MuseLetter

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The thread running through this month's Museletter is energy. The first essay, "A Simple Way to Understand What's Happening and What to Do," explains the systemic consequences of fossil fuel depletion and the policy options that make sense in response to it; the second, "Has Oil Peaked?", points to key and perhaps culminating developments in the ongoing peak oil discussion.

A simple way to understand what's happening ... and what to do

The world seems to be coming apart at the seams. It's critical to understand why, so that we can avoid the worst and find the best responses so as to move toward the environmentally and socially healthy future we want. It turns out that there's a relatively simple frame for gaining such understanding.

This straightforward explanation proposes that the main force driving societal change is available energy—an assertion that's backed by a substantial amount of scientific research. Those with the patience and curiosity to investigate further can find other contributing factors to societal evolution—technology, investment, laws regarding property rights, histories of injustice, and more, many of which entail complex systemic interactions that take time to tease apart and comprehend mentally. These are important. But not as important as energy.

Energy is necessary in order for any organism to do anything whatsoever. For humans, food is energy that powers labor. But, in addition, people long ago learned how to harness energy from fire, water, and wind. Using firewood, paddlewheels, and sails, we built agrarian societies with irrigation systems, cities, cathedrals, mills, and seagoing ships, and created some pretty great art, music, and literature along the way. People also used energy from various sources to engage in wars and conquests, and to enslave millions of others in order to steal the fruits of their forced labor. In addition, humans deforested enormous regions to harvest firewood, and ruined millions of acres of soil with unsustainable farming methods.

When humans started using fossil fuels, a couple of centuries ago, they gained access to millions of years' worth of solar energy that nature had gathered, stored, and transformed into energy sources that were far superior, at least over the short term, to firewood. It was a game-changing moment. Now, fossil-fuel "slaves" could do more work, and more cheaply, than flesh-and-blood human slaves. After all, a single barrel of oil, costing roughly $40 in today's market, contains energy that's equivalent to roughly five years of hard physical work.

Here were the main trends during the up-ramp phase of the fossil-fuel age, as more cheap

energy became available to be used year after year:

Production became more profitable. Fossil-fuel energy inputs worked miraculously to cheapen the processes of extracting raw materials and transforming them into products. It also became cheaper to transport materials and products across the globe in order to take advantage of relatively more abundant resources and cheap labor, as well as rising demand, wherever they happened to exist. Profits could then be re-invested in even more resource extraction, manufacturing, and transport: rinse and repeat.

Consumption grew more affordable. With more fuels powering more machines, labor became less about muscle power, and more about brain power—the ability to intelligently direct machines. Rising productivity and profitability enabled employers to pay higher wages to more workers. The middle class expanded, and people moved from the countryside to cities. Meanwhile, since manufactured goods were getting cheaper to produce, businesses could afford to sell them for less in order to undercut competitors. The result: people could afford to consume more. And they were constantly encouraged to do so, in order to buy the boatloads of goods being produced by factories and shipped across the globe. Food and medicines became cheaper, too, and population grew rapidly as a result (from a billion at the start of the fossil-fuel revolution to nearly 8 billion today).

Inequality became more tolerable (with exceptions). Economic inequality has existed since the first agrarian state appeared in Mesopotamia 6,000 years ago. Complex societies acted as a wealth pump, with taxes and military conquests constantly funneling riches to kings, generals, and aristocrats. But with limited labor and energy, the unequal distribution of wealth in agrarian societies had limits: if the peasants starved, the entire social system could collapse. Fossil fuels enabled the continual growth of the system, so that even if those at the top of the heap were raking in colossal fortunes, those at the bottom could still realistically expect their children to have easier lives than their own. Societal collapse and peasant revolts became problems for historians, not policy makers. Exceptions: the Russian Revolution of 1917 and the Great Depression; in both cases, the impacts of inequality threatened the world system to a significant degree.

Debt became generally more repayable. In pre-fossil-fuel economies, the total amount of wealth in societies tended to grow very slowly if at all, which meant that debts were often hard to repay. The payment of interest on debt was so onerous that Christianity and Islam regarded interest (“usury”) as evil. As fossil fuels enabled economies to grow, repayment of debt with interest became far easier, and the use of debt as a way of funding new enterprises of all kinds expanded greatly. Households increasingly used debt to move consumption forward in time (consume now, pay later!), thereby helping to soak up the glut of production.

Political and economic systems grew more stable (with a few very big exceptions). The exceptions were, of course, the two World Wars, the Great Depression, and the Cold War. However, once policy makers felt they had learned the lessons from these dire events, they came up with what they regarded as a winning formula. Within nations, progressive taxation and redistribution programs would prevent the poor from falling into utter destitution and triggering political crises. Global trade would lift all boats, reducing international tensions. Meanwhile the constant adjustment of interest rates by central banks would keep consumption, production, and investment on an even keel. Decades of relative peace and prosperity ensued.

Nature was pillaged. As population and consumption grew, natural resources were depleted ever more rapidly, while ever more pollution was discharged into the environment. Wildlife disappeared as habitat was degraded or conscripted for agriculture. The burning of ever-

increasing amounts of fossil fuels began to destabilize the climate, threatening civilization itself. But policy makers reassured themselves and their constituents that these problems could only be solved with more energy and money. Growth was the answer to all problems.

The downhill terrain ahead

Fossil fuels come with a couple of serious problems. First, of course, is the familiar one: greenhouse gas emissions from burning coal, oil, and natural gas are warming the planet, resulting in record-breaking droughts, floods, and heat waves. A subtler problem is that fossil fuels are depleting, non-renewable resources that we harvest using the low-hanging fruit principle. Humans have generally extracted the highest-quality, easiest-accessed energy resources first, leaving the lower-quality and harder-to-get resources for later. After a couple of centuries of this, the best of the fossil fuels are mostly gone. More energy has to be used to extract and process these fuels, so the net energy they can deliver to society is declining. That means there will be less and less energy available as time goes by for *any activity* we want to do in our homes, communities, and nations.

Alternative energy sources are available. But the most viable of these sources, solar and wind, are intermittent, which means that society will have to invest in costly energy storage strategies to deploy them at scale. Comparatively little of our energy currently comes from these sources, so huge infrastructure projects will be needed in order for us to make the transition—and the requirement for building all that new infrastructure comes just as our best sources of cheap fossil-fuel energy have begun their inevitable decline. Altogether, it's nearly impossible to avoid the conclusion that our future holds less available energy, and probably a lot less. World oil production has probably just peaked, so we've already started the long energy descent. And it's fairly clear what the trends will be.

Production is becoming less profitable. This trend has started with the oil industry itself: fuel prices are no longer high enough to generate profits; when prices do rise sufficiently, they depress demand, which also eats into profits (this is the result of the depletion of the highest-quality petroleum resources). The oil industry just isn't as profitable as it used to be: while Saudi Aramco appears still to be doing fairly well, most of the companies that have been responsible for the increase in world oil production in the last decade are seeing capital expenditures exceeding revenues. Since all production throughout the economy requires an energy input, the trend toward declining profitability is likely to spread to manufacturing and agriculture as well.

Consumption is growing less affordable. Declining profitability will exert downward pressure on wages, making it harder for workers to afford to buy stuff. Already, most members of Generation Z do not expect to earn as much than their parents did.

Inequality is becoming less tolerable. With less growth, no growth, or even substantial economic contraction in the offing, people at the bottom of the economic ladder are getting squeezed. Poverty rates are increasing in the US and many other countries. Meanwhile, the wealth pump is still at work: eight people now control as much wealth as the poorer half of humanity. Protests for racial equality have erupted in the US, following years of unrest in Middle Eastern and Latin American countries, based on demands for fairer distribution of wealth and political power. Among the young in North America, the idea of socialism is becoming increasingly attractive.

Debt is about to become less easily repayable. Recall that debt grew during the energy upswing, as it was more easily repayable. Perversely, as economic growth slowed in the US during the past three decades, the total amount of debt started to grow even faster. This was a deliberate strategy on the part of policy makers and central bankers to offset the effects of

slowing growth. But it is a strategy with a limited shelf life. After a certain point, bailouts will cease to enable companies and households to keep taking on debt which they will never be able to repay. This is already happening in the oil industry, where companies that specialized in fracking are going bankrupt and defaulting on loans.

Political and economic systems are growing less stable. Unfortunately, the vast majority of people do not understand the simple historical dynamic described in this essay. They find themselves less able to afford what they need, and less able to repay their debts. There are competing partisan explanations for why life is getting harder, and as people embrace those explanations they are becoming more politically polarized; as a result, policy makers find it more difficult to reach compromises to solve problems.

Pandemic is accelerating the process. Due to the COVID-19 pandemic, production, consumption, and transport are all depressed. Governments and central banks have stepped in to keep the bottom from falling out of the economy, but most of the bailout cash has been channeled toward the financial system, thereby increasing economic inequality. Further, the bailouts have just created more debt in order to keep existing debt from being defaulted upon. Partisanship is increasing. And so political and economic systems are being destabilized faster than was the case prior to the pandemic.

Environmental collapse is accelerating, and is speeding the process of societal collapse. Climate change is being worsened by self-reinforcing feedbacks (for example, melting arctic ice leaves dark water in its place, which absorbs more solar heat and melts more ice). An unstable climate makes agriculture more problematic and causes more natural disasters, which cost money for recovery. Beyond a certain point, money spent for recovery from one disaster makes less money available for recovery from the next disaster (already a problem for California). People feel more miserable, and, presented with competing narratives, become more partisan; on and on the cycle goes.

What to do

Because they don’t understand the underlying dynamic described above, policy makers are flailing blindly. Above all, they are trying to do something that’s ultimately impossible—maintain economic growth in perpetuity. Doing anything else is inconceivable to them because failure to maintain growth will result in casualties. What policy makers actually need to do is minimize casualties in the absence of growth. Our best goal would be to adapt to declining energy while laying the groundwork for a sustainable post-fossil-fuel society. Pursuing that alternative goal will require intelligent and courageous action. Mistakes are inevitable. But if we all keep doing what seemed to make sense during the fossil-fuel era, we are likely to see a dismal if not horrific outcome.

Once policy makers understand what’s happening and why, the most important thing they can do is to *share that information with everyone else*. Only if everyone understands the situation are members of competing economic sectors and politically polarized social groups likely to join together. Social cohesion will be required if we are to collectively alter expectations and behavior while working hard and making sacrifices.

Since the unraveling of the status quo will be driven by reductions in useful energy, it makes sense to *give energy a high priority* in response planning. We need non-fossil energy sources. However, since these sources will not be able to supply as much energy as fossil fuels, we must deploy them strategically—not with the intent to maintain current patterns of industrial production and consumption, but with the goal of keeping necessities available while the amount of useful energy declines. Forget 5G, the Internet of Things, and self-driving cars. Concentrate on low tech for the most part, and use renewable energy to supply

electricity for applications that are especially important. During the last few decades we have digitized all human knowledge; if the grid goes down, we lose civilization altogether. We must choose what knowledge is essential and let the rest go, but that will take a while; in the interim, we need electricity to keep the grid up and running—and solar and wind can provide it.

Food is also top priority. Provide incentives and education for city kids to move to the country and start small farms. Make land available to them if they will work it sustainably, and do whatever is necessary to enable them to make a decent living. Promote urban gardening. Support local food distribution networks as well as small-scale, energy-efficient local storage and processing facilities.

Ratchet down production and consumption of manufactured goods controllably. The best way to do this is to remove the elements of profit and affordability from distribution as much as possible. That means distributing necessities more by quota than by price. Rationing has often worked well in the past; we need it now more than ever.

Reducing inequality will help. If inequality remains at current levels, social cohesion will be difficult to maintain. Reduction in inequality can substitute for overall economic growth in keeping the poorest from descending into destitution. Tax the rich.

Focus on the local economy. That means letting go of empire-building aspirations and many aspects of global trade—but re-localization will yield upsides from more robust and satisfying community relationships.

Forgive debts. Start with student loans, but don't stop there. Defaults will occur anyway; what's important is that there is support for people thrown out of work as a result of bankruptcies. Save bailouts for industries that are actually essential (we really don't need hedge funds, airlines, and car companies).

Reduce population by incentivizing small families rather than large ones, and by fully supporting the rights of women.

Reduce harms to the environment so that it doesn't cost as much to recover from natural disasters or to clean up pollution. Reducing population, production, and consumption will certainly help, but we could achieve just as much by transforming agriculture so that farms build topsoil rather than ruining it, and capture atmospheric carbon rather than adding to it.

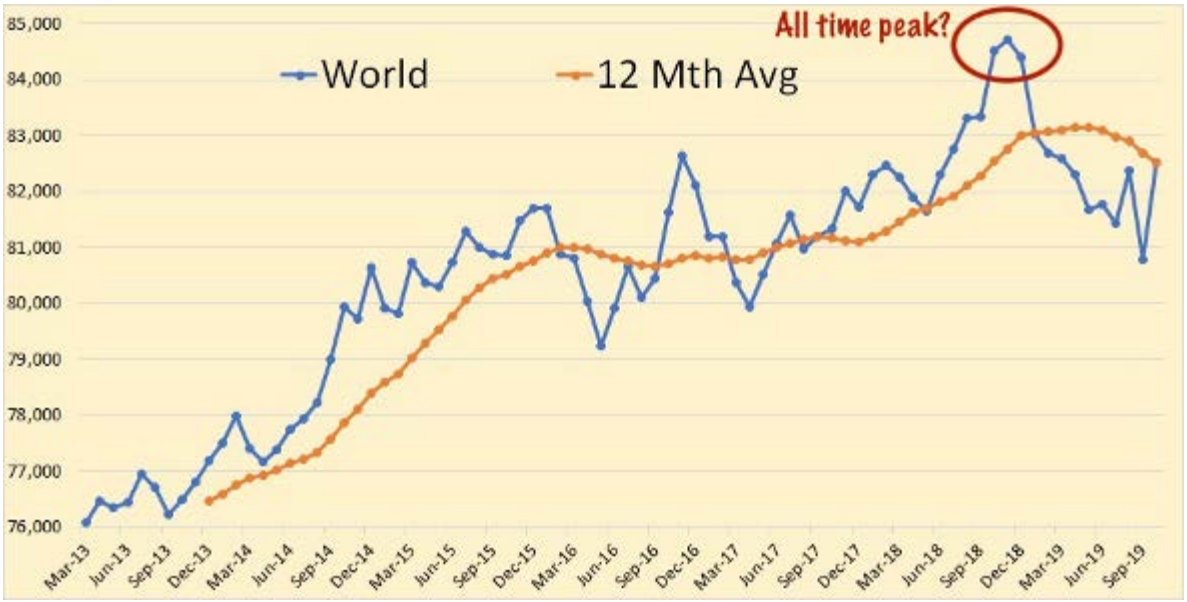
With regard to the pandemic, everyone should emulate New Zealand. That means total lockdowns for a period of weeks, then massive testing and tracing efforts directed by compassionate but strong, science-minded leaders. No excuses. No arguments about facemasks and contact questionnaires. Just do it. Eliminate the virus. Then we can move on and celebrate.

Which brings me to a final point: *life is about more than survival*. We are all more likely to engage willingly in the collective effort described above if we are able to enjoy ourselves in the process. Over the next few decades, we need to build a social system that differs radically from the industrial, consumption-oriented, growth economy of the 20th century. Let's make it a beautiful human world, filled with opportunities for singing, dancing, reflecting, remembering, imagining, mourning, meditating, and all the other life-sustaining activities that go on in a healthy culture. Enlist creative artists in the process, and enable everyone with even an ounce of creativity to find ways to express it.

Has oil peaked?

Last month, the world's 4th largest oil company—BP—predicted that the world will never again consume as much petroleum as it did last year. So, have we finally hit peak oil? And if so, what does that mean for our economy and our world?

There was fierce controversy in the first decade of this century over claims by petroleum geologists and energy commentators that peak oil was imminent (I was a figure in that debate, writing several books on the topic). Most of those early claims were based on analysis of oil depletion and consequent supply constraints. BP, however, is talking about a peak in oil *demand*—which, according to its forecast, could fall by more than 10 percent this decade and as much as 50 percent over the next 20 years if the world takes strong action to limit climate change.



Source: PeakOilBarrel.com; production in thousands of barrels per day.

Numbers from the US Energy Information Administration's Monthly Review tell us that world oil production (not counting biofuels and natural gas liquids) actually hit its zenith, so far at least, in November 2018, nearly reaching 84.5 million barrels per day. After that, production rates stalled, then plummeted in response to collapsing demand during the coronavirus pandemic. The current production level stands at about 76 mb/d.

Many early peak oil analysts predicted that the maximum rate of oil production would be achieved in the 2005-to-2010 timeframe, after which supplies would decline minimally at first, then more rapidly, causing prices to skyrocket and the economy to crash.

Those forecasters were partly right and partly wrong. *Conventional* oil production did plateau starting in 2005, and oil prices soared in 2007, helping trigger the Great Recession. Afterward, however, there was strong growth in production of *unconventional* oil from deepwater wells and Canadian oil sands, and especially from tight oil (also referred to as shale oil) extracted by horizontal drilling and fracking. The US, whose petroleum production rate had been generally declining since the early 1970s, hit new all-time highs as tight oil gushed from North Dakota and Texas.

After 2010, the focus of the peak oil debate shifted from supply constraints to demand reduction. Electric cars and climate action, it was claimed, would limit the world's usage of

petroleum, leading to falling oil prices and the eventual failure of the oil industry.

Even though early peak oilers underestimated the rise of unconventional oil through the "magic" of easy credit, and thus miscalculated the timing of maximum overall production, they did improve the public's energy literacy with two key observations:

- **Energy is overwhelmingly important.** Energy flows are key factors in the development of both ecosystems and social systems. Mainstream economists make the mistake of considering energy merely as a component of GDP; in fact, the entire economy depends on energy. Further, nearly all modern manufacturing and distribution channels rely on fuels derived from petroleum.

- **The depletion of non-renewable resources (such as fossil fuels) proceeds according to the low-hanging-fruit principle.** The highest-quality and easiest-to-get resources are usually harvested first. Therefore, supply constraints are likely to be felt long before resources are exhausted. With energy resources such as oil, more effort (i.e., energy) is continually required to find, extract, and process each new increment of production than was the case with the previous one, resulting in a gradually falling energy profit ratio (measured as energy returned on energy invested, or EROEI).

In retrospect, by focusing so much on the dynamics of production, peak oil analysts largely failed to elucidate the subtler relationships between oil demand and the larger economy. Following the Global Financial Crisis, as the world rate of conventional oil production flatlined and the rate of unconventional oil production soared, they realized they had missed two important points:

- **Commodity prices can give misleading signals with regard to future resource abundance.** It had been assumed that petroleum depletion would inexorably lead to higher fuel prices. However, since world conventional oil production topped out 15 years ago, prices have seen all-time lows as well as all-time highs. If there is a general price trend at work, it seems to be for oil increasingly to become either too expensive for customers to afford, or too cheap to be profitable for producers. There is no longer a "Goldilocks" price that satisfies everyone. And that's bad for both the global economy and for oil producers.

- **Oil production levels are driven not just by geology and technology, but also by investment—and that adds another source of predictive uncertainty.** In the wake of the Great Recession, central banks (notably the US Federal Reserve) pumped enormous amounts of new money into the world financial system while also keeping interest rates at historically rock-bottom levels. Suddenly, small oil companies pursuing marginal tight oil plays, who had been insisting that shale oil was a potential bonanza, had the ears of investors who were flush with cash and looking for the "next big thing." Those same companies were able to take on loads of debt at ultra-low interest rates. As it turned out, very little tight oil was produced profitably in the subsequent years. If normal financial conditions had prevailed, there likely would have been no US shale oil production boom. But conditions were anything but normal, and the boom was deafening—while it lasted. Then, just as the fracking frenzy was reaching its geological limits (more on that below), another seemingly unforeseeable event—the coronavirus pandemic—came along, crushing global oil demand almost instantaneously.

Between 30 and 40 small-to-medium-sized oil companies have gone bankrupt since the pandemic began; over a hundred more are teetering on the brink. The Fed has bought up $355 million in oil company debt to stanch the bleeding. Oil prices are currently stuck at

about $40 per barrel. The industry says shale oil production would be profitable with prices above $50; but with all costs added in, the real break-even price is probably closer to $60, and higher still for many producers. Meanwhile, Shell and BP are promising to go "carbon neutral," mostly via their efforts to use captured carbon dioxide in enhanced oil recovery (analysis suggests this is, at best, merely a carbon accounting "shell game"). The oil companies are anticipating a slew of new climate regulations if Democrats prevail in the upcoming election; they evidently figure it's time to give their business model a coat of green paint.

Some commentators suggest that, if the pandemic is resolved soon, planes will resume flying, business will return to normal, and oil demand will hit new highs. That scenario seems unlikely, not only because a full recovery anytime soon is unlikely, but also because oil supply constraints could reinforce demand limits in ways that will be hard for analysts to untangle. For example, the bankruptcy of the shale industry could help precipitate another financial crisis, thereby driving down oil demand. In the subsequent hand-wringing in the financial press, there would likely be relatively little reflection on the role of simple resource depletion in the complex chain of failures and defaults that followed.

The fracking business was always a bubble. Financially, it required low interest rates and a conveyor belt of gullible new investors. From a geophysics point of view, tight oil production could be described as an effort to scrape the bottom of the barrel. Post Carbon Institute has published a series of technical reports by Dave Hughes explaining that tight oil plays consist of bounded areas where residual oil is trapped in source rock with low permeability. Individual wells deplete quickly, so many new wells must continually be drilled and fracked at great expense if overall production rates are to be maintained. Moreover, plays are characterized by small "sweet spots" of concentrated resource, surrounded by lower-quality regions that will likely never be profitable to drill. And, for the most part, the sweet spots already have been tapped. At the risk of oversimplifying Hughes's data and analysis, it's probably fair to conclude that, even if the coronavirus pandemic hadn't hit, US shale oil production would be peaking in the near future.

Fracking was an encore for the oil industry's spectacular performance over the past century-and-a-half. But there isn't likely to be a second curtain call, as customers are leaving the theater. For those customers—that is, for society as a whole—there will be consequences. If we were going to have anything like a seamless transition to a post-petroleum future, we should have started it a couple of decades prior to the peak. As it is, it's going to be tough going. Industries that depend on petroleum (particularly aviation, shipping, industrial agriculture, and trucking), and industries that rely on *those* industries (including manufacturing and retailing) likely will be hard-pressed to regain their pre-pandemic vigor, and over time will have to adjust to ever-tightening global flows of fuel. As will the rest of us who like to shop, travel, and eat.

A new era has begun.