How the Peak Oil story could be "close," but not quite right

Posted on January 30, 2019 by Gail Tverberg

A few years ago, especially in the 2005-2008 period, many people were concerned that the **oil supply would run out**. They were concerned about high oil prices and a possible need for rationing. The story was often called "Peak Oil." Peak Oil theorists have also branched out into providing calculations that might be used to determine which substitutes for fossil fuels seem to have the most promise. What is right about the Peak Oil story, and what is misleading or wrong? Let's look at a few of the pieces.

[1] What Is the Role of Energy in the Economy?

The real story is that **the operation of the economy depends on the supply of affordable energy**. Without this energy supply, we could not make goods and services of any kind. The world's GDP would be zero. Everything we have, from the food on our dinner table, to the pixels on our computer, to the roads we drive on is only possible because the economy "dissipates" energy. **Even our jobs depend on energy dissipation**. Some of this energy is human energy. The vast majority of it is the energy of fossil fuels and of other supplements to human energy.

Peak Oilers generally have gotten this story right, but they often miss the "affordable" part of the story. Economists have been in denial of this story. A big part of the problem is that it would be problematic to admit that the economy is tied to fossil fuels and to other energy sources whose supply seems to be limited. It would be impossible to talk about growth forever, if economic growth were directly tied to the consumption of limited energy resources.

[2] What Happens When Oil and Other Energy Supplies Become Increasingly Difficult to Extract?

Fossil fuel producers tend to extract the fuels that are easiest to extract first. Over time, even with technology changes, this tends to lead to **higher extraction costs** for the remaining fuels. Peak Oilers have been quick to notice this relationship.

The question that then arises is, "**Can these higher extraction costs be passed on to the consumer as higher prices?**" Peak Oil theorists, as well as many others, have tended to say, "Of course, the higher cost of oil extraction will lead to higher oil prices. Energy is essential to the economy." In fact, we did see very high oil prices in the 1974-1981 period, in the 2004-2008 period, and in the 2011-2013 period.

Unfortunately, **it is not true that higher extraction costs always can be passed on to consumers as higher prices**. Many energy costs are very well "buried" in finished goods, such as food, cars, air conditioners, and trucks. **After a point, energy prices "top out" at what is *affordable* for citizens, considering**

current wage levels and interest rate levels. This level of the affordable energy price will vary over time, with lower interest rates and higher debt amounts generally allowing higher energy prices. Greater wage disparity will tend to reduce the affordable price level, because fewer workers can afford these finished goods.

The underlying problem is that, from the consumer's perspective, high oil prices look like inefficiency on the part of the oil company. Normally, being inefficient leads to costs that can't be passed along to the consumer. We should not be surprised if, at some point, it is no longer possible to pass these higher costs on as higher prices.

If higher extraction costs cannot be passed on to consumers, this is a terrible situation for energy producers. After not too many years, this situation tends to lead to peak energy output because producers and their governments tend to go bankrupt. This seems to be the situation we are reaching for oil, coal and natural gas. This is a much worse situation than the high price situation because the high price situation tends to lead to more supply; low prices tend to collapse the production system.

The underlying problem is that low prices, even if they are satisfactory to the consumer, tend to be too low for the companies producing energy products. Peak Oilers miss the fact that a two-way tug of war is taking place. Low prices look like a great outcome from the perspective of consumers, but they are a disaster from the perspective of producers.

[3] How Important Is Hubbert's Curve for Determining the Shape of Future Oil (or Coal or Natural Gas) Extraction?

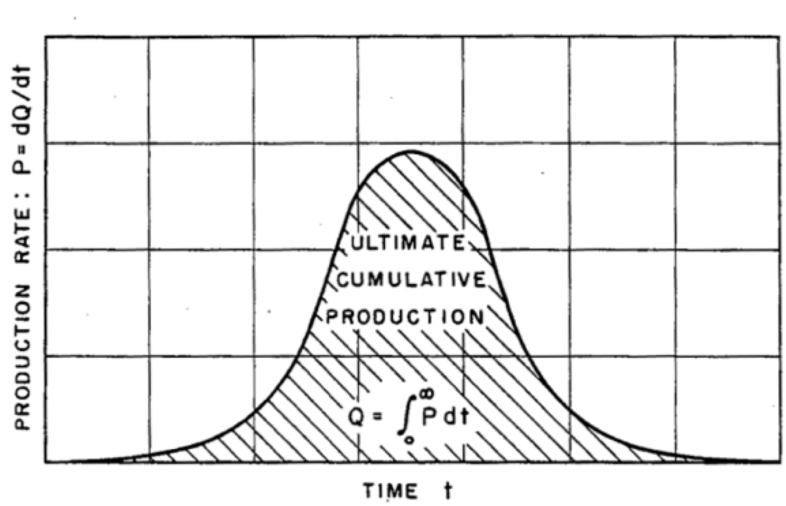

Figure II – Mathematical relations involved in the complete cycle of production of any exhaustible resource.

Figure 1. M. King Hubbert symmetric curve from *Nuclear Energy and the Fossil Fuels*. Total quantity of resources that will ultimately be extracted is Q.

Most Peak Oilers seem to believe that if we see Hubbert shaped curves in individual fields, we should expect to see a similar shaped curve for total oil supply or for the supply of other fossil fuels. They think that production patterns to date plus outstanding reserves can give realistic views of the future extraction patterns. Frequently, Peak Oilers will assume that once production of oil, coal or natural gas starts to fall, we will still have about 50%

of the beginning amount left. Thus, we can plan on a fairly long, slow decline in fossil fuel production.

However, many Peak Oilers will agree that if the energy used to extract energy is subtracted, the result will be more of a Seneca Cliff (Figure 2). Seneca is known for saying, “Increases are of sluggish growth, but the way to ruin is rapid.”

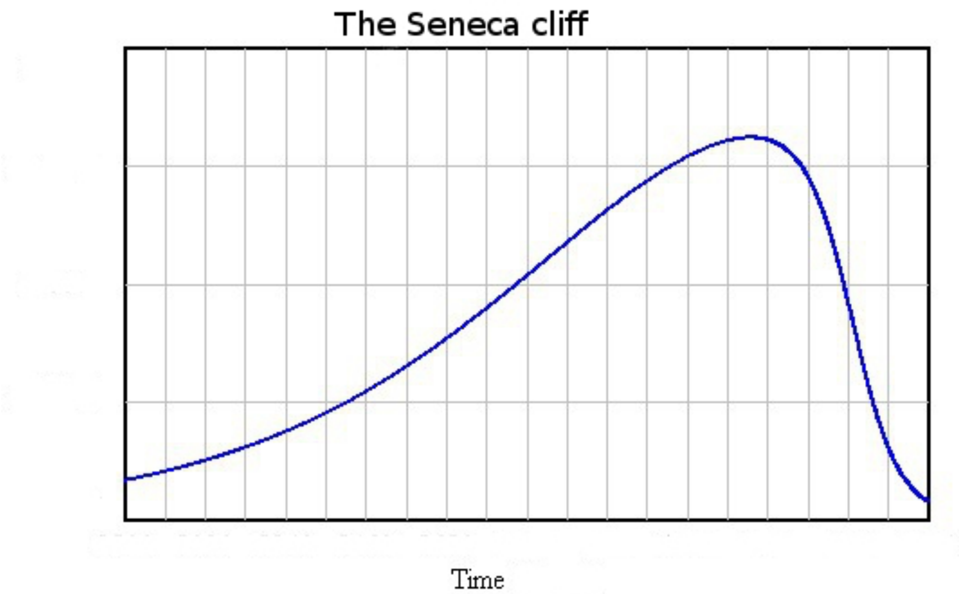

Figure 2. Seneca Cliff by Ugo Bardi.

Peak Oilers also tend to limit the amount of resources that they consider extractible, to exclude those that are particularly high in cost.

Even with these adjustments, it seems to me that the situation is likely to be even worse than most Peak Oil analyses suggest because of the interconnected nature of the economy and the fact that world population continues to grow. The economy cannot get along with a sharp reduction in energy consumption per capita. Some governments may collapse; many debtors may default; some banks may be forced to close. The situation may resemble the “societal collapse” situation experienced by many early economies.

One concern I have is that the Hubbert model, once it became the standard model for what energy supply might be available in the future, could easily be distorted. With enough assumptions about ever-rising energy prices and ever-improving technology, it became possible to claim that any fossil fuel resource in the ground could be extracted at some point in the future. Such outrageous assumptions can be used to claim that our biggest future problem will be climate change. After hearing enough climate change forecasts, people tend to forget about our immediate energy problems, since current problems are mostly hidden from consumers by low energy prices.

[4] Is Running Out of *Oil* Our Biggest Energy Problem?

The story told by Peak Oilers is based on the assumption that oil is our big problem and that we have plenty of other fuels. Oil is indeed our highest cost fuel and is very energy dense. Nevertheless, I think this is an incorrect assessment of our situation; the real issue is **keeping the average cost of energy consumption low**

enough so that goods and services made from energy products will be affordable by consumers. Even factory workers need to be able to buy goods made by the economy.

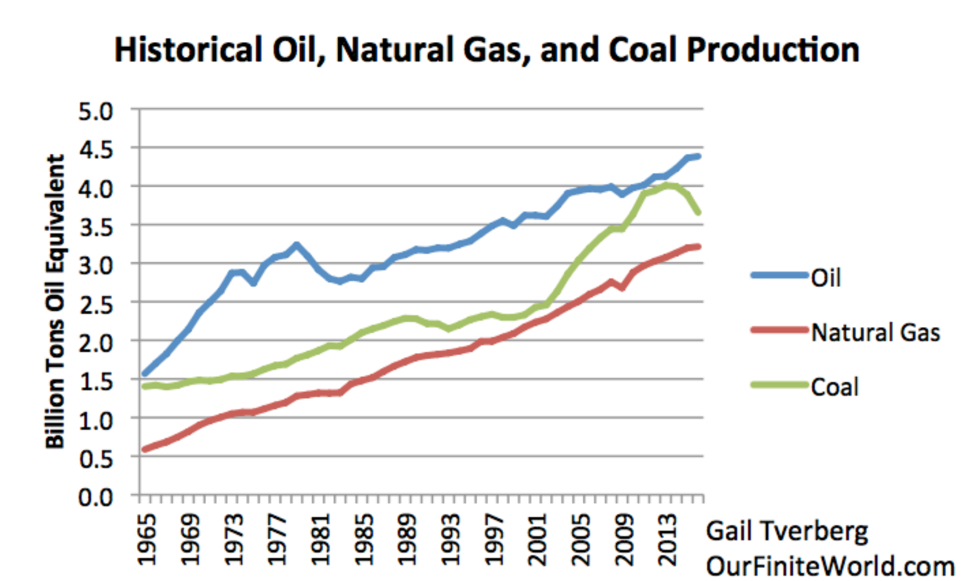

Figure 2. Historical oil, natural gas, and oil production, based on *Statistical Review of World Energy*, 2017.

The way the cost of energy consumption can be kept low is mostly a "mix" issue. If the mix of energy products is heavily weighted toward low cost energy-related products, such as coal and labor from low wage countries, then the overall cost of energy can be kept low. This is a major reason why the economies of China and India have been able to grow rapidly in recent years.

If underlying costs of production are rising, mix changes cannot be expected to keep the problem hidden indefinitely. A recession is a likely outcome if the average price of energy, even with the mix changes, isn't kept low enough for consumers. Energy producers, on the other hand, depend on energy prices that are high enough that they can make adequate reinvestment. If they cannot make adequate reinvestment, the whole system will tend to collapse.

A collapse based on prices that are too low for producers will not occur immediately, however. The problem can be hidden for a while by a variety of techniques, including additional debt for producers and lower interest rates for consumers. We seem to be in the period during which the problems of producers can be temporarily hidden. Once this grace period has passed, the economy is in danger of collapsing, with oil not necessarily singled out first.

Following collapse, large amounts oil, coal and natural gas are likely to be left in the ground. Some of it may even cease to be available before the 50% point of the Hubbert curve is reached. Electricity may very well collapse at the same time as fossil fuels.

[5] How Should We Measure Whether an Energy-Producing Device Is Actually Providing a Worthwhile Service to the Economy?

The answer that some energy researchers have come up with is, "We need to compare energy output with energy input" in a calculation called Energy Return on Energy Invested (EROI). This approach looks like a simple ratio of (Energy Output)/(Energy Input), but "the devil is in the details."

As I looked through the workings of the Limits to Growth model, it occurred to me that the EROI calculation needs to line up with how the economy really operates. If this is the case, we really need a very rapid return of the energy output, relative to the energy input. Also, in the aggregate, the energy output needs to scale up very rapidly. Furthermore, the energy output needs to match the types of energy needed for the devices the economy is currently using. If the output is different (such as electricity instead of fossil fuels), the EROI calculation needs to be adjusted to reflect the expected energy cost and time delay associated with a changeover in devices to match the new type of energy output.

In a footnote, I have attached a list of what I see as requirements that seem to be needed for EROI calculations, based on the LTG model, as well as other considerations.[1]

Of course, in a setting of many researchers working on a subject and many peer reviewed papers, a concept such as EROI is gradually modified and enhanced by different researchers. For example, EROI is turned around to become the Energy Payback Period. This is used to show prospective buyers of a device how helpful a particular device supposedly is. Researchers who are trying to "push" a type of energy product will find ways to perform the EROI calculation that are as helpful as possible to their cause.

The problem, though, is that if more stringent EROI requirements are put into effect, wind and solar can be expected to do much less well in EROI calculations. They very likely drop below the threshold of being useful to the economy as energy producers. This is especially the case if they are added to the economy in great numbers to try to significantly replace fossil fuels.

Regardless of their value as energy producers, there might still be a reason for building wind and solar. Building them probably does help the economy in the same sense that building unneeded roads and apartment buildings does. In theory, all of these things might someday be somewhat useful. They are helpful now in that they add jobs. Also, the building of wind and solar devices adds "demand," which helps keep the price of coal in China high enough to encourage additional extraction. But in terms of truly keeping the world economy operating over the long haul, or in terms of scaling up to the quantity of energy supply that is really needed to operate the economy, wind and solar do very little.

[6] How Should Net Energy Be Defined?

Net Energy is defined by EROI researchers as (Energy Output) minus (Energy Input). Unfortunately, as far as I can see, this calculation provides virtually no valid information. Instead, it promotes the belief that the benefit of a device can be defined in terms of (Energy Output) minus (Energy Input). In practice, it is very difficult to measure more than a small fraction of the Energy Inputs needed to produce an Energy Output, while Energy Output *does* tend to be easily measurable. This imbalance leads to a situation where the calculation of (Energy Output) minus (Energy Input) provides a gross overestimate of how helpful an energy device really is.

If we are dealing with a fish or some other animal, the amount of energy that the animal can expend on gathering food is not very high because it needs to use the vast majority of its energy for other purposes, such as respiration, reproduction, and digestion. In general, a fish can only use about 10% of its energy from food for gathering food. Limits to Growth modeling seems to suggest a similar maximum energy-gathering usage percentage of 10%. In this case, this percentage would apply to the resources needed for capturing, processing, and distributing energy to the world economy.

Perhaps there is a need for a substitute for Net Energy, calculated compared to the budgeted maximum expenditure for the function of "Energy gathering, processing and distribution." For example, the term *Surplus Energy* might be used instead, calculated as (10% x Energy Output) minus (Energy Input), where Energy Inputs are subject to suitably wide boundaries. If an energy product has a very favorable evaluation on this basis, it will be inexpensive to produce, making it affordable to buyers. At the same time, the cost of production will be low, leaving plenty of funds with which to pay taxes.

Alternately, *Surplus Energy* might be calculated in terms of the tax revenue that governments are able to collect, relative to the new energy type. Tax revenue based on fossil fuel production and/or consumption is very signification today. Oil exporting nations often rely primarily on oil-based tax revenue to support their programs. Many countries tax gasoline consumption highly. Another type of fossil fuel tax is a carbon tax. Any replacement for fossil fuels will need to replace the loss of tax revenue associated with fossil fuels, because taxation is the way Surplus Energy is captured for the good of the economy as a whole.

When we consider the tax aspect, we find that any replacement for fossil fuels has three conflicting demands on its pricing:

(a) Prices to the consumer must be low enough to prevent recession.

(b) Prices must be high enough that the producer of the replacement energy supply can earn adequate after-tax revenue to support its operations.

(c) The mark-up between the cost of production and the sales price must be high enough that governments can take a very significant share of gross receipts as tax revenue.

The only way that it is possible to meet these three demands simultaneously is if the unsubsidized cost of energy production is extremely low. Wind and solar clearly come nowhere near being able to meet this very low price threshold; they still rely on subsidies. One of the biggest subsidies is being allowed to "go first" when their energy supply is available. The greater the share of intermittent wind and solar that is added to the electric grid, the more disruptive this subsidy becomes.

Afterword: Is this a criticism of Peak Oil energy researchers?

No. I know many of these researchers quite well. They are hard working individuals who have tried to figure out what is happening in the energy arena with very little funding. Some of them are aware of the collapse issue, but it is not something that they can discuss in the journals they usually write in. The 1972 *The Limits to Growth* modeling that I mentioned in my last post was ridiculed by a large number of people. It was not possible to believe that the world economy could collapse, certainly not in the near term.

Early researchers were not aware that the physics of energy extraction extends to the economy as a whole, rather than ending at the wellhead. Because of this, they tended to overlook the importance of affordability. Affordability is important because there is a pricing conflict between the low prices needed by buyers of energy products and the high prices needed by producers. This conflict becomes especially apparent as the world approaches energy limits; this conflict was not easily seen in the data reviewed by Hubbert. Once Hubbert missed the affordability issue, his followers tended to go follow the same path.

Researchers needed to start from somewhere. The start that Peak Oil researchers made was as reasonable as any. They were convinced that there was an energy problem, and they wanted to convince others of the problem. But this was difficult to do. When they would develop an approach that they thought would make the energy problem clear to everyone, other researchers would modify it. They would take whatever aspect of the research seemed to be helpful to them and would tweak it to support whatever view they wanted to encourage–often with precisely the opposite intent to what the original researchers had expected.

Thus, the approaches that Peak Oil researchers thought would show that there was a likely energy shortage ahead ended up being used to "prove" that we have an almost unlimited amount of fossil fuel energy available. It seems as though the world has such a strong need for happily-ever-after endings that self-organization pushes research in the direction of showing outcomes people want to see, even if they are untrue.

Footnote:

[1] The following is from an e-mail I sent to some energy researchers concerned about EROI calculations:

A concern I have is that EROI really needs to match up with the concept of Fraction of Capital to Obtaining Non-Renewable Resources (FCONRR) in the Limits to Growth model. If a person looks at how the 2003 World3 model functions, the person can figure out several things:

1. FCONRR is what I would call a calendar year "in and out" function. Forecasting EROI using a model year approach gives artificially favorable indications. FCONRR calculations line up fairly well with many fossil fuel EROI calculations, but not with the usual model approach used for capital devices used to generate electricity.

2. I would describe FCONRR as corresponding to "Point of Use (POU) EROI," not Wellhead EROI.

3. If a newly built device causes a previously built capital device to be closed down before the end of its useful lifetime (for example, solar output leads to distorted electricity prices, which in turn leads to unprofitable nuclear), this has an adverse impact on FCONRR. Thus, intermittent renewables need to be evaluated on a very broad basis.

4. In the model, FCONRR starts at 5% and gradually increases to 10%. This is equivalent to overall average calendar year POU EROI starting at 20:1 and falling to 10:1. The model shows the world economy growing nicely, when total FCONRR is 5%. It gradually slows, as FCONRR increases to 10%. Once overall FCONRR exceeds 10%, the model shows the world economy contracting.

5. I was struck by the fact that FCONRR equaling 10% corresponds to the ratio that Charlie Hall describes as the

share of energy that a fish can afford to use to gather its food. Once a fish starts using more than 10% of its energy for gathering food, it is all downhill from there. The fish cannot live very long, without enough energy to support the rest of it functions. Similarly, an economy cannot last very long, without enough energy to support its other functions.

6. In the model, necessary resources out depend on the population. The higher the population, the more resources out are needed. It is falling resources per capita that causes the system to collapse. This is why FCONRR needs to stay strictly below 10% and energy consumption must be ramped up rapidly. This would suggest that average POU EROI needs to stay strictly above 10:1, to keep the system away from collapse.

7. If there are not enough resources out in total, for a given calendar year, this becomes a huge problem. The way this works out in practice is that if a device uses a lot of upfront capital, these devices can sort of work out OK, if (a) only a few are built each year, (b) they have very high EROI, and (c) they last a long time. Thus, hydro and dams can work. But devices with an EROI close to 10:1 cannot work, especially if they need to be scaled up quickly and need a lot of supporting infrastructure.

8. Clearly, using the FCONRR approach, eliminating a high EROI fuel is as detrimental to the system as adding a low EROI device with a lot of upfront capital spending required. It is the overall output compared to population that is important. The quantity of output is even more important than the EROI ratio.

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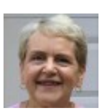

About Gail Tverberg
My name is Gail Tverberg. I am an actuary interested in finite world issues - oil depletion, natural gas depletion, water shortages, and climate change. Oil limits look very different from what most expect, with high prices leading to recession, and low prices leading to financial 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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