Fossil Fuel Production Is Reaching Limits in a Strange Way

Strangely enough, the limit we seem to be reaching with respect to fossil fuel extraction comes from low prices. At low prices, the extraction of oil, coal, and natural gas becomes unprofitable. Producers go bankrupt, or they voluntarily cut back production in an attempt to force prices higher. As the result of these forces, production tends to fall. This limit comes long before the limit that many people imagine: the amount of fossil fuels in the ground that seems to be available with current extraction techniques.

The last time there was a similar problem was back in 1913, when coal was the predominant fossil fuel used and the United Kingdom was the largest coal producer in the world. The cost of production was rising due to depletion, but coal prices would not rise sufficiently to cover the higher cost of production. As a result, the United Kingdom's coal production reached its highest level in 1913, the year before World War I started, and began to fall in 1914.

Between 1913 and 1945, the world economy was very troubled. There were two world wars, the Spanish Flu pandemic and the Great Depression. My concern is that we are again headed into another very troubled period that could last for many years.

The way the energy problems of the period between 1913 and 1945 were resolved was through the rapid ramp-up of oil production. Oil was, as that time, inexpensive to produce and could be sold for a very large multiple of the cost of production. If population is to remain at the current level or possibly grow, we need a similar “energy savior.” Unfortunately, none of the alternatives we are looking at now yield a high enough return relative to the required investment.

I recently gave a talk to an engineering group interested in energy research talking about these issues. In this post, I will discuss the slides of this presentation. A PDF of the presentation can be found at this link.
Oil prices seem to bounce around wildly. One major issue is that there is a two-way tug of war between the 
prices that citizens can afford and the prices that oil companies require. We can look back now and say that the mid-2008 price of over $150 per barrel was too high for consumers. But strangely enough, oil producers began complaining about oil prices being too low to cover their rising cost levels, starting in 2012. Prices, at a 2019 cost level, were at about $120 per barrel at that time. I wrote about this issue in the post, Beginning of the End? Oil Companies Cut Back on Spending. Oil prices now are in the $40 range, so are way, way below both $120 per barrel and $150 per barrel.

Interest rates and the availability of debt also play a role in oil prices. If interest rates are low and debt is readily available, it is easy to buy a new home or new car, and oil prices tend to rise because of the higher demand. When prices are too low for producers, central banks have been able to lower interest rates through a program called “quantitative easing.” This program seems to have helped oil prices to rise again, over a three-year period, after they crashed in 2008.
OPEC producers are known for their low cost of production, but even they report needing high oil prices. The cost of extracting the oil is reported to be very low (perhaps $10 per barrel), but the price charged needs to be high enough to allow governments to collect very high taxes on the oil extracted. If prices are high enough, these countries can continue the food subsidies that their populations depend upon. They can also sponsor development programs to provide jobs for the ever-growing populations of these countries. OPEC producers also need to develop new oil fields because the old ones deplete.
Oil production outside of the United States and Canada entered a bumpy plateau in 2005. The US and Canada added oil production from shale and bitumen in recent years, helping to keep world oil production (including natural gas liquids) rising.

#2) Oil producers need higher prices to match their higher cost of production.

- **OPEC** needs much higher prices to fund its programs
  - Needs higher funds for higher taxes
  - Danger of governments being overthrown
  - Likely much less production if warring factions in country

- Both US and Canada have added oil from shale and from bitumen since 2005
  - Many bankruptcies
  - Banks no longer willing to lend to oil and gas companies
  - Cutting back on investment in new drilling

- Even the “Rest of World” producers need high prices, to offset depletion
One reason why producers need higher prices is because their cost of extraction tends to rise over time. This happens because the oil that is cheapest to extract and process tends to be extracted first, leaving the oil with higher cost of extraction until later.

Some OPEC countries, such as Saudi Arabia, can hide the low price problem for a while by borrowing money. But even this approach does not work well for long. The longer low oil prices last, the greater the danger is of governments being overthrown by unhappy citizens. Oil production can then be expected to become erratic because of internal conflicts.

In the US and Canada, oil companies have been funded by bank loans, bond sales and the sale of shares of stock. These sources of funding are drying up, as many oil companies report poor earnings, year after year, and some are seeking bankruptcy protection.

![Chart 6](#)

#2) Drilling rigs are down dramatically in 2020, likely leading to lower oil production in 2021 and beyond

Chart 6 shows that the number of drilling rigs in operation has dropped dramatically in both the United States and Canada, as oil companies cut back on drilling. There is a lag between the time the number of drilling rigs is cut back and the time production starts to fall of perhaps a year, in the case of shale. These low drilling rig counts suggest that US and Canadian oil production from shale will fall in 2021.

Of course, unused drilling rigs cannot be mothballed indefinitely. At some point, they are sold as scrap and the workers who operated them find other employment. It then becomes difficult to restart oil extraction.

**How the Economy Works, and What Goes Wrong as Limits Are Reached**
Slide 7 shows one way of visualizing how the world economy, as a self-organizing system, operates. It is somewhat like a child’s building toy. New layers are added as new consumers, new businesses and new laws are added. Old layers tend to disappear, as old consumers die, old products are replaced by new products, and new laws replace old laws. Thus, the structure is to some extent hollow.

Self-organizing objects that grow require energy under the laws of physics. Our human bodies are self-organizing systems that grow. We use food as our source of energy. The economy also requires energy products of many kinds, such as gasoline, jet fuel, coal and electricity to allow it to operate.

It is easy to see that energy consumption allows the economy to produce finished goods and services, such as homes, automobiles, and medical services. It is less obvious, but just as important, that energy consumption provides jobs that pay well. Without energy supplies in addition to food, typical jobs would be digging in the dirt with a stick or gathering food with our hands. These jobs don’t pay well.

Finally, Slide 7 shows an important equivalence between consumers and employees. If consumers are going to be able to afford to buy the output of the economy, they need to have adequate wages.

A typical situation that arises is that population rises more quickly than energy resources, such as land to grow food. For a while, it is possible to work around this shortfall with what is called added complexity: hierarchical organization, specialization, technology, and globalization. Unfortunately, as more complexity is added, the economic system increasingly produces winners and losers. The losers end up with very low wage jobs, or with no jobs at all. The winners get huge wages and often asset ownership, as well. The winners end up with far more revenue than they need to purchase basic goods and services. The losers often do not have enough revenue to feed their families and to buy basic necessities, such as a home and some form of basic transportation.

The strange way the economy works has to do with the physics of the situation. Physicist Francois Roddier explains this as
being similar to what happens to water at different temperatures. When the world economy has somewhat inadequate energy supplies, the goods and services produced by the economy tend to bubble to the top members of the world economy, similar to the way steam rises. The bottom members of the economy tend to get “frozen out.” This way, the economy can downsize without losing all members of the economy, simultaneously. This is the way ecosystems of all kinds adapt to changing conditions: The plants and animals that are best adapted to the conditions of the time tend to be the survivors.

These issues are related to the fact that the economy is, in physics terms, a dissipative structure. The economy, like hurricanes and like humans, requires adequate energy if it is not to collapse. Dissipative structures attempt to work around temporary shortfalls in energy supplies. A human being will lose weight if his caloric intake is restricted for a while. A hurricane will lose speed, if the energy it gets from the warm water of the ocean is restricted. A world economy with inadequate energy is likely to shrink back in many ways: unprofitable businesses may fail, layers of government may disappear and population may fall, for example.

#3) Many reasons why potential consumers cannot purchase the output of the economy:

- Workers often have very low wages
  - Can’t afford homes, vehicles, restaurant meals
  - Globalization contributes to low-wage problem
  - Paying high wages to high tech workers leaves less for those less skilled
- Loans aren’t as helpful to low-wage workers
  - Interest rates are likely to be high
- Robots sometimes replace workers completely
- COVID shutdowns make problem much worse
  - Many more unemployed
  - Rich can no longer purchase overseas vacations; need fewer fancy clothes
  - Like taking out sticks supporting dome

In the discussion of Slide 7, I mentioned the fact that if we try to “stretch” energy supply with added complexity, many workers would end up with very low wages. Some of these low wage workers would be in the US and Europe, but many of them would be in China, India and Africa. Even though these workers are producing goods for the world economy, they often cannot afford to buy those same goods themselves. Henry Ford is remembered to have said something to the effect that he needed to pay his workers enough so that they, themselves, could buy the cars they were making. To a significant extent, this is no longer happening when a person takes into account international workers.

The high interest rates that low-wage workers pay mean that loans don’t really help low-wage workers as much as they help high-wage workers. The high interest on credit card debt and personal loans tend to transfer part of the income of low-wage workers to the financial sector, leaving poor people worse off than they would have been without the loans.
COVID shutdowns are extremely damaging to the world economy. They are like taking support sticks out of the dome on Slide 7. They produce many more unemployed people around the world. People in low wage countries that produce clothing for a living have been particularly hard hit, for example. Migrant workers and miners of various kinds have also been hard hit.

**We Seem to Be Reaching a Major Turning Point**

Oil production and consumption have both fallen in 2020; oil prices are far too low for producers; wage disparity is a major problem; countries seem to be increasingly having problems getting along. Many analysts are forecasting a prolonged recession.

The last time that we had a similar situation was in 1913, when the largest coal producer in the world was the United Kingdom. The UK’s cost of coal production kept rising because of depletion (deeper mines, thinner seams), but prices would not rise to compensate for the higher cost of production. Miners were paid very inadequate wages; poor workers regularly held strikes for higher wages. World War I started in 1914, the same year coal production of the UK started to fall. The UK’s coal production has fallen nearly every year since then.

3) **Low wage problem is similar to the late 1920s**

- Fix is likely to take years; much pain
- We are likely past “peak oil”; oil production may fall for years

![Graph showing U.S. Income Shares of Top 1% and Top 0.1% Households - Incl. Capital Gains (1913-2013)](source: Patty & Seby - January 2015)

The last time that wage disparity started to spike as badly as it has in recent years occurred back in the late 1920s, or perhaps as early as 1913 to 1915. The chart shown above is for the US; problems were greater in Europe at that time.

With continued low oil prices, production is likely to start falling and may continue to fall for years. It is hard to bring scrapped drilling rigs back into service, for example. The experience in the UK with coal shows that energy prices don’t necessarily rise to compensate for higher costs due to depletion. There need to be buyers for higher-priced goods made with higher-priced coal. If there is too much wage disparity, the many poor people in the system will tend to keep demand, and
prices, too low. They may eat poorly, making it easier for pandemics to spread, as with the Spanish Flu in 1918-1919. These people will be unhappy, leading to the rise of leaders promising to change the system to make things better.

My concern is that we may be heading into a long period of unrest, as occurred in the 1913 to 1945 era. Instead of getting high energy prices, we will get disruption of the world economy. The self-organizing economy is attempting to fix itself, either by getting more energy supply or by eliminating parts of the economy that aren’t contributing enough to the overall system. Conflict between countries, pandemics, bankruptcies and economic contraction are likely to be part of the mix.

**Coal Seems to Be Reaching Extraction Limits as Well**

Coal has essentially the same problem as oil: Prices tend to be too low for producers to extract coal profitably. Many coal producers have gone bankrupt. Prices were higher back in 2008, when demand was high for everything, and again in 2011, when quantitative easing had been helpful.

There have been stories in the press in the past week about China limiting coal imports from Australia, so as to make more jobs for coal miners in China. The big conflict among countries relates to “not enough jobs that pay well” and “not enough profitable companies.” These indirectly are energy issues. If there was more “affordability” of goods made with high-priced coal, there would be no problem.
Coal production worldwide has been on a bumpy plateau since 2012. In fact, China, the largest producer of coal, found its production stagnating, starting about 2012. The problem was a familiar one: The cost of extraction rose because many mines that had been used for quite a number of years were depleted. The selling price would not rise to match the higher cost of extraction because of affordability issues.

The underlying problem is that the economy is a dissipative structure. Commodity prices are set by the laws of physics. Prices don’t rise high enough for producers, if there are not enough customers willing and able to buy the goods made with high-priced coal.

We Have a Major Problem if Both Coal and Oil Production Are in Danger of Falling Because of Low Prices
Oil and coal are the two largest sources of energy in the world. We can't get along without them. While natural gas production is fairly high, there is not nearly enough natural gas to replace both oil and coal.

Looking down the list, we see that nuclear production hit a maximum back in 2006 and has fallen since then.

Hydroelectric continues to grow, but from a small base. Most of the good sites have already been taken. In many cases, there are conflicts between countries regarding who should get the benefit of water from a given river.

The only grouping that is growing rapidly is Renewables. (This is really Renewables Other than Hydroelectric.) It includes wind and solar plus a few other energy types, including geothermal. This grouping, too, is very small compared to oil and coal.

**Natural Gas Has a Low Price Problem as Well**
Natural gas, at first glance, looks like it might be a partial solution to the world’s energy problems: It is lower in carbon than coal and oil, and it is fairly abundant. The problem with natural gas is that it is terribly expensive to ship. At one time, people used to talk about there being a lot of “stranded” natural gas. This natural gas seemed to be available, but when shipping costs were included, the price of goods made with it (such as electricity or winter heat for homes) was often unaffordable.

After the run-up in oil prices in the early 2000s, many people became optimistic that, with energy scarcity, natural gas prices would rise sufficiently to make extraction and shipping long distances profitable. Unfortunately, it is becoming increasingly clear that, while prices can temporarily spike due to scarcity and perhaps a debt bubble, keeping the prices up for the long run is extremely difficult. Customers need to be able to afford the goods and services made with these energy products, or the laws of physics bring market prices back down to an affordable level.

The prices in the chart reflect three different natural gas products. The lowest priced one is US Henry Hub, which is priced near the place of extraction, so long distance shipping is not an issue. The other two, German Import and Japan Liquefied Natural Gas (LNG), include different quantities of long distance shipping. Prices in 2020 are even lower than in 2019. For example, some LNG imported by Japan has been purchased for $4 per million Btu in 2020.

The Economy Needs a Bail-Out Similar to the Growth of Oil After WWII
Issue #6) The economy needs a bail-out similar to the growth of oil production after World War II

- **Oil:** Very inexpensive to produce, initially
- **Value to customers was very much higher**
  - Sales price could be high above the cost of production
  - Very high “energy return on energy investment”
  - Opposite of “needing a subsidy”

- **Oil profits benefited economy as a whole**
  - High taxes helped governments; high dividends helped pensions
  - Easy to add new jobs, roads, electricity transmission lines

- **Without a new, exceedingly inexpensive-to-produce energy source, the economy will tend to shrink back and may even collapse**

The oil that was produced shortly after World War II had very important characteristics:

1. It was very inexpensive to produce, and
2. It could be sold to customers at a far higher price than its cost of production.

It was as if, today, we had a very useful energy product that could be produced and delivered for $4, but it was so valuable to consumers that they were willing to pay $120 for it. In other words, the consumer was willing to pay 30 times as much as the cost that went into extracting and refining the oil.

With an energy product this valuable, a company producing it would need virtually no debt. It could drill a well or two, and with the profits from the first wells, finance the investment of many more wells. The company could pay very high taxes, allowing governments to build roads, schools, electricity transmission lines and much other infrastructure, without having to raise taxes on citizens.

Besides using the profits for reinvestment and for taxes, oil companies could pay high dividends. This made oil company stocks favorites of pension plans. Thus, in a way, oil company profits could help subsidize pension plans, as well.

Now, because of depletion, we have reached a situation where oil companies, and in fact most companies, are unprofitable. Companies and governments keep adding debt at ever lower interest rates. In fact, the tradition of ever-increasing debt at ever-lower interest rates goes back to 1981. Thus, we have been using debt manipulation to hide energy problems for almost 40 years now.

We need a way to counteract this trend toward ever-lower returns. Some people talk about “Energy Return on Energy
Investment” or EROEI. I gave an example in dollars, but a major thing those dollars are buying is energy, so the result is very similar.

I think researchers have set the “bar” far too low, in looking at what is an adequate EROEI. Today's wind and solar don't really have an adequate EROEI, when the full cost of delivery is included. If they did, they would not need the subsidy of “going first” on the electric grid. They would also be able to pay high taxes instead of requiring subsidies, year after year. We need much better solutions than the ones we have today.

Some researchers talk about “Net Energy per Capita,” calculated as ((Energy Delivered to the End User) minus (Energy Used in Making and Transporting Energy to the End User)) divided by (Population). It seems to me that Net Energy per Capita needs to stay at least constant, and perhaps rise. If net energy per capita could actually rise, it would allow the economy to increasingly fight depletion and pollution.

**Conclusion: We Need a New Very Inexpensive Energy Source Now**

- **Current economic situation makes it difficult to reach this goal**
  - Economy is doing poorly
  - Overall “energy return” of today's fuel mix seems to be too low
  - Makes it difficult to fund temporary subsidies for alternatives

- **Economic crisis may take years to resolve**
  - Energy innovations may have a chance in the rebuilding stage

- **Perhaps hope?**
  - Recent headline: [UAE Bets Big on Space Tech to Diversify from Oil](#)
  - Funds for research may be available, even if not for full implementation

We need a new, very inexpensive energy source that buyers will willingly pay a disproportionately high price for right now, not 20 or 50 years from now.

The alternative may be an economy that does poorly for a long time or collapses completely.

The one ray of hope, from a researcher's perspective, is the fact that people are always looking for solutions. They may be able to provide funds for research at this time, even if funds for full implementation are unlikely.
1,351 THOUGHTS ON “FOSSIL FUEL PRODUCTION IS REACHING LIMITS IN A STRANGE WAY”

Ed

on October 23, 2020 at 10:29 am said:

10 GW of solar and a big battery. Anyone know how big a battery?


Nehemiah

on October 23, 2020 at 1:15 pm said:

I don’t know, but the previous “world’s biggest battery” in South Australia was reported to be 100MW and cost $90 million dollars (since the article mentioned at the prevailing “exchange rate,” I guess this was US dollars and not Aussie dollars). It was built by Elon Musk/Tes-