Whole System Efficiency Limits

DRAFT RESEARCH NOTE

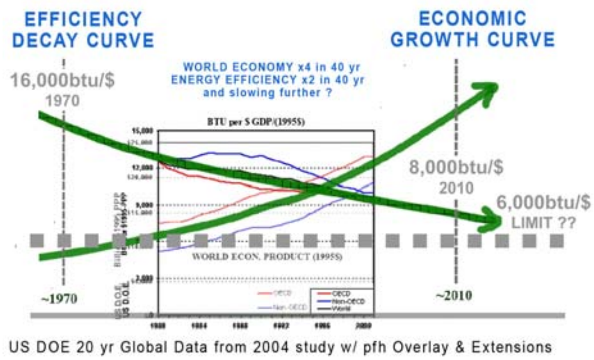

Figure 1 – Global economic energy efficiency & growth

The approach of diminishing returns for any whole system is consistent with natural thermodynamic limits and the expected result of perfecting any process. ***Is that 'good news'? Well sure, getting the picture right is always good news.*** Seeing a useful indicator of approaching limits of efficiency of one sort can direct attention to the particular mechanisms causing it, and toward opportunities of other sorts. It implies changing our approach and offers new alternatives.

For decades there has been a consistent slowing in the improvement in the efficiency of the global economic system in creating wealth per energy unit of fuel use. That directly conflicts with the established plans for economic development and avoiding climate change with accelerating efficiencies. Looking at individual technologies makes it appear there are extensive energy efficiency opportunities. Despite it always being a high priority in economic competition, though, and the economy as a whole has not been finding them, displaying the opposite of the hoped for trend. Figure 1. (1) displays the conflicting trends, continued economic growth with energy efficiency decay. The figures are based on the 2004 US DOE 20 year study of energy and the world economies (2), showing the historic and expected ~3.5%/yr world economic growth rate (4x in 40 years) and the problematic slowing decline in purchased energy use per dollar of GDP (.5x waste reduction = 2x efficiency gain in 40 years) and seeming to approach an asymptote for the global fuels/$ of economic product at around 6,000btu/$ (1995$). The implication is that for natural causes there is a requirement minimum energy cost to creating wealth and natural growing costs for growing wealth. That conflicts with the planning assumptions for the future of growth and climate change.

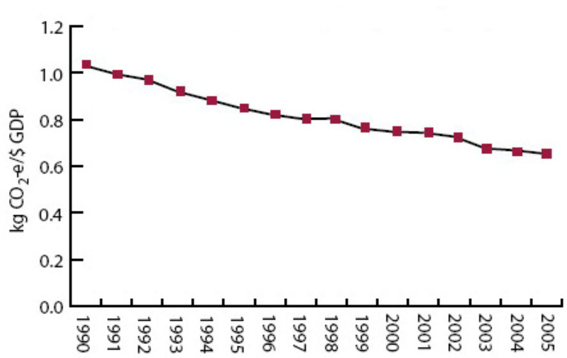

Figure 2 – Australian CO^2 emissions per $ GDP

The same phenomenon can be seen in the Australian Government's record of their national progress in reducing the amount of CO^2 required to produce GDP(3). The curve and its components can be analyzed by various means, but it shows that under steady competitive pressure for energy efficiency improvement there has been steadily slowing progress. The last 10 years of increasing political and social pressure, new R & D and a longer range investment focus have had no apparent effect on the shape of the curve. ***This broad consistent evidence*** of shrinking rather than expanding opportunities for new efficiencies ***does not match the expectation that 'what worked before will work again', but the opposite.***

Quite often people look at complicated questions that seem to conflict with their assumptions and respond as if to a 'dark cloud', even as if comically like a caterpillar curling up in a ball, and just hoping it will 'blow over'. Defensive thinking like that is a marvelous and successful adaptive response for many naturally confusing things. Indeed, historically, the subject of economic limits has been one of these questions. For centuries people have wondered why opportunities seemed to open up further the faster we exhausted them. Turning a b0lind eye in the face of building contradictions and assuming 'something will work out', *worked*. Seeing whole system efficiency limits approach, however, is turning a corner in that, and takes more explaining than a just wishing things away. Efficiency asymptotes are the common natural evidence of the end of expanding opportunity for all kinds of investment systems, and are well recognized and somewhat broadly studied as the principle of entropy for physical systems (4), and as diminishing returns for technology, market development, manufacture, project design, managing large organizations, etc(5), for planning around limits of system responsiveness. The usual explanation is simply that new processes begin because they find returns increasing more easily, and by taking the easy opportunities first, naturally find harder and harder ones later.

The destructive syndrome, struggling to maintain high rates of return even as it becomes naturally more and more difficult, is implicated as a central cause of ending the largest of complex human systems. It's displayed in several of the collapses of advanced civilizations over the last 5000 years. Efficiency limits seem highly enduring, and so predictable. They display steady progression, long term asymptotic trends, that once established are very easy to project with confidence. ***That raises the bar for alternate assumptions, requiring a theory of whole system change that is more convincing than the clear evidence of whole system behavior.***

The difference between our physical experience, of real natural limits to perfecting things, and the behavior of theoretical models we use to plan for the future, is the issue. Our models, with only an environment of their own definitions, may well have no limit of perfection. Using them as a guide makes this other aspect of nature quite confusing. A sophisticated view could be that our process of representing complex things with simple models, when you include the model maker, becomes a natural system itself. The models then adapt to their environment by our successively adjusting them to fit the world's changing shapes. ***Turning modeling into a natural system that way, including the expectation diminishing returns of effort and utility, can relieve the confusion.***

The simple relevant interpretation of the entropy principle and the 2nd law of thermodynamics is that any process results in an irreducible minimum amount of waste. ***The idea here is to use that principle a little backward, instead of using the predictions of the hard science, develop a steering principle using the experience of how the science has been found to be embedded in nature.*** For mathematically described physical processes the ultimate limits of efficiency can be precisely specified. The path of how any process approaches that limit is not defined at all, well , not defined except that 1) it not move along its the path infinitely fast and then 2) however fast it goes it never quite gets there... Starting from considering definable systems, the wide experience in engineering, design and control is that waste reduction never gets to its theoretical perfectibility. The path of approach is generally the same, consistently diminishing returns toward becoming a waste of effort. The principle also appears to apply to any other kind of consistent method, purpose, or direction of effort. That means that the limiting value of investing in it can be determined by gauging the rate of diminishing returns and the profitable end of perfecting it projected.

The normal business experience is that there are approaches to limits of efficiency that are both too close and too far from the limits, with different kinds of 'profitability' values being considered. The simple example may be that familiar tension in product or building design, that one always seeks to perfect things by making them *both* efficient *and* generous. ***Efficiency is measured in terms of minimizing the distance from the limit of perfection. Generosity is more related to maximizing distance from limits, to minimize the whole design's constraint by them.*** In combination a limit of efficiency is found as a 'comfortable distance'. Balancing such 'alternate definitions of progress', by their interaction at the limits of progress, is the normal way people choose to limit going further with investments in perfecting things. Without generosity in setting limits the returns shrink to zero, and with generosity the returns are shifted to some other purpose.

The limits of perfection for mathematically defined systems may be predictable, and until they are discovered for undefined directions of progress unpredictable. The basic physics necessitates ther be finite limits of waste reduction for both. It suggests that observing the same pattern of diminishing returns in nature, absent human designs on perfecting them, might also identify a similar independent process in nature, of the natural systems somehow 'negotiating' their own approach to an optimum of efficiency and generosity too. The test for that would be to see if natural systems with slowing efficiency improvement then divert the resources that were used for that (their investment resource) to something else, and stabilize before exhausting themselves with investing in unproductive causes. ***Said more simply, the question is whether natural systems achieve a comfortable stable climax partly by disinvesting in what have become lost causes.*** It's fairly obvious that this question might be asked of a tremendous array of natural systems, like storms and organisms, as well as businesses and technologies, all of which approach their limits of development with diminishing development toward a limit, becoming both resilient as well as stable.

Progress in anything that displays a pattern of approaching a limit probably indicates that the system producing it is approaching a real limit and exhausting it's natural opportunities for waste reduction, for its present form and direction of change. The end of useful returns on investment in any process is ***highly*** predictable, first that it will occur, and then once begun at what level it will occur. Even with a clear idea for how to begin anew with a different process or whole new direction of progress, the long slow growth period that new things take to develop guarantees a delay in the transition. ***The natural choice for approaching natural limits for any direction of progress would seem to be to find a comfortable distance from the evident limits for it to stabilize.***

DRAFT IN PROGRESS

Some of the Ref's

1) www.synapse9.com/design/DOE-World%20energy%20IntensityTrend.jpg
- overlaying two curves from (2)

2) www.eia.doe.gov/emeu/cabs/carbonemiss/chapter1.html
- 20 yr global energy & economy study published in 2004

3) http://www.greenhouse.gov.au/inventory/2005/pubs/inventory2005.pdf
- Australian energy inventory

4) http://en.wikipedia.org/wiki/Entropy
- entropy

5) http://en.wikipedia.org/wiki/Law_of_diminishing_returns
- economic law of diminishing returns

6) http://www.ecologyandsociety.org/vol7/iss3/art4/main.html
- JA Tainter – the societal collapses related increasing complexity with diminishing returns (& The Collapse of Complex Societies, 1988)

www.pnl.gov/main/publications/external/technical_reports/PNNL-16820.pdf
- DOE funded 40 yr study to 2006 of commercial electricity intensity/sf

www.synapse9.com/design/ClimateLags.pdf
- figure from a DEFRA study showing the long term assumptions of the IPCC models with zero impact from continued growth.

www.nrel.gov/docs/fy07osti/41347.pdf
- the Mar 2007 DOE comprehensive US alternative energy plan showing as on p8 unbounded benefit growth in all sector efficiencies (as well as alternate energy sources).

www.osti.gov/bridge/index.jsp
- DOE sci & tech library

http://www.earthportal.org/forum/?p=416
- an online conversation on the question

http://en.wikipedia.org/wiki/Product_lifecycle
- product life cycles

http://en.wikipedia.org/wiki/Software_development_process
- software life cycles