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MuseLetter #300 / May 2017 by Richard Heinberg

Juggling Live Hand Grenades

Here are a few useful recent contributions to the global sustainability conversation, with relevant comments interspersed. Toward the end of this essay I offer some general thoughts about converging challenges to the civilizational system.

"Oil Extraction, Economic Growth, and Oil Price Dynamics," by Aude Illig and Ian Schiller. *BioPhysical Economics and Resource Quality,* March 2017, 2:1.

Once upon a time it was assumed that as world oil supplies were depleted and burned, prices would simply march upward until they either crashed the economy or incentivized both substitute fuels and changes to systems that use petroleum (mainly transportation). With a little hindsight—that is, in view of the past decade of extreme oil price volatility—it's obvious that that assumption was simplistic and useless for planning purposes. Illig's and Schiller's paper is an effort to find a more realistic and rigorously supported (i.e., with lots of data and equations) explanation for the behavior of oil prices and the economy as the oil resource further depletes.

The authors find, in short, that before oil production begins to decline, high prices incentivize new production without affecting demand too much, while low prices incentivize rising demand without reducing production too much. The economy grows. It's a self-balancing, self-regulating system that's familiar territory to every trained economist.

However, because oil is a key factor of economic production, a depleting non-renewable resource, and is hard to replace, conventional economic theory does a lousy job describing the declining phase of extraction. It turns out that once depletion has proceeded to the point where extraction rates start to decline, the relationship between oil prices and the economy shifts significantly. Now high prices kill demand without doing much to incentivize new production that's actually profitable), while low prices kill production without doing much to increase demand. The system becomes self-destabilizing, the economy stagnates or contracts, the oil industry invests less in future production capacity, and oil production rates begin to fall faster and faster.

The authors conclude:

> *Our analysis and empirical evidence are consistent with oil being a fundamental quantity in economic production. Our analysis indicates that once the contraction period for oil extraction begins, price dynamics will accelerate the decline in extraction rates: extraction rates decline because of a decrease in profitability of the extraction business. . . . We believe that the contraction period in oil extraction has begun and that policy makers should be making contingency plans.*

As I was reading this paper, the following thoughts crossed my mind. Perhaps the real deficiency of the peak oil "movement" was not its inability to forecast the exact timing of the peak (at least one prominent contributor to the discussion, petroleum geologist Jean Laherrère, made in 2002 what could turn out to have been an astonishingly accurate estimate for the global conventional oil peak in 2010, and global unconventional oil peak in 2015). Rather, its shortcoming was twofold: 1) it didn't appreciate the complexity of the likely (and, as noted above, poorly understood) price-economy dynamics that would accompany the peak, and 2) it lacked capacity to significantly influence policy makers. Of course, the purpose of the peak oil movement's efforts was not to score points with forecasting precision but to change the trajectory of society so that the inevitable peak in world oil production, whenever it occurred, would not result in economic collapse. The Hirsch Report of 2005 showed that that change of trajectory would need to start at least a decade before the peak in order to achieve the goal of averting collapse. As it turned out, the peak oil movement did provide society with a decade of warning, but there was no trajectory change on the part of policy makers. Instead, many pundits clouded the issue by spending that crucial decade deriding the peak oil argument because of insufficient predictive accuracy on the part of some of its proponents. And now? See this article:

"Saudi Aramco Chief Warns of Looming Oil Shortage," by Anjli Raval and Ed Crooks, *Financial Times*, April 14, 2017.

The message itself should be no surprise. Everyone who's been paying attention to the oil industry knows that investments in future production capacity have fallen dramatically in the past three years as prices have languished. It's important to have some longer-term historical perspective, though: today's price of $50 per barrel is actually a high price for the fuel in the post-WWII era, even taking inflation into account. The industry's problem isn't really that prices are too low; it's that the costs of finding and producing the remaining oil are too high. In any case, with prices not high enough to generate profits, the industry has no choice but to cut back on investments, and that means production will soon start to lag. Again, anyone who's paying attention knows this.

What's remarkable is hearing the head of Saudi Arabia's state energy company convey the news. Here's an excerpt from the article:

> *Amin Nasser, chief executive of Saudi Aramco, the world's largest oil producing company, said on Friday that 20 [million] barrels a day in future production capacity was required to meet demand growth and offset natural field*

> *declines in the coming years. "That is a lot of production capacity, and the investments we now see coming back—which are mostly smaller and shorter term—are not going to be enough to get us there," he said at the Columbia University Energy Summit in New York. Mr. Nasser said that the oil market was getting closer to rebalancing supply and demand, but the short-term market still points to a surplus as U.S. drilling rig levels rise and growth in shale output returns. Even so, he said it was not enough to meet supplies required in the coming years, which were "falling behind substantially." About $1 [trillion] in oil and gas investments had been deferred and cancelled since the oil downturn began in 2014.*

Mr. Nasser went on to point out that conventional oil discoveries have more than halved during the past four years.

The Saudis have never promoted the notion of peak oil. Their mantra has always been, "supplies are sufficient." Now their tune has changed—though Mr. Nasser's statement does not mention peak oil by name. No doubt he would argue that *resources* are plentiful; the problem lies with prices and investment levels. Yes, of course. Never mention depletion; that would give away the game.

"How Does Energy Resource Depletion Affect Prosperity? Mathematics of a Minimum Energy Return on Investment (EROI)." by Adam R. Brandt. *BioPhysical Economics and Resource Quality*, (2017) 2:2.

Adam Brandt's latest paper follows on work by Charlie Hall and others, inquiring whether there is a minimum energy return on investment (EROI) required in order for industrial societies to function. Unfortunately EROI calculations tend to be slippery because they depend upon system boundaries. Draw a close boundary around an energy production system and you are likely to arrive at a higher EROI calculation; draw a wide boundary, and the EROI ratio will be lower. That's why some EROI calculations for solar PV are in the range of 20:1 while others are closer to 2:1. That's a very wide divergence, with enormous practical implications.

In his paper, Brandt largely avoids the boundary question and therefore doesn't attempt to come up with a hard number for a minimum societal EROI. What he does is to validate the general notion of minimum EROI; he also notes that society's overall EROI has been falling during the last decade. Brandt likewise offers support for the notion of an EROI "cliff": that is, if EROI is greater than 10:1, the practical impact of an incremental rise or decline in the ratio is relatively small; however, if EROI is below 10:1, each increment becomes much more significant. This also supports Ugo Bardi's idea of the "Seneca cliff," according to which societal decline following a peak in energy production, consumption, and EROI may be far quicker than the build-up to the peak.

"Burden of Proof: A Comprehensive Review of the Feasibility of 100% Renewable-Electricity Systems," by B.P. Heard, B.W. Brook, T.M.L. Wigley, and C.J.A. Bradshaw. *Renewable and Sustainable Energy Reviews*, Volume 76, September 2017, Pages

1122–1133.

This study largely underscores what David Fridley and I wrote in our recent book *Our Renewable Future*. None of the plans reviewed here (including those by Mark Jacobson and co-authors) passes muster. Clearly, it is possible to reduce fossil fuels while partly replacing them with wind and solar, using current fossil generation capacity as a fallback (this is already happening in many countries). But getting to 100 percent renewables will be very difficult and expensive. It will ultimately require a dramatic reduction in energy usage, and a redesign of entire systems (food, transport, buildings, and manufacturing), as we detail in our book.

"Social Instability Lies Ahead, Researcher Says," by Peter Turchin. January 4, 2017, Phys.org.

Over a decade ago, ecologist Peter Turchin began developing a science he calls cliodynamics, which treats history using empirical methods including statistical analysis and modeling. He has applied the same methods to his home country, the United States, and arrives at startling conclusions.

> *My research showed that about 40 seemingly disparate (but, according to cliodynamics, related) social indicators experienced turning points during the 1970s. Historically, such developments have served as leading indicators of political turmoil. My model indicated that social instability and political violence would peak in the 2020s.*

Turchin sees the recent U.S. presidential election as confirming his forecast: "We seem to be well on track for the 2020s instability peak. . . . If anything, the negative trends seem to be accelerating." He regards Donald Trump as more of a symptom, rather than a driver, of these trends.

The author's model tracks factors including "growing income and wealth inequality, stagnating and even declining well-being of most Americans, growing political fragmentation and governmental dysfunction." Often social scientists focus on just one of these issues; but in Turchin's view, "these developments are all interconnected. Our society is a system in which different parts affect each other, often in unexpected ways."

One issue he gives special weight is what he calls "elite overproduction," where a society generates more elites than can practically participate in shaping policy. The result is increasing competition among the elites that wastes resources needlessly and drives overall social decline and disintegration. He sees plenty of historical antecedents where elite overproduction drove waves of political violence. In today's America there are far more millionaires than was the case only a couple of decades ago, and rich people tend to be more politically active than poor ones. This causes increasing political polarization (millionaires funding extreme candidates), erodes cooperation, and results in a political class that is incapable of solving real problems.

I think Turchin's method of identifying and tracking social variables,

using history as a guide, is relevant and useful. And it certainly offers a sober warning about where America is headed during the next few years. However, I would argue that in the current instance his method actually misses several layers of threat. Historical societies were not subject to the same extraordinary boom-bust cycle driven by the use of fossil fuels as our civilization saw during the past century. Nor did they experience such rapid population growth as we've experienced in recent decades (Syria and Egypt saw 4 percent per annum growth in the years after 1960), nor were they subject to global anthropogenic climate change. Thus the case for near-term societal and ecosystem collapse is actually stronger than the one he makes.

Some Concluding Thoughts

Maintaining a civilization is always a delicate balancing act that is sooner or later destined to fail. Some combination of population pressure, resource depletion, economic inequality, pollution, and climate change has undermined every complex society since the beginnings of recorded history roughly seven thousand years ago. Urban centers managed to flourish for a while by importing resources from their peripheries, exporting wastes and disorder beyond their borders, and using social stratification to generate temporary surpluses of wealth. But these processes are all subject to the law of diminishing returns: eventually, every boom turns to bust. In some respects the cycles of civilizational advance and decline mirror the adaptive cycle in ecological systems, where the crash of one cycle clears the way for the start of a new one. Maybe civilization will have yet another chance, and possibly the next iteration will be better, built on mutual aid and balance with nature. We should be planting the seeds now.

Yet while modern civilization is subject to cyclical constraints, in our case the boom has been fueled to an unprecedented extreme by a one-time-only energy subsidy from tens of millions of years' worth of bio-energy transformed into fossil fuels by agonizingly slow geological processes. One way or another, our locomotive of industrial progress is destined to run off the rails, and because we've chugged to such perilous heights of population size and consumption rates, we have a long way to fall—much further than any previous civilization.

Perhaps a few million people globally know enough of history, anthropology, environmental science, and ecological economics to have arrived at general understandings and expectations along these lines. For those who are paying attention, only the specific details of the inevitable processes of societal simplification and economic/population shrinkage remain unknown.

There's a small cottage industry of websites and commenters keeping track of signs of imminent collapse and hypothesizing various possible future collapse trajectories. Efforts to this end may have practical usefulness for those who hope to escape the worst of the mayhem in the process—which is likely to be prolonged and uneven—and perhaps even improve lives by building community resilience. However, many collapsitarians are quite admittedly just indulging a morbid fascination with history's greatest train wreck. In many of my writings I try my best to avoid morbid fascination and focus on

practical usefulness. But every so often it's helpful to step back and take it all in. It's quite a show.