the population in line with resources.
- Learned behaviors or instincts may limit when mating takes place.
- High population will tend to attract predators (germs, in the case of humans)
- If population is too high, hierarchical behavior (another instinctual mechanism) may appear or increase. Because individuals who do not need resources get a disproportionate share of the total, there is less for those at the bottom of the hierarchy, helping to reduce population size more quickly than if resources are shared equally. Those at the top are spared.

Humans have managed to overcome territoriality to a significant extent. One mechanism is language, since it allows humans to communicate with one another. Another is trade. If an outsider is of some value to us because of goods we gain through trade, then an individual is less likely to kill the outsider when he comes into contact with him. Another is religious beliefs that encourage respect for human life, and thus prevents killing of infants. The availability of sufficient resources, as has mostly been the case since World War II thanks to fossil fuels, may also act to reduce territoriality.

The Role of Hierarchical Behavior

A person often hears the comment, “We would have plenty of resources, if we would just share them more equally.” Yes, that is true, but as mentioned in the previous section hierarchical behavior is an instinct, put in place in other species to help keep population down. If individuals at the top hoard more of the resources, then individuals at the bottom of the hierarchy are starved out-part of survival of the fittest, that humans (including myself) find so objectionable.

Hierarchical behavior, if combined with a taxation system that helps transfer money to the poor, seems likely to lead to *greater* use of resources. If nature had been allowed to run its course, the portion of the population that nature considers excess would have been starved out. With the combination of hierarchical behavior and taxes to protect the poor, we have (from an energy demand perspective) the worst of both worlds: lots of people at the bottom of the hierarchy, who thanks to the transfer payments have the financial ability to buy goods and services made with energy products, plus we have all of the people at various distances from the top, who want to gather as much of the resources as they are able to, in an attempt to get to the top of the hierarchy.

The Connection of Energy With the Economy

Apart from all of the biological issues associated with the need for energy use, there is an economic aspect. External energy is needed for any kind of manufacturing (except the simplest home handicrafts, such as picking reeds and making baskets from them). It is needed for any kind of transportation of goods or people, except walking or transport based on animal labor. External energy is used extensively in today's production of food,even when produced organically. A person would expect there to be a connection between the amount of energy available, and the amount of goods, such as food or new homes, produced.

Gross Domestic Product (GDP) is a measure of how much goods and services an economy is producing. In the version I am using here, it is "real" GDP, which takes out the effect of inflation. Thus, if an economy grows by 1%, there are 1% more goods such as houses built and food sold, on average during that year. Having more goods and services available is especially helpful if population is growing, and new members need to be fed and housed.

When we look back over the past 2000+ years, we see a pattern of gradually increasing GDP growth. (See Table 1 below) The rise in growth seems to match up with increasing external energy. Although data on energy usage is not available prior to 1820, we know from other sources that there was a gradual growth in other types of energy usage prior to that date, such as the burning of peat most, water power, wind power, and a little coal usage. I will talk more about this in a future post.

Comparison of World Average GDP Growth and Average Growth in World Energy Consumption

Years	GDP Growth	Energy Growth	Difference
1 - 1000	0.0%	0	0.0%
1000-1500	0.1%	0	0.1%
1500-1600	0.3%	0	0.3%
1600-1700	0.1%	0	0.1%
1700-1820	0.5%	0	0.5%
1820-1870	0.9%	0.6%	0.3%
1870-1900	1.9%	1.2%	0.8%
1900-1920	3.1%	2.0%	1.0%
1920-1940	1.1%	1.2%	-0.1%
1940-1950	1.7%	2.2%	-0.5%
1950-1960	4.7%	3.9%	0.8%
1960-1970	5.0%	5.1%	-0.1%
1970-1980	3.8%	2.6%	1.2%
1980-1990	3.1%	1.8%	1.3%
1990-2000	3.1%	1.3%	1.7%
2000-2010	3.5%	2.3%	1.2%
Ave. of Above	2.07%	1.52%	0.55%
Weighted Ave (by number of years)	0.31%	0.16%	0.15%

Table 1. GDP Growth based on Angus Magnuson Estimates of World GDP since 1 CE. Energy Growth estimates are based on estimates by Vaclav Smil in Energy Transitions: History, Requirements, and Prospects. Energy amounts prior to 1820 are really unknown, but are shown as "0".

If we look at the long term, we can see that the really big increases in GDP growth (that is, over 1% per year), all came after 1870. That was about the same time that energy growth started ramping up over 1% as well, because of the growth in coal usage. (Of course, economists who have only looked at GDP growth since World War II would consider GDP growth of 1% very low. They would prefer GDP growth of 3% or more a year.)

It is not surprising that GDP growth is a little higher than energy growth on Table 1, because GDP reflects growth in "goods and services". Goods take energy to produce and transport. Services, such as financial services or the cutting of hair, can often be done with little energy input. To the extent that part of the growth in the economy is services, less than the full amount of energy is required to produce the corresponding GDP percentage growth. There may also be savings through more efficient use of energy, for example, through more energy-efficient cars, trucks, or light bulbs.

We can also show the GDP growth listed in Table 1 as a graph, shown below as Figure 2, below.

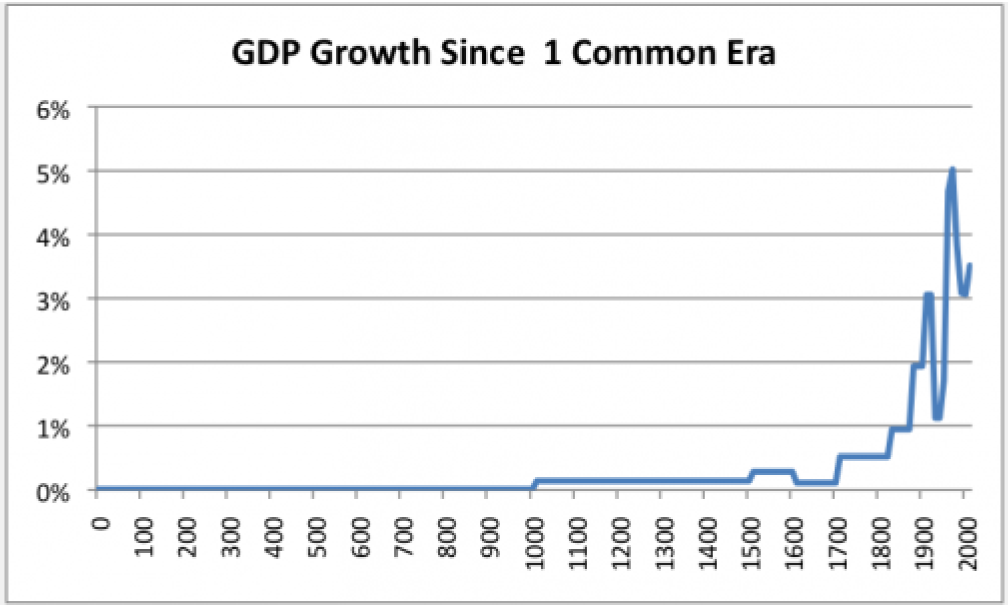

Figure 2. GDP growth from the first column in Table 1, graphed.

The Relationship Between Energy Growth and Population Growth

The impression a person gets from looking over the long history is that as more energy products became available to society, people found ways to put them to use that allowed more goods and services to be sold. With more goods and services available, it was possible to feed and clothe more people, so the "survival of the fittest" issue referred to above became less of a problem. If we compare Figure 2 with Figure 1, we can see that the spike in population coincided with the rapid rise in GDP, in the last couple of centuries.

We can also look at the relationship between population growth and GDP growth more closely using estimates by Angus Maddison going back to 1 CE. Here we find that prior to 1820, about 80% of GDP growth was absorbed by population growth. It is only since the growth in the use of fossil fuels, and especially since World War II, that rising GDP has been far above population growth, permitting a sustained rise in standard of living.

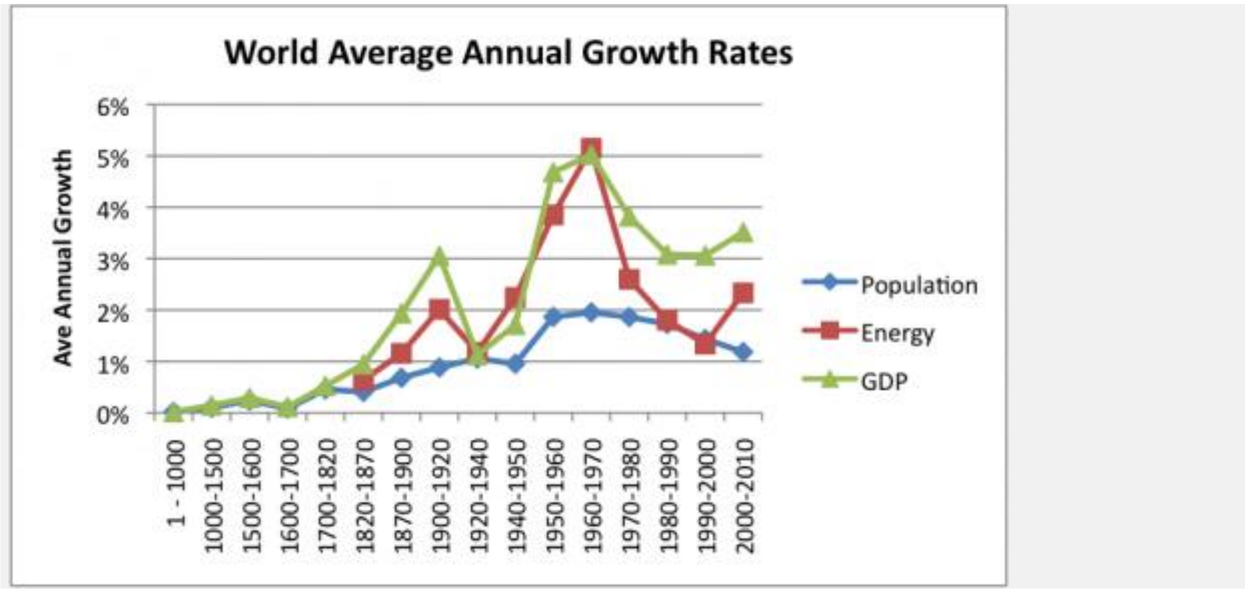

Figure 3. World average growth rates in population, energy, and GDP based on data of Angus Maddison (GDP and population) and Vaclav Smil (energy).

Can We Reduce Human Demand for External Energy?

It's clearly not easy to reduce human demand for external energy. (One exception: If you are an economist, it is very easy to reduce demand for external energy. All you have to do is either (1) increase the price of that energy, so the poorer folks can't afford it, or (2) reduce consumers' incomes (perhaps by laying them off from work), so they can't afford it. Either of these will reduce demand, according to their definition of demand. When you hear the term "demand destruction," this seems to be what is meant.)

But what if we really want to cut back on the amount energy that the world's population wants, at a fixed price, without reducing the buying capacity of consumers?

Here, I think the first issue in stopping demand growth is stopping the continued rise in the world's population. As long as the world's population is rising, even in lesser developed countries, there is going to be a continuing need for more food, clothing and housing. This is an issue we don't seem to be able even to talk about. It may offend people.

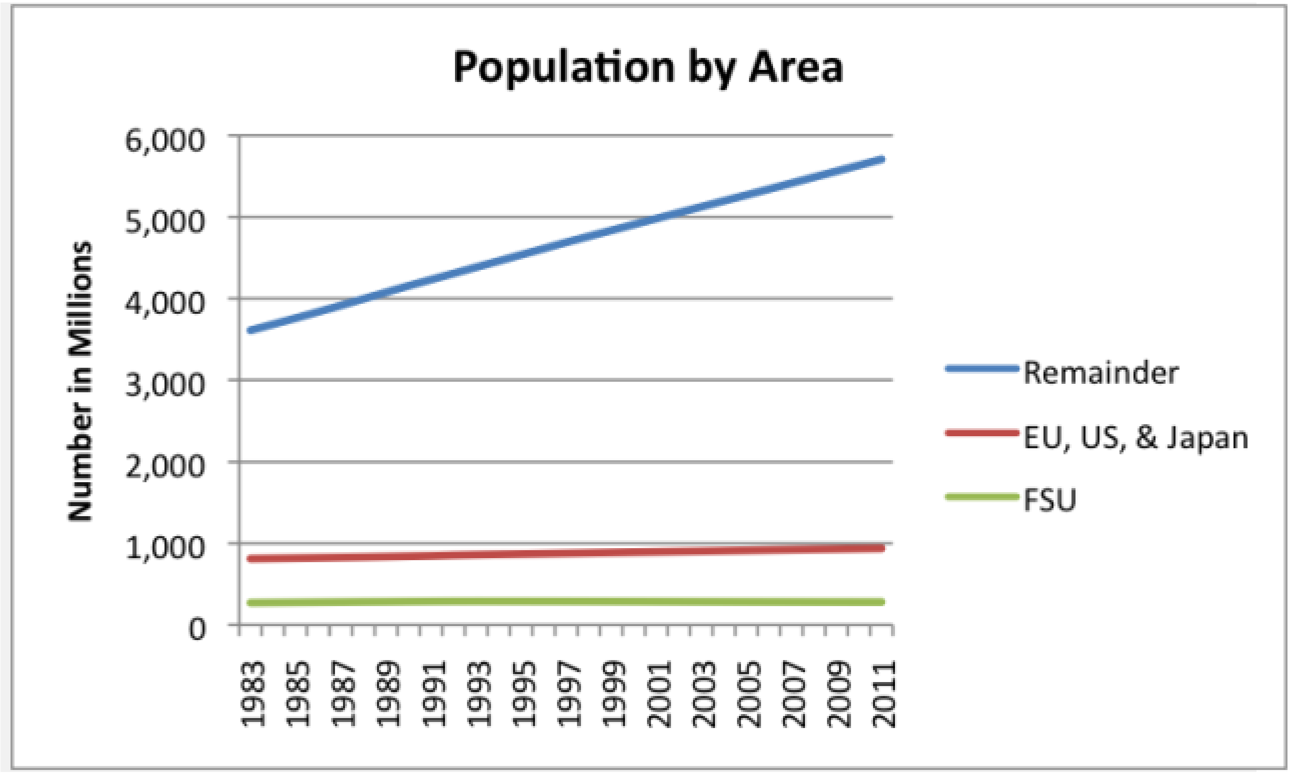

Figure 4. World Population by Area, based on data of the US Energy Information Administration. FSU is Former Soviet Union. EU is the European Union-27.

Second, there is room for making vehicles more efficient, for insulating homes better, and for making other similar changes. But getting large savings in this manner is not as easy as it looks, partly because an initial investment is involved, and partly because when people find that they can save money by the change, they are likely to spend the money they have saved on another product that also requires energy to make, such as taking a vacation. When the overall picture is considered, the net savings are lower. This issue is common enough that it has a name-Jevons' Paradox.

Third, a country can easily make its energy consumption appear lower by "offshoring" heavy industry (which uses lots of energy), and changing to more of a service economy. If it still continues to use products created by heavy industry, just importing the products rather than making the products itself, it is not at all clear that there are savings for the world as a whole. If we look at Figure 3, we can see that energy consumption definitely rose more rapidly in the 2000 to 2010 period than in the previous two ten-year periods. The 2000-2010 period is a time-period when much industry (and jobs) shifted to Asia. While there was some energy savings in countries that sent manufacturing overseas, the energy consumption of developing countries in Asia grew more rapidly than the energy savings, resulting in higher overall growth in world energy consumption.

To a significant extent, we start finding ourselves with what I call a "Whac a Mole" problem. (In the Whac-a-Mole game, a person is faced with trying to whack down a mole that keeps popping up from one of five holes, but whenever it is whacked down into one hole, it reappears in another one.) Especially with oil which is high-priced and internationally traded, we have a situation where if one buyer chooses to buy less oil (or gasoline, or diesel), there is a good chance that some other buyer, perhaps in China or India, wants to purchase it. It all comes down to financial issues, which I will discuss in future posts.

The energy demand issue is a frustrating one. The more you look into it, the knottier the problem seems.

Note:

[1] Richard Wrangham's findings are disputed by some anthropologists, because we do not have direct evidence of human cooking as far back as he indicates. They also believe that there might be other explanations for his findings, such as greater eating of meat. Wrangham in a 2009 paper argues that the early date isn't really necessary for his finding to be true; even 250,000 years ago would be sufficient for evolutionary changes to take place. He also argues that compared to chimpanzees, humans seem to be adapted for a higher-quality diet because they "exhibit higher energy use, but have reduced structures for mastication and digestion".

Source: http://ourfiniteworld.com/2012/08/17/humans-seem-to-need-external-energy/