Living On A Space Ship

By Dale Lugenbehl (November 16, 2017)

The Nature of Spaceships

The concepts and mental models we have for understanding our situation in life impact how we see the world and what choices seem reasonable to us. If we change our mental model for understanding the world, we automatically make different choices about how to live. The most appropriate model for understanding our situation as a species is that of a space ship.

This planet called Earth that we live on is literally a space ship: it is traveling through space at thousands of miles per hour, it is the only home we have ever had, and it provides us protection from the harshness of space and gives us all of the things that we need in order to sustain our lives.

When we pay close attention, we notice that all space ships, both natural and human made, have three basic characteristics. First, all space ships are finite in size and resources. The Earth is about 8,000 miles in diameter, it only has so much land, so much water, only so much air, and so on.

Second, all space ships are closed systems: nothing enters and nothing leaves the space ship. If we run out of some crucial supply, such as fuel or air, we cannot stop along the way and pick up a new supply. The only exception to this is the energy from the sun that strikes the Earth every day, more than 99% of which is not currently being used by humans to power their various devices and machines.

Third, on a space ship there is no such place as "away." We like to think that when we no longer want something anymore we can simply "throw it away," but on a space ship all you can do with some toxic waste you have produced is move it to some other location on the space ship. So if I am operating a factory that produce some very poisonous waste product that causes cancer, I cannot throw it "away," I can only move it to someone else's living space on spaceship Earth. Nothing leaves the space ship.

Four Basic Questions

Once we realize we are passengers on a space ship, we can begin to ask ourselves some very useful questions about what sorts of behaviors make sense on a space ship and what sorts do not. There are four questions which are central.

First, "Does it make sense to continually add more passengers to our space ship each year?" Presently, we are increasing the number of passengers on planet Earth by about 83 million people each year (Earth's population grew by 1.11% in 2016). That's like adding the population of Germany each year, but without adding any new land, petroleum, coal, iron ore, timber, or fresh water or air. Our space ship hasn't gotten any bigger or taken on more supplies, but we have 80 million more passengers than the year before, and we are doing this year after year. Actually, the supplies on board Earth are shrinking each year: less oil and coal and natural gas, fewer forests, smaller depth of topsoil in which to grow food, less clean water and air, and less capacity to absorb toxics and other wastes. Adding more and more passengers to a finite space ship does not seem like a wise decision.

Our second question asks "Does eating food crops second hand make sense?" "Second hand food" refers to the fact that we take agricultural crops that people could eat—corn, oats, soy beans, and so on—and feed them to cows, pigs, and chickens and then eat their flesh, eggs, and milk. It's a very wasteful process. It takes 12 to 16 pounds of corn or soy beans to make just one pound of beef, 4 pounds to make a pound of pork, and about 3 pounds to make either a pound of chicken meat or a pound of eggs.

Third, "Does it make sense to ship food an average of 2,000 miles before we eat it?" This is what we do in America. We ship strawberries grown California to New York, and grapes grown in Chile to Illinois. This may sometimes give us food with a lower dollar cost, but it comes at a very high cost in terms of fossil fuel usage and greenhouse gas production. If we live in Oregon, it makes much more environmental sense to eat apples, plums, and hazelnuts, rather than oranges, bananas, and coconuts.

And our fourth question asks "Does continuous economic growth make sense on a space ship?" We have been taught to believe that economic growth is a good thing: it creates more goods and services, creates jobs, and makes everyone better off. Typically, our only discussions about growth revolve only around *how much* growth we should have—3% or 4% or 5%--and it is simply assumed that growth is always a good thing and that if we don't have it we are failing and stagnating. Almost no one asks whether growth might actually be bad. But there is, in fact, a hidden and darker side to economic growth. We can begin to evaluate whether continuous growth makes sense by first understanding what economic growth actually is.

The Idea of Continuous Economic Growth

Fundamentally, growth is not that complicated. We can use a small isolated island-village as a model for understanding growth. Suppose this village produces $1,000 worth of stuff in a given year. Economists call this the "total economy" for the village. Now suppose the next year the village produces $1,050 worth of stuff. When this happens, we say that their economy has grown 5%. If the following year they produce $1,100 worth of stuff, we say they have had another 5% growth, and in two years their economy has grown a total of 10%. Everyone says this is wonderful: we are more prosperous, there is more employment, and people have more "stuff."

This *appears* to be a good thing… but is it really? Everything that is growing has what is called a doubling time: whether it is the national economy, cancer cells in the body, or money in an interestbearing bank account. If I have money in the bank and it is growing at the rate of 1%, it will double in 70 years, and the same is true of the economy in our little village. If it grows at 2% it doubles in 35 years, and if it grows at 5% (as in our example) it will double in 12.5 years. We are supposed to think that this is good, but there is a real problem here.

If the economy has doubled in 12 years, that means that we are using twice as much material resources as just 12 years ago, twice as much energy, and are producing twice as much greenhouse gases and twice as much toxic pollution. And all of this is occurring on a space ship that has not gotten any larger or better supplied and has no ability to stop and pick up more supplies, or get rid of harmful toxic wastes along the way. This seems like a recipe for disaster.

We measure how we are doing by something called Gross Domestic Product (GDP) which is essentially what we have so far in this article been calling "the total economy" of a nation. Let's ask another question: "What do organic apple sales, heart attacks, hurricanes, ship wrecks, and war all have in common?" Answer: every single one of these things increases the GDP, and so from a traditional economic perspective, should be viewed as a good thing. If a ship runs aground on the coast of Oregon, people will drive out to see it (buy gasoline, eat in restaurants, sleep in motels), salvage and cleanup crews will be hired, and a new ship may be built to replace the old one—and all of these things add dollars to the GDP.   If a hurricane strikes, any damage it causes requires rebuilding and there will also be resources given over to caring for the injured –once again, the GDP goes up. If someone has a heart attack, this generates sales for hospitals and other healthcare related industries. War requires enormous amounts of fossil fuels and materials and then there is re-building afterward—all of it "good" for GDP.

Surely there is something wrong here if these events are seen as good things. Shouldn't we be measuring how we are doing by looking at health? Clean air and water and soil? An Earth with a livable climate? Social justice? Meaningful work for everyone? Wouldn't it make more sense to reduce our rate of using up resources to a level that the Earth can actually keep up with?

Many other civilizations that have gone before us have collapsed because they used up their soil fertility, forests, and the environment's ability to absorb wastes faster than any of these things were being replaced. If you use up what keeps you alive faster than it is being replaced, you will perish and that is exactly the path that we are on today. We are using up coal, natural gas, and oil at a rapid pace and these things will NEVER be replaced. Other things, such as soil fertility, forests, clean water and clean air, we are using up at a rate that far exceeds the Earth's capacity to replenish them.

And yet, we still insist growth. In the early 1950's, U.S retailing analyst Victor Lebow proclaimed that: "Our enormously productive economy...demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfaction, our ego satisfaction, in consumption....We need things consumed, burned up, worn out, replaced, and discarded at an ever increasing rate."

<u>Sustainability</u>

If you spend money at a rate that is equal to or less than your income, you life style can be maintained indefinitely. If you spend more money than you take in, you will go broke. Living within in the limits of your resources is called living sustainably. As a species, we are not presently living in a way that is sustainable.

However, for a while, it may not seem like there is a problem. If I have $20,000 in the bank, I can earn $2,000 a month and spend $3,000 a month and live quite comfortably—but only for a while, because I am operating in deficit mode and continually drawing down my accumulated resources (my capital). Things may seem ok now, but there will come a day of reckoning. Similarly, we are drawing down on a rich inheritance of coal, oil, natural gas, rich soil, forests and more and our huge inheritance from nature makes it appear that we can spend endlessly and still continue on. It is like we had a rich uncle die and will us a fortune in natural resources. But our spending is vastly higher than what is being regenerated so we, too, face a day of reckoning.

Americans' high rate of "spending" the capital of nature (soil, petroleum, forests, fresh water) is creating a crisis for other humans on our space ship. U.S. population is presently about 320 million, which is about 4.3% of the total human population of the Earth. However, that 4.3% which is us, uses 30% of all the resources used by all humans each year, and generates 30% of the pollution created by all humans. The average U.S citizen does 100 to 200 times the environmental damage of a person living in an "undeveloped" country. This means that although the birthrate in many less developed countries is very high, countries like the U.S. which have lower birth rates are still part of the population problem. If a pair average citizens of this country decide to have two children, that is the environmental equivalent of a couple in a less developed country deciding to have200 to 400 children!

Our living the way we do is harming the life prospects of people in other countries, making it difficult or impossible for them to have decent lives because we are taking so much of the Earth's resources. It is, for the same reason, harming future generations who will have to try to live on a depleted planet. And lastly, it is harming the environment (wrecking our space ship). Ironically, our way of living is also harming ourselves because we are beating ourselves up working to support our craving for more and more "stuff." We work 160 hours more per year than people in this country worked just 30 years ago, due to the fact that we have 50% more "stuff" to pay for than they did. And yet, research consistently shows that we are no happier now than we were then.

Additionally, people in other countries see the way we live, assume it is making us happy, and then want to live at the level of consumption—and resource usage—that we do. However, if all people on the planet lived the way we do, it would take three more planet Earths to provide the necessary resources to make that possible. Clearly everyone attempting to live as we do is a recipe for disaster.

This brings us to an important related concept called carrying capacity.

<u>Carrying Capacity</u>

A certain piece of land has the capacity to support only so many individuals. We recognize this in regard to other species. If we have several years of good rainfall followed by sunny weather, this may cause an abundance of plant food and an upsurge in the deer population. These unusual conditions can create what biologists call "overshoot," a condition in which the local population has exceeded the long term capacity of the land to support the population. So when food supplies drop back down to normal, a "correction" occurs in which there is a die back of the population. Being on the receiving end of a "correction" (as biologists put it) can be very unpleasant.

Humans seem to think (or act as though) they are exempt from this kind of process.
Here is an easy way to understand carrying capacity and overshoot. Suppose you have a two bedroom apartment, with one bathroom, a kitchen and about 600 square feet of living space. You *could* have 25 people stay with you for the weekend, and it would be crowded, but still ok with everyone getting their basic needs taken care of. But what happens when Monday arrives? You are completely out of food, bath soap, toilet paper, clean towels, and the place is probably a mess, and the utility bills are through the roof. You could, of course, go out and buy more food and so on, but eventually you would be broke and "the party is finally over." So 25 people may be the *short term carrying capacity* for the apartment, but the *long term capacity* is very different—perhaps only two people can live there month after month, year after year. This is the difference between long term carrying capacity and short term carrying capacity. Both the long term carrying capacity and the short term carrying capacity are influenced by three factors.

1) *How well stocked* is the apartment (and the apartment owner's bank account) in the first place? In regard to our existence on planet Earth, this would refer to how much fertile land is here, how much clean water, clean air, forests, oil and coal and natural gas, metal ores, and so on.

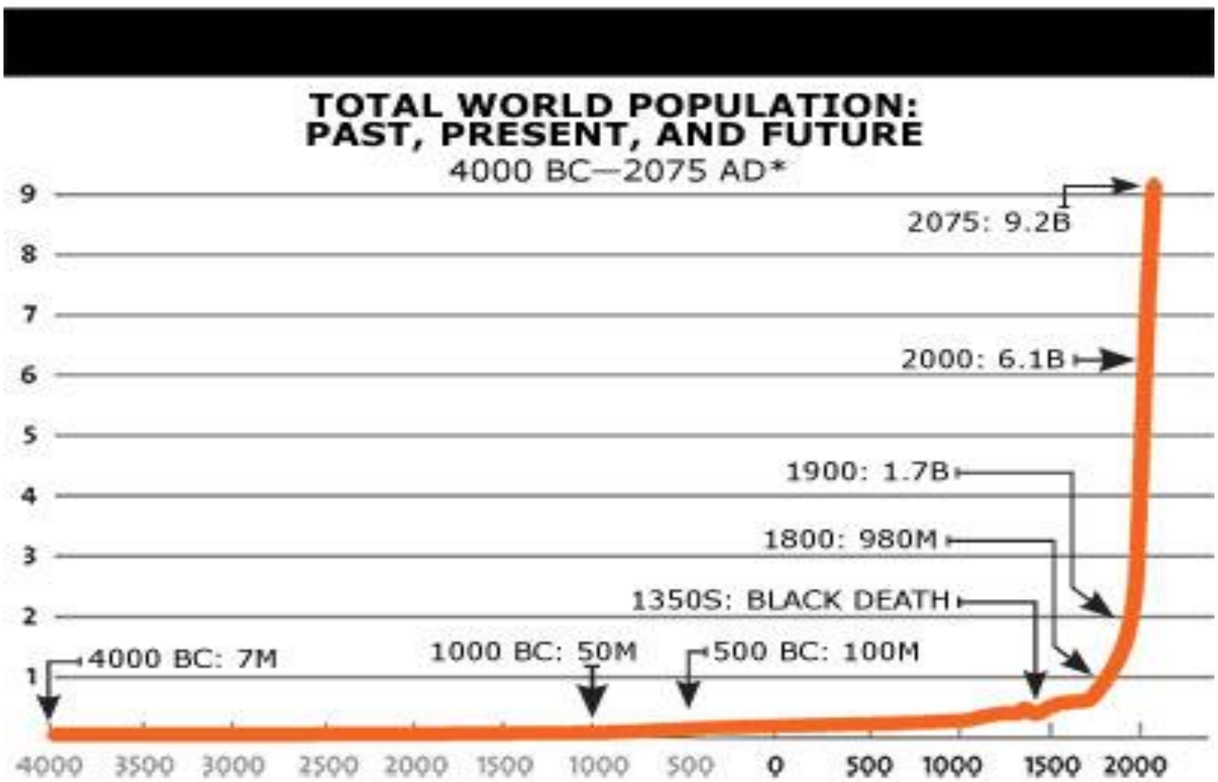
2) How conservatively or luxuriously are the 25 people in the apartment choosing to live (how much and what kind of food do they eat, how many hot showers a day are they taking, how many trips to the store each week…?). This factor could be called "lifestyle level."

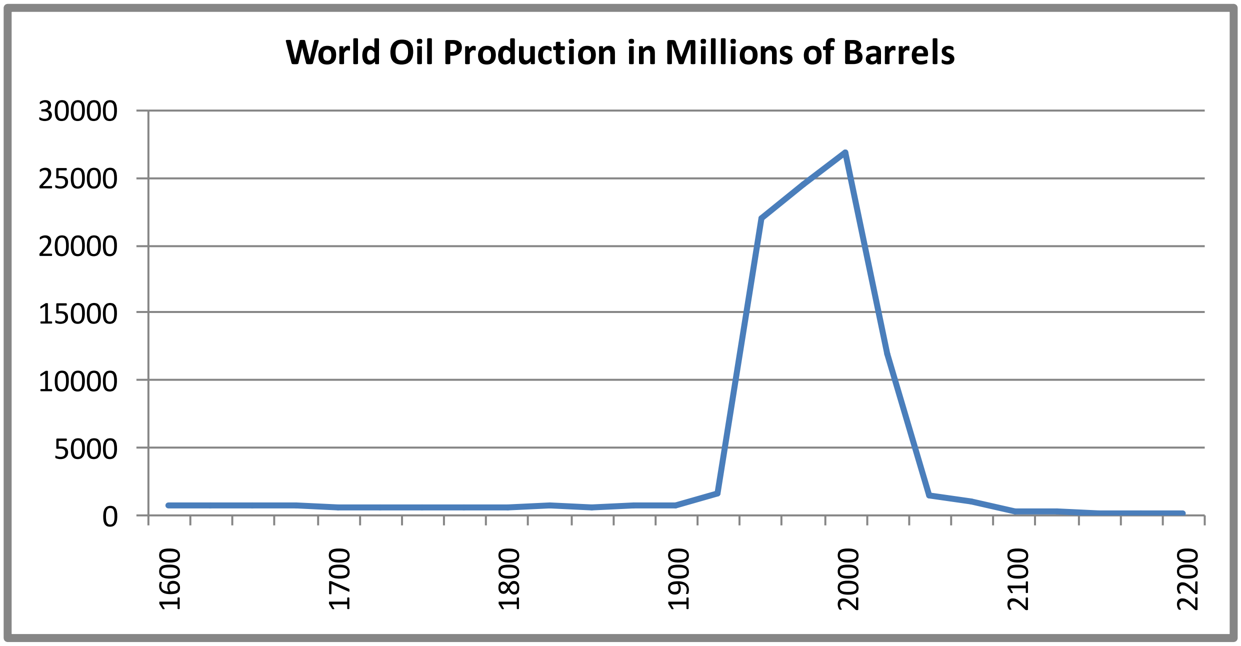
3) What is the specific technology that is being used to produce a given level of lifestyle? Taking 5 hot showers a day versus 12 hot showers a day obviously impacts energy and water usage, as well as greenhouse gas production. But is also makes a difference what technology is used to produce those hot showers. The water could be heated by a coal-fired electrical plant, or the water could be heated by solar energy. Coal is not a renewable energy source (coal on the planet is rapidly being used up and not replaced), solar power will be available to us for millions of years. Burning coal releases massive amounts of greenhouse gases in to the air which strongly promote climate change, while solar electrical power generation produces almost NO greenhouse gases. This can be seen very clearly in the simple example of drying laundry in a gas or electric dryer vs hanging laundry in the sun on a clothes line or drying it in the house on a simple rack.

If I go to the store three times a week, how do I get there: drive SUV at 10 miles per gallon or take public transportation or drive an electric car? The technology I choose in each case makes a huge difference.

The relationship between the human population and the Earth as a whole works in exactly the same way as it does for the deer population. If people exceed the carrying capacity of their own country or that of the world, the population goes into "overshoot" and inevitably there will be a "correction" (die-back) in population to a level that the environment actually can support. And again, there is short term and long term carrying capacity. The Earth may be able to sustain 7.4 billion people (the current population) or 10 billion people for a while, but that does not mean that is possible year after year into the indefinite future. Just like the little apartment, the carrying capacity of the Earth is influenced by 1) how well the Earth is presently "stocked" with the materials needed to support a population, 2) the amount of consumption people are choosing in order to maintain a certain lifestyle, and 3) the technology being utilized to support that level of lifestyle.

The carrying capacity of the Earth was *temporarily* expanded by the discovery of abundant, cheap, and highly concentrated and portable energy in the form of fossil fuels—first coal, and then oil and natural gas (see two charts below). However, these resources are not replaceable (they are nonrenewable) and are being rapidly depleted. When they are gone, it is estimated that the carrying capacity of the Earth will drop from the current 7.4 billion to 2 billion people—this is a huge "correction." **(Heinberg, pp. 177-179)** Other resources are also being depleted: timber, fresh water, clean air, iron ore, uranium and so on.





In the case of our planet, it is not possible to pick up more supplies and "restock the pantry." What are our reasonable options? 1) conserve nonrenewable (and other) resources by reducing consumption and living a low-consumption lifestyle, 2)voluntarily reduce population by reducing the birth rate, 3) focus on using renewable nonpolluting resources to sustain our more realistic lifestyle choices (solar, wind, geothermal, hydroelectric, tidal).

Efficiency

Obviously efficiency is very important on a space ship, but have we been measuring efficiency in the correct way? Our inappropriate mental models of the world and how it operates tend to blind us in many areas. We tend to see efficiency, for example, from a business perspective. Let's take growing food as an example and see how this works.

From a business or economic perspective, we produce food efficiently when we get a lot of pounds of food for each dollar invested in the growing of food. A farm that produces 100 pounds of food for each $20 invested in growing the food is more efficient that a farm that produces only 60 pounds of food for each dollar invested in growing the food. But this analysis based solely on dollars can hide other aspects of the issue that are hugely important.

A "calorie" is simply a unit of measurement for measuring how much energy is contained in something—whether it is a pound of coal, a gallon of oil, a ton of wood, or an ounce of corn. How many of us know that it takes 10 calories of energy from diesel and gasoline to produce just 1 calorie of food energy from corn if we are growing it industrially and using chemical fertilizers and pesticides? (See

Shiva footnote on p. 93) This may be the most dollar-efficient way to grow corn —given tax-supported government handouts to corporate agriculture—but from an energy and greenhouse gas perspective it is horribly inefficient. Organic small farmers in India can produce 1 calorie of energy from corn using only a total energy input of only 1 or 2 calories.

And it gets worse, because in the U.S. we take that petroleum-based corn we grow and we feed it to cattle, pigs, and chickens—and it takes 3 to 16 pounds of corn to make just one pound of meat, eggs, or milk. Overall, it takes about 100 calories of fossil fuel (oil, coal, natural gas) to make just one calorie of energy in the form of beef. (Ohio State University study quoted in *DNA*)

In summary, the energy efficiency in growing food depends on 1) the particular kind of food being produced, 2) the method of producing that food, and 3) how far away the production location is from where it will be eaten.

A Side Bar on Energy Efficiency In Growing Food

Calculating the energy efficiency of producing a particular food in a particular way can be complicated business. The following material is taken directly from Richard Heinberg's *The Party's Over* (see specific page number references inserted in parentheses).

"In agriculture, for example, the amount of fuel used directly on a cornfield to grow a kilogram of corn fell 14.6 percent between 1959 and 1970l However, when the calculation includes the fuel used elsewhere in the economy to build the tractors, make the fertilizers and pesticides [from fossil fuels], and so on, it turns out that the total energy cost of a kilogram of corn actually rose by 3 percent during that period." (Footnote 33 in Chapter 4) The inescapable implication of these findings are first, that many efforts toward energy efficiency actually constitute a kind of shell game in which direct fuel uses are replaced by indirect ones…which exact energy costs elsewhere. (Heinberg, p. 163)

"Tractors and other farm machinery burn diesel fuel or gasoline; nitrogen fertilizers are produced from natural gas; pesticides and herbicides are synthesized from oil; seeds, chemicals, and crops are transported long distances by truck… If food production efficiency is measured by the ratio between the amount of energy input required to produce a given amount of food and the energy contained in that food, then industrial agriculture is by far the least efficient form of food production ever practiced. Traditional forms of agriculture [small] organic farms] produced a small solar-energy surplus: each pound of food contained somewhat more stored energy from sunlight than humans… had to expend in growing it… Today, from farm to plate, depending on the degree to which it has been processed, a typical food item may embody input energy between four and several hundred times its food energy. This energy deficit can only be maintained because of the availability of cheap fossil fuels, a

temporary gift from the Earth's geologic past." (Heinberg on p. 175; Editor's note: For future use, this passage needs to be paraphrased in simpler language.)

John McDougall, M.D., in *The Starch Solution*, p. 78: "Crops like potatoes can produce 17 times the calories as animals on the same piece of land. (FN 16 of Chapter 5) "Fossil fuels used in the production of food could be reduced fortyfold [4,000 percent]. Consider that about 2 calories of fossil-fuel energy are required to cultivate 1 calorie [of food energy from] starchy vegetables [potatoes, yams, corn, beans]; With beef the ratio can be as high as 80 to 1. (See footnote number 17 in Chapter 5 in McDougall)."

Another way of looking at efficiency in regard to food asks us to consider how many pounds of food can be produced per gallon of water utilized. Once again, corporate industrial agriculture in general, and animal agriculture in particular, reveals itself as being very inefficient environmentally. [This issue will be explored in depth during class discussion.]

Externalization of Costs

And lastly, is huge-scale corporate industrial agriculture even as efficient as it claims to be even if we look at it from a strictly dollars point of view? The short answer is, no. Large scale corporate industrial agriculture has found ways to provide what appears to be inexpensive food by engaging in something called *externalization of costs*. Basically what this means is that a business is able to avoid paying large portions of their costs in doing business by transferring these costs to other individuals who are outside the business itself—and may be totally unaware that they are paying a significant portion of the costs of a corporation operating its business. Let's take a very simple and personal example to see how this works.

Suppose I live in your neighborhood and am operating a business out of my home—I make ornamental iron products such as stair railings, gates, garden statuary, and sculpture. In operating my business I burn a lot of coal to heat my metal forge…

- Soot gets on your house, car, laundry, and in your lungs (extra cleaning and health expenses that you pay but which are caused by me).
- Coal truck deliveries and increased traffic and scarce parking due to customer visits; must take your kids to a playground to play; you often can't park in front of your own house/apartment. These are costs generated by my business but they are paid by you.
- Noise at night when I work, you can't sleep so you buy soundproofing
- I pump lots of water from my well to cool my iron products; now the water table in our neighborhood is lower and your well frequently runs dry as a result; you have to pay to have

your well dug deeper. The cost of my damaging underground water availability is "externalized" and is paid directly by you.

- I illegally dump harsh chemicals down the drain (I use them in my business) which damages local sewage treatment plant which must then be repaired (at taxpayer expense). Again, damage I cause is paid for by others.

- My activities and their consequences also lower the value of your home so your house is now worth less and harder to sell when you need to move. This is a condition caused by me, but you are the one who pays for it.

Another way costs of running a business get externalized is by having the government make payments to businesses for the products they produce—these payments are over and above what the business gets from the actual sale of the product to a customer. Large corporations also are supported by government dollars by getting the things they need to operate the business at a discount rate. Agriculture, for example, buys water at a much cheaper price than private citizens; the cattle industry, as another example, is allowed to graze their cattle on public lands for a much cheaper rate than what it would be if they paid the going rate for grazing on anyone else's (nongovernment) land.

The United States Department of Agriculture (USDA) tells us that ideally about 58% of healthy diet should come from vegetables and fruit, and 30% should come from grains such as wheat, corn, and oats. Only 10% of a healthy diet needs to come from protein foods such as meat, nuts, and beans. But who does the U.S government give dollar support to in order to help lower food prices? The producers of vegetables and fruit only get 0.37% of government support dollars, and the producers of grains (wheat, corn, oats, barley) only get 13.2% of government support dollars. So where is most of the government money going? A full 74% of it goes to the meat and dairy industries. (Source: *Physicians Committee for Responsible Medicine*, 2007) Is it any surprise that a fast food hamburger is so much cheaper than a loaf of whole grain bread or a serving of fresh vegetables or fruit?

Peak Oil: A Brief Outline

Understanding Peak Oil: Key Points

- For every industrialized country there is a peak in Discovery of New Oil
- In the US, discovery of new oil peaked in the mid 1930's. Over time, the discovery of new oil takes the shape of a bell curve.
- A peak in the Discovery of New Oil is inevitably followed later by a peak in the Production/Extraction of Oil
- In the US, oil production/extraction peaked around 1971. Again, the history of oil extraction takes the shape of a bell curve (with "lumps").
- This peak was accurately predicted my oil geologist M. King Hubbard in the early 1950's
- This peak can only be seen with certainty as a "rear view mirror event."
- What applies to individual countries also applies to the world taken as a whole.

- The Discovery of new oil worldwide peaked in the 1960's, and less new oil is discovered with each passing year.
- We are now approaching, or have already passed, World Peak Oil Extraction. This is inevitable because there is a finite amount of oil in the ground, and natural processes are not creating any more of it.

Peak Oil: Yes, but… #1

- Some say "There is still enough oil in the ground to last 100 (or 500) years." How can we reconcile this the peak oil analysis we just looked at?
- Answer #1 They are simply making numbers (aka, lying)
- Answer #2 With the less extravagant estimates, they are stating the number of years of oil left BASED ON PRESENT LEVELS OF CONSUMPTION. But if oil consumption is INCREASING by 7% per year, the amount of oil consumed in a year will DOUBLE in only 10 years (remember "doubling times?") And at only 4% growth, it will double in 17 years. These estimates, even the low ones, are totally unrealistic.

Peak Oil: Yes, but… #2

- Some say "Yes, all this is true, but there are still billions of barrels of oil left in the ground; we have only extracted about half of all the oil that was originally available to us all over the world. There is lots of oil left."
- Answer #1 Theoretically this is true. But it ignores key facts.
- Any time any energy source is being harvested, people always harvest the easiest portions first. If you are using WOOD as your source of energy, as many prior civilizations have, you will take the wood that is already lying on the ground first rather than expend the energy necessary to cut down new trees--this is simply easier. And you will cut down trees that are close to where you live first, before cutting down trees that are at a distance from you. This also makes sense--it takes a great deal of energy to haul a tree five miles so you can make use of it.
- The same is true of oil extraction--people have extracted the easiest oil first, the oil that was close to the surface, that was in highly liquid form, that was close to home, and so on. The oil that will be available to us in coming years is deeper in the earth, farther from where we live, will require the injection of water or steam or chemicals to get it to release from the rock or sand in which it is trapped, and so on.

Peak Oil: Yes, but… #3

- Some say "Well, that's true, but that simply means that oil will become more expensive. But wages seem to go steadily upward, so we will still be able to afford it."
- Answer: But this looks at the cost of energy only in terms of *DOLLARS.* It takes *energy* to produce energy: drilling an oil well requires diesel fuel to run the drilling rig; more energy is required to pump the oil, refine it, transport it. The less available the oil (the harder it is to extract), the more energy it takes to extract it.
- This brings us to a very useful concept called EROEI. EROEI stands for Energy Returned on Energy Invested.
- **Prior to 1950**, when the really easy-to-get oil was being extracted in Texas, Oklahoma, and Pennsylvania, **for every one barrel of oil** energy invested to extract oil, **we got back about 100 barrels of new oil**. This is wonderful! It didn't take that much energy to get more energy.
- But things have changed drastically since then. The ratio of Energy Returned to Energy Invested fell to about **40 to 1 in the 1960's**, and fell again to **30 to 1 in the 1970's**.
- In **2003 the ratio stood at about 10 to 1**, and this ratio is **still falling**. (3)
- When it falls to 1.5 to one, that means that it will take 1 barrel of oil energy to get 1.5 barrels out of the ground.
- What happens when it reaches **1.0 to 1.0?** This means that for every barrel invested we get one barrel back--our oil extraction efforts are getting us nowhere!
- At some point, it will cost us **one barrel of oil to get 3/4 of a barrel back**--we are actually losing net energy in our efforts to extract more oil.
- So even though there may be billions of barrels of oil still in the ground, if it costs us more energy to extract them than we get in return, that oil in the ground is totally useless to us.
- So in reality, **WE ARE OUT OF OIL EVEN IF THERE IS STILL OIL LEFT IN THE GROUND.**
- And the same sort of analysis also **applies to the other fossil fuels, coal and natural gas**. (See note (4) in References for an additional measure of how energy is becoming less available.)
- And, these other fossil fuels—**coal and natural gas—are similarly reaching their peak** levels and will inevitably decline in exactly the same way as oil.

Peak Oil: Conclusions

- Continuous economic growth on a finite planet is impossible.
- Attempting to do so will create catastrophe. The carrying capacity of Earth once the fossil fuels are gone is approximately 1.5 billion people (we are not at 7.4 billion and still increasing)
- We need to limit growth both of consumption and population.
- We need to shift to renewable energy.
- Nature will eventually stop us. If we change ourselves, we can have a softer landing rather than a very hard crash.

The End of the Petroleum Era*

Dale Lugenbehl

The past 100 years or so has been an era of huge economic expansion made possible by the availability of cheap energy in the form of oil. According to scientists, and the oil industry itself, this is all going to change dramatically.

The world's production of oil is expected to peak and then start declining some time between 2005 and 2010. Once the peak is passed (we may have already passed it), less and less oil will be produced with each passing year. At the same time, the world is *increasing* its use of oil by about 2% each year.

The *discovery* of new oil fields peaked in the U.S. in the 1930's. Ever since then, the number of barrels of new oil in the ground discovered each year has declined. We are finding less and less new oil with each passing year. A peak in the discovery of new oil sources is inevitably followed by a peak in the rate of oil *production*, and oil production did, in fact, peak in the U.S. in 1970 and has been declining ever since. (1) Meanwhile, U.S. oil consumption has been steadily increasing, so the difference had to be made up by increasing oil imports from outside the country. (Prior to oil production peaking in the U.S., the U.S. *exported* oil for sale to other countries every year.)

The discovery of new oil fields *worldwide* has also already peaked--in the 1960's-- and less and less new oil is being discovered each year. (2) The global peak in new oil discoveries will also be inevitably followed by a peak in oil production, just as took place with the peak in new U.S. oil discoveries being followed by the peak in U.S. production. We are now at or very near that peak in worldwide oil production. Even the oil industry itself acknowledges these facts.

Some people will respond by saying, "Yes, all this is true, but there are still billions of barrels of oil left in the ground; we have only extracted about half of all the oil that was originally available to us all over the world." This thought may be technically correct, but it overlooks some very important facts. Any time any energy source is being harvested, people always harvest the easiest portions first. If you are using wood as your source of energy, as many prior civilizations have, you will take the wood that is already lying on the ground first rather than expend the energy necessary to cut down new trees--this is simply easier. And you will cut down trees that are close to where you live first, before cutting down trees that are at a distance from you. This also makes sense--it takes a great deal of energy to haul a tree five miles so you can make use of it. The same is true of oil extraction--people have extracted the easiest oil first, the oil that was close to the surface, that was in highly liquid form,that was close to home, and so on. The oil that will be available to us in coming years is deeper in the earth, farther from where we live, will require the injection of water or steam or chemicals to get it to release from the rock or sand in which it is trapped, and so on.

Again, we may say, "Well, that's true, but that simply means that oil will become more expensive. But wages seem to go steadily upward, so we will still be able to afford it." But this looks at the cost of energy only in terms of *dollars*. It takes *energy* to produce energy: drilling an oil well requires diesel fuel to run the drilling rig; more energy is required to pump the oil, refine it, transport it. The less available the oil (the harder it is to extract), the more energy it takes to extract it.

This brings us to a very useful concept called EROEI. EROEI stands for Energy Returned on Energy Invested. Prior to 1950, when the really easy-to-get oil was being extracted in Texas, Oklahoma, and Pennsylvania, for every one barrel of oil energy invested to extract oil, we got back about 100 barrels of new oil. This is wonderful! It didn't take that much energy to get more energy. But things have changed drastically since then. The ratio of Energy Returned to Energy Invested fell to about 40 to 1 in the 1960's, and fell again to 30 to 1 in the 1970's. In 2003 the ratio stood at about 10 to 1, and this ratio is still falling. (3) When it falls to 1.5 to one, that means that it will take 1 barrel of oil energy to get 1.5 barrels out of the ground. What happens when it reaches 1.0 to 1.0? This means that for every barrel invested we get one barrel back--our oil extraction efforts are getting us nowhere! At some point, it will cost us one barrel of oil to get 3/4 of a barrel back--we are actually losing net energy in our efforts to extract more oil. So even though there may be billions of barrels of oil still in the ground, if it costs us more energy to extract them than we get in return, that oil in the ground is totally useless to us. And the same sort of analysis also applies to the other fossil fuels, coal and natural gas. (See note (4) in References for an additional measure of how energy is becoming less available.)

Not surprisingly, the other fossil fuels—coal and natural gas—are similarly reaching their peak levels and will inevitably decline in exactly the same way as oil.

With available energy shrinking, and global demand increasing by 2% per year, we are clearly on an unsustainable path. The realistic alternatives suggested by Richard Heinberg are 1) we must choose to reduce the size of our population, and 2) we must choose to reduce the individual rate of consumption (choose to live a more modest lifestyle). Making these changes will allow us to live comfortably (though not extravagantly) on the energy provided to us by renewable forms of energy such as water, solar, wind, geothermal, and perhaps wood or straw.

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*The above material peak oil is developed from Richard Heinberg's book, *The Party's Over: Oil, War, and the Fate of Industrial Societies,* New Society Publishers, 2003. This book is highly recommended for achieving a better grasp of our present and future energy situation. References: (1) p. 108, (2) p. 108, (3) pp. 124-5, (4) On page 109, Heinberg explains that until 1920, 240 barrels of oil were extracted for every foot of exploratory drilling done, and peaked at 300 barrels per foot in the 1930's. It has dropped steadily since then, and today, despite advanced technology, we are now producing less than 10 barrels of oil for every foot of exploratory drilling that is done.

An Additional Note on Nuclear Energy

In response to the information on peak oil, some may say, “But wait, nuclear energy is a cheap and clean form of energy that can save us in the absence of fossil fuels.” Is this true?

First, it should be clear that nuclear energy will simply not work for cars, trucks, bulldozers and excavators, farm tractors and harvesters, rail freight, and airplanes. These things are absolutely essential in maintaining the continued existence of present-day western society as we know it.

Second, nuclear energy only appears to be clean (“green”) because we have only been given a very small piece of the overall nuclear picture. It is true that a nuclear power plant does not emit any greenhouse gases from the plant itself during the time it is generating electricity.

However, to get an accurate picture of the environmental impact we need to look at greenhouse gases and other pollutants that are created 1) during the construction of the power plant, 2) during the mining and processing of nuclear fuel, and 3) during the process of dealing with the highly toxic radioactive waste created from operating the plant.

"In a study on the environmental impact of nuclear power the *Ecologist* found that each nuclear reactor emits 20 million tons of CO2 in its construction." (1) Nuclear reactors are typically built with a life expectancy of about 40 years. Spread over the course of the reactor's lifetime, this works out to half a million tons of CO2 per year.

Additionally, the mining of uranium for reactor fuel also burns petroleum and produces additional greenhouse gases. Because most uranium deposits are low grade, 100,000 tons of rock or more have to be mined each year to fuel a large (1000 Mega Watt-electric) reactor. (2)

Obvioulsy, an enormous amount of gasoline and diesel must be expended (and greenhouse gases emitted) to mine, transport, and crush 100,000 tons of rock each year of plant operation. A standard reactor needs 200 tons of uranium per year. (3) In addition, the conversion of raw rock ore and enrichment (concentration) uses halogenated compounds, which are 10,000 *times* more powerful as greenhouse gases than CO2. (4)

Lastly, even more fossil fuel energy is used, and greenhouse gases created, in the process of dealing with the extremely toxic radioactive wastes created by nuclear reactors. Direct wastes from used up fuel amount to 1,000 tons per year (for one plant), plus an additional 100,000 tons of radioactive waste created in the refining process in concentrating the nuclear fuel. (5)

All of the above has led energy specialist Richard Heinberg to conclude that "If the whole fuel cycle is taken into account, nuclear power produces several times as much CO2 as renewable energy sources." (6) Additionally, when the full dollar costs of nuclear power are taken into account "…nuclear power is by far our most expensive conventional energy source." (7) It is only because nuclear plants are so heavily subsidized by government (through taxpayer money) that their extremely high cost is hidden from us.

Jon Hughs (8) has stated that when all factors are taken into account "mining and milling uranium is uneconomic and uses more energy to recover than it will ultimately produce."

Without the availability of cheap and abundant oil, as well as huge financial support from government, nuclear energy would be exposed for the energy dead end which it truly is.

<u>Footnotes</u>

(1) Jon Hughes, in *Ecologist*, June 2006.
(2) World Nuclear Association, June 2016, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview.aspx
(3) World Nuclear Association, June 2016

(4) Jon Hughes, *Ecologist*, June 2006.
(5) Richard Heinberg, *The Party's Over: Oil, War, and the Fate of Industrial Societies,* New Society Publishers, 2003, p. 135.
(6) Heinberg, p. 135.
(7) Heinberg, p. 136.
(8) Jon Hughes, in *Ecologist*, June 2006.