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The curious case of Stimulus as Constraint

promoting growth to prevent resource depletion

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I. Abstract

A rather obvious error in economic systems thinking seems to have persisted in popular thinking despite being well enough understood for about 150 years by some economic systems scientists. The popular thinking about how economies work then appears to have controlled the terms of the sustainability policy discussion in recent decades. Why the science didn't get communicated also exposes the problem that the natural and social sciences also construct separate explanatory languages, as if popular cultures themselves. That naturally leaves large gaps between what these various explanatory view points on reality can say to each other. In this case what slipped through the gaps was that efficiency improvements which are used to increase productivity came to be thought of as a way to reduce resource use. That confusion let promoting profitable efficiencies become relied on as a world consensus sustainability policy for reducing resource use. The specific reason why people got confused is that the two effects are separate effects, cost reduction and productivity enhancement. The whole effect comes from connecting them. The popular policy idea, now relied on to "save the planet", assumes that efficiencies are not used for productivity. The attempt here is to tell the story as somewhat of a mystery narrative of nature, science and practice. It offers brief discussions of the telling evidence of each part of the problem, the barriers to communicating it and the hints of a new view of nature it points toward as being explorable.

KEYWORDS: efficiency effect, Jevons, whole systems, whole effects, costs, productivity, growth, language gaps, scientific methods, sustainability science

II. Introduction (word count = 5300)

By all counts sustainability science and policy communities should be in turmoil, for having long ignored the strong evidence that it's main sustainability policy was always more often used for having the opposite effect. Efficiency is very productive in stimulating economic growth and all that goes with it. The world consensus sustainability policy to reduce economic impacts using efficiency improvements apparently developed without an awareness of the usual practice and clear evidence that efficiency was used more for multiplying them.

The problem could first appear to be our simply not believing the clear data. Looking closely at why we don't, though, points to a deeper misunderstanding of the physical world and how both our popular and scientific languages are disconnection from each other. No one seems to understand the whole world scientifically, except in rather limited and disconnected ways. Common language represents the complex physical world with the metaphors and explanations we develop through social interaction, representing nature as working according to our own cultural constructs. It's problematic that mankind is interfering with planetary systems at an ever increasing scale, treating nature if it worked by our own "mental maps". We construct and follow so many different ones. We appear to let our social constructs take precedence, and take our eye off "the territory" of observable physical relationships and processes that our explanations are meant to represent. The result is partly that the world consensus policy for delaying resource depletion now seems to be a primary cause of our ever increased resource consumption.

If popular social constructs control the terms of discussion then policy is based on metaphors that take the place of real theories about the effects we observe. The most troubling of these seem to be the kinds of solutions that multiply the problems they were intended to solve, like stimulus used for constraint. If the terms of policy are based on social constructs then valid theories based on other constructs can't be communicated, even simply that a policy is clearly not having the stated effect. The intriguing part of it is that it's never been possible to speak to someone except in their own language. Thus, if our languages seem to be disconnected we need to find what they have in common. What they have in common seems to be the origin of all language in pointing and gesturing. Pointing and gesturing makes the common subject the physical world we experience. In complex languages, though, physical subjects are often replaced by subjects internal to the language itself, and detached from the common reality shared with other languages.

The intent here is to somewhat carefully dissect the one critical policy problem of using efficiency for both economic stimulus and constraint at the same time. The philosophy of science issues are raised more to just suggest that looking at how our socially constructed maps become disconnected from reality can be a fruitful territory itself. For example, just as science finds it hard to offer advice on policies based on socially constructed models of reality, it also brings into question why the sciences usually limit themselves to subjects that are well defined in their own socially constructed terms. What is unavoidable is that much of importance in the natural world can only be 'defined' by pointing and gesturing, and otherwise remains quite indefinable. Social cultures and their decision making processes themselves are quite distinct and identifiable physical phenomena of that kind, for example. It's not just the limitation of mathematics and how it forces models to represent complex systems as zero dimension numbers that seems ill-suited to the task. It's also that science is better designed to study categories of things and we live in a world of individual systems that have their own continually changing organization. It seems to expose an interesting large gap in the scientific method. Being left to steer a planet on matters of great consequence with a disconnected mix of under-defined and over-defined terminologies for understanding it, we get confused.

III. Does efficiency slow resource depletion?

The data shows that continually improving economic efficiency has always accompanied ever faster rates of growing resource consumption. Since the early finding that efficiency accelerated growth and resource consumption 145 years ago (Jevons 1885) various communities have voiced various conflicting opinions on the subject (Tainter, 2008). In reviewing the present literature (Henshaw, 2010) the environmental movement appears to have developed around the contrary view that efficiency efforts would have the same effect as resource conservation. That eventually became the present popular faith in using profitable efficiencies as the world resource conservation strategy, without study. In recent years there have been relatively few journal articles on the subject of whether improving efficiency could reverse the long trend of increasing resource use, or if it would have the opposite effect as originally observed by Jevons. Only about three dozen citations were found on the question. Some were conclusive on both sides of the question, but most concluded that the traceable effects of efficiency are to reduce resource use, but leave open the possibility that untraceable effects might contribute to the observed trend in the opposite direction. So, the great majority of authors seem to give equal credit to theories that predict the opposite of what is observably happening.

What gets lost is what gives people confidence that efficiency will save the earth from rapid resource depletion when it has always been so very clearly ineffective for that purpose. Efficiencies of all kinds have been improving steadily throughout history as resource use and depletion rates have accelerated. Public policy, though, is now clearly being guided by the popular conviction that the opposite will occur, having no scientific consensus that it reliably could, nor any explanation for why it never did. The principle that energy conservation and efficiency should reduce energy use appears to be treated as a matter of "free speech". It's the kind of cultural belief we feel obligated to treat as having the same merit as any other popular cultural belief, a matter of belief rather than a reliable finding. It exposes how dependent people are on their cultural models, and don't believe what they see until they have a socially acceptable explanation for it. The real "paradox" is that we tend to believe an incorrect theory that fits our cultural values when we don't have a good explanation for the easily observed evidence of the opposite. It appears to have even become the world consensus sustainability policy without any expert study to determine the likelihood of it working. The bottom line, though, is that policy makers have a fiduciary responsibility to adopt workable policies, respecting the real interests of others. That is not satisfied by just going along with the popular ideas of how people would like the world to work.

The better explanation for the observed connection between efficiency improvement and resource use was first presented to the Oct, 2009 BioPhysical Economics meeting (Henshaw, 2009). The talk also covered a range of other effects of efficiency in natural systems at different stages of their growth and development. Those other effects include accelerating developmental processes in some circumstances and making them inflexible and intolerant of change in others. In explaining the efficiency effect on economic resource use the factor seemingly neglected by Jevons and others is that the purpose for investing in efficiencies is to expand businesses, using the market response to offering less expensive and better working products. What most other researchers have focused on is how efficiency reduces the costs of business operations in the process, not the increase in sales that was the objective. Efficiency is always a major focus of attention and effort in business as a matter of maintaining competitive advantage, expanding businesses and the economy.

It's that productivity effect of efficiency in increasing sales that seems to overwhelm the cost reduction effect of stream-lining operating processes. The reason the productivity effect seems to be larger than the cost reduction effect is that effect is what businesses choose efficiencies for to bring the most profit. The efficiencies businesses choose to invest in are the ones using a little less of one resource to leverage the use of a lot more of <u>other</u> resources. That's the key to understanding it. Profitable efficiencies let you do more, removing bottlenecks to release a flood of other resource uses. That effect of "expert know-how", driven by profit, becomes the main purpose for the effort businesses give to efficiency improvement, producing more with less. Promoting that, one of the things businesses most regularly use for expanding their resource uses, with the intention of having the opposite effect, is using a stimulus as a constraint.

Some examples of how efficiencies are used to remove bottlenecks to let you do more, generally cutting unit costs for one thing for an advantage in having access to more of other things.

1. *greater fuel efficiency lets you drive further (York, 2006) to maybe make commuting more affordable so people can live further out of town in bigger homes.*
2. *computer designed architecture lets fewer people build larger, more efficient and more complex buildings.*
3. *water saving appliances let developers build larger sub-divisions and drip irrigation creates larger farming communities in the desert (NY Times, 2008).*
4. *Even such things as the business community movement to promote a creative business culture and supportive work environment are driven as being more efficient uses of the knowledge and capabilities of employees for increasing business products and profits. (Casson 1994)*

This use of efficiencies for removing barriers to increasing our use of other things is very consistent with the dominant effect we see in the data. Figure 1 shows 35 years of world data on GDP and energy use, along with the ratio of GDP/energy as economic energy efficiency. The GDP curve is scaled to 1.0 at 1971 and the other curves are scaled in proportion to GDP according to their relative rates of growth. Scaling them in relation to their growth rates presents their relative changes of scale. In this case because GDP and energy use both had constant growth rates, their relative scales were unchanging during the period. Clearly GDP is growing faster than energy use or economic energy efficiency, but the same proportional change in energy or efficiency results in the same proportional change of GDP. As world GDP and its effects have had a steady doubling rate of 22 years, energy use and its effects have had a doubling rate of 37 years and efficiency a doubling rate of 56 years.

The equations in Figure 1 show that with a gain of 1 unit of energy savings from efficiency the economy then uses 1.5 more units of energy. So 1.5 is the net combination of stimulus and constraint effects. That's the stimulus effect reduced by the constraint effect, making the total stimulus effect 2.5. This is the math of the growth rates, interpreting "expertly using less to do more" which pervades the learning and decision making of everyone in the economy to be the cause of growth. The result is that the stimulus effect is the relative rate of growth of GDP to efficiency:

For a *Constraint effect* = 1.0, then the *Relative stimulus* = lnGDP/lnEE = 2.5 1.

Net consumption *Stimulus effect* of efficiency = 1.5 = (2.5 – 1.0) 2.

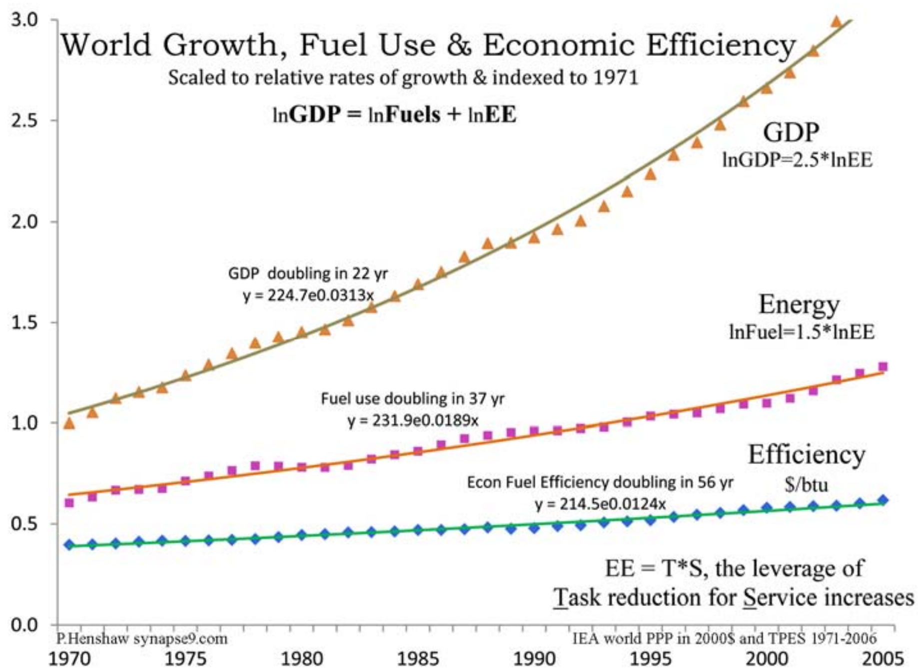

Figure 1 – IEA world data 1971-2006: Economic product (GDP in 2000$) compared to World Fuel use (TPES in Quad btu's) & Economic efficiency ($/btu), scaled by their relative growth rates in proportion to GDP = 1 in 1971.

Understanding complex systems and their causal linkages can be made very complex, and the best recent book on the efficiency effect, by Polimeni et all (2008) has been somewhat criticized for allowing thoroughness to obscure rather than clarifying the issue (Bauer, 2009). Still it's a struggle to make the explanation simple, but possible if you find what it is that nature is making simple by organizing the system to work simply as a whole. My approach is as if to “work backwards”, from finding what the system is doing simply to the questions those simple whole system behaviors would answer, starting with the answer and looking for the question. Sometimes that’s not easy because our questions are so different from nature’s simple behaviors.

What’s really special about complex systems is that they are nature’s way of making things simple. In figure 1 the most important thing to notice is that the curves move together. It indicates that they reflect proportionally constant parts of one system that is working steadily and smoothly as a whole. It’s actually the smoothness of the curves that is most telling. The hypothesis is that the smoothness of the curves is evidence of the system efficiently equalizing stresses with each part responding to each other, like in a fluid. This is supported when looking closely at the small fluctuations discussed below in relation to Figure 2. It’s also supported by the surprising irregularity in these same metrics for the separate parts of the world economy, the national economic accounts. That the whole system integrates the variation of its parts to work smoothly as a whole is what matters. It indicates that the system consistently allocates energy resources to its various parts in response to their improving productivity, having what I call “ESP” (displaying an “equal stress principle”). That displays the whole system, up to 2006 at least, working as a single coordinated process, for becoming more productive in using energy.

Recent studies of national economic accounts show a particular diversity of movements in GDP and efficiency (Hall, 2007; Gupta, 2009). Individual national accounts show widely varying energy use and efficiency trends in relation to their GDP. The smooth regularity of the global data shows that the local variations compensate for each other. The plausible reason is that the world market mechanism is being efficient in allocating its resources to maximize growth. Having a system of complementary parts, like waking smoothly with alternating steps, is one of the things it means to be “part of a system”.

For energy use and GDP at least, it shows that every part of the world economy is responsive to every other part in working as a whole. That suddenly makes the world economy appear to be organized and behaving more like an individual organism than the chaotic tangle of conflicting directions of change one hears about in the news. That evidence of simplicity arising from confusion is the same effect seen when looking inside a living organism to see how it works. All you ever see is a somewhat bewildering complexity and little hint of how it is that nature makes it work with such singlar purpose.

Still, despite most approaches to this subject not having the advantage of asking the question from a view of the economy as a whole, it does seem odd that the main reason businesses struggle to be more efficient would be overlooked on such an important question. That businesses use efficiency to increase sales seems fairly obvious. The effect of that on resource depletion was first well described by Stanley Jevons 145 years ago (Jevons 1865). Even then people were hoping efficiency would extend England's resources, and so it was called "Jevons' Paradox". The idea that efficiency might somehow have a constraint effect without a stimulus effect has haunted the whole discussion ever since. Some recent authors such as Greenhalgh (1990), Hall (2004, 2007), Alcott (2005), Polimeni et all (2008), Madlenera and Alcot (2009) and Henshaw (2009) describe efficiency as a growth stimulus, concurring with Jevons' first observation. In a world where the "pervasive assumption" held by the public, policy makers and other scientists (Tainter, 2008), that the constraint effect can act without a stimulus effect, even these authors have mostly found it necessary to speak of it as an open question.

This sort of consistent pattern of widely popular denial of the main direct purpose and effect of something seems to point a genuine cognitive gap in our thinking. For 145 years our economic planners as well as our environmental protectors have both overlooked a rather obvious reason for the clear evidence. Now we find ourselves relying on a strategy to "save the planet" from critical resource depletion, buy using a method that appears to have always had the opposite effect. It's surely troubling. It's also possibly a very interesting discovery, potentially indicating that other new understandings of the problem might follow.

IV. What it seems sincere people are missing

The normal business use of efficiency is as a key to expanding production, sales and profits, called "productivity". If you look at the units and what is measured, "efficiency" and "productivity" measure the exact same thing, material returns on investment. They may measure it in different places too, but the main difference is that one measures the upstream (use less) effect and the other the downstream (get more) effect. The apparent difference in the meaning of the two words, and reason for having two words for much the same thing, is that efficiency is used when thinking about reducing costs and productivity when thinking about increasing returns. The blind spot appears to be not adding up the total in both directions. One response might be to use a general methodology for whole system impact accounting such as demonstrated for measuring the whole system EROI for energy technologies like wind energy (King, 2010).

The other big thing sincere people missed for having faith in a faulty solution was that we didn't have a solution other than that. Believing in a solution that wouldn't work kept us from looking for a real solution, and asking how to change a whole economic system that has been continually multiplying its environmental impacts if efficiency clearly was not it.

Efficiency per se, is not the culprit of course, but what we do with it. Presently we select efficiencies for giving us the greatest increase in positive downstream benefits. If Jevons had called it the "productivity effect of efficiency" it might never have seemed like a paradox. The sustainable science community, though, has still largely focused on the cost effects and ignoring the productivity effects, being strongly supported in that by both the popular environmental community and the business community. It's a cognitive error in systems thinking. Productivity is the effectiveness of using one resource in commanding the use of others, for ever increasing "remote control" of nature as a policy. As it has throughout history it expands our access to existing resource stocks, even as it also accelerates their depletion. It does make resources more available for use, but does the opposite of making more resources.

V. The fine detail

Another indication of active coordination between efficiency improvement and growth is the regular alternation between periods of faster energy use increase and faster energy efficiency improvement, like alternating steps in one process, as seen in Figure 2.

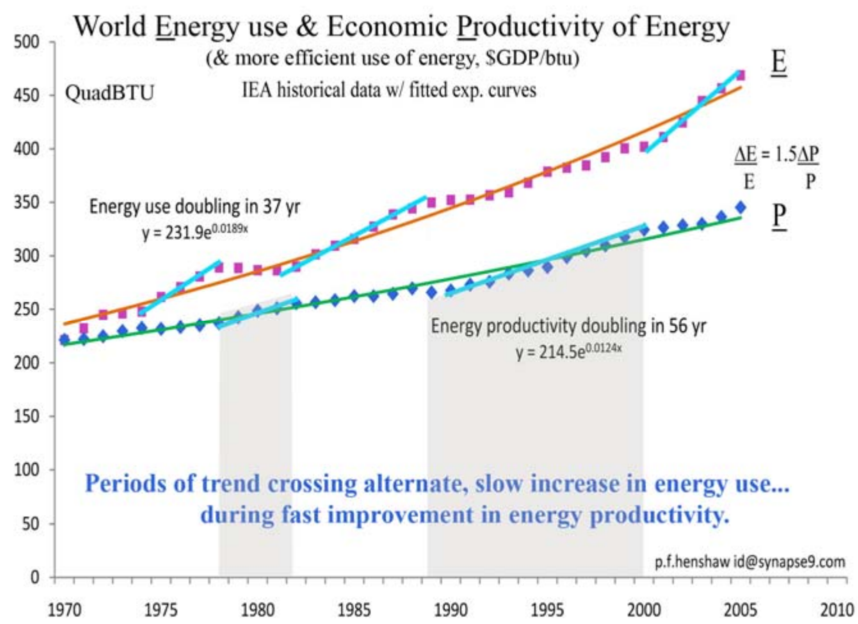

Figure 2 - Alternating periods of faster world energy use and efficiency gains. [Same data as Fig. 1, presented with Energy Efficiency/Productivity indexed to 1971 value of Energy Use]

In Figure 2 you see the small scale waves in energy use are out of phase with the small scale waves in efficiency improvement. The periods of fastest efficiency improvement and fastest increasing energy use alternate. Even without knowing why, the alternation further indicates that the two are part of the same process.

One plausible reason for it has to do with what causes normal recessions. The evidence is that increasing energy use pauses when efficiency improvements accelerate, and the reverse. That would be quite logical if pauses in growth were times when inefficient parts of the economy were lost and more efficient ones created. In that "creative destruction" process economies might logically be pausing to reorganize and retool for faster growth after running into local limits to growth. So each recession might be seen as reorganizing the economy to be efficient for its new environment, to then allow the next little growth spurt. Whatever the real reason, it shows another level of consistent close coordination between increases in GDP, efficiency and energy use. Seeing it as working by a stepwise learning and reorganizing process could either be taken to suggest there are no growth limits, or that learning is constantly running into limits.

VI. Other cases and using stimulus for constraint

It seems our ancient “hunter-gatherer” thinking does not distinguish between increasing our access to things and increasing the availability of things to access. That mental error turns up in lots of places, like the belief that continual reorganization and substitution of resources will make the earth infinite and allow limitless growth. That error can be avoided by representing resources as “stocks and flows” in a mathematical model of conserved properties. Then addition one place is recognized as subtraction in another. For learning processes that’s not so practical, though. If you can identify whole systems, though, you can still set up the basic conservation equation even without a model. The two sides of the equation are “resource producing” and “resource consuming”, and they need to balance and be constrained by the conservation of energy and momentum. Local indicators of returns on investment for each side tell you when their task is getting easier and harder implying local natural limits of efficiency due to entropy.

One of our resource consuming “growth centers” is healthcare, where because we are mortal, curing incurable diseases tends to give us even more expensive incurable diseases. It’s not that healthcare is ‘wrong’, but that our economic model for it is not a solution for our desire to live as well and as long as we can. Our economic approach to it rewards the expansion of solutions that increase the problem to be solved. That would inevitably have gotten to a point of making the resource conservation equation for healthcare ever more out of balance. Making healthcare profitable stimulates more need for healthcare in the name of reducing it, stimulus as constraint.

Our approach to global warming works this way too, following a similar economic model. The plan is to respond to the irreversible environmental impacts of the past, but uses a method of doing so that assures larger irreversible impacts to respond to in the future. We plan to use profitable science and investment to grow the economy fast enough to make all our energy systems to costly zero-carbon technology profitable. Certainly, by all appearances, global warming is an exceptionally dangerous irreversible process if allowed to continue. Due to the rapid societal and technological changes required to respond to it at scale, it also seems quite legitimately to call for a “wartime speed of response” as many scientists describe (Brown 2008, IPCC 2007).

The puzzle is that these and nearly all other far reaching proposals for doing it call for stimulating economic growth with profitable efficiencies as a method of reducing our impacts and make the hard limits on target pollutants affordable. It proposes to continue doubling the scale of the economy so we can correct the errors of technology development made fifty and a hundred years ago, to continually double the scale of productive technologies until there was a problem. However risky the engineering and economics of mitigating global warming is, the bigger problem would come from its success. Even if it its seemingly improbable technology solutions were to work perfectly for the impacts of the past, it assures that the spectrum of other impacts of multiplying the scale of our energy and other resource uses would continue. That's not solving the problem but creating more unmanageable ones.

If you believe the conservation of energy is a valid explanatory principle, the future impacts of growing energy use would be "at scale" and more costly. So responding to growth impacts would continue to multiply growth impacts. One of those next more costly and unmanageable impacts now emerging is to have ever increasing competition over shrinking rather than expanding resources, an unappealing world of increasingly intense conflict rather than plenty.

VII. Discussion

The most scientifically interesting aspect of how we have been confidently misinterpreting how the world works is that apparently the world does work. It just works on its own, though, and in a way significantly unlike the many different ways we have been explaining it to ourselves. We can also begin to see that nature appears to have individual whole systems that have explorable organization independent of our explanations. That nature seems to have a way of working we don't understand seems obvious but so is the puzzle that the sciences have only been able to define nature in terms of their own theories, and those separate theories often don't have a way to connect with each other or our cultural terms of discussion. Sometimes you just need to go back to basics.

The original question of science "I wonder how that works?" was quite undefined. It sometimes worked, though. So, maybe everyone's idea that nature works according to their own different explanations hides how they could still all be valid as different perspectives on the same subject, but unable to connect. The old Buddhist fable about that concerns a proverbial "elephant" and six blind men called upon to describe it to the king and are unable to mentally connect the different body parts they touch. They might each be mostly valid except for interpreting each other. When that situation arises the next task would be to look for what connects each part of the whole.

Though there is surely more to consider on the question, it's a curiously strategic oversight to use consumption stimulus for resource use constraint. It does say something interesting about how the various sciences and policy discussions involved have been disconnected from each other and the physical world. For example physicists don't have any problem with addition and subtraction or with the conservation of energy, but would need to define abstract variables in an equation to comment on public policies. It's the same for ecology and economics which also use the basic structure of physics as a way of explaining the processes of nature with equations. In nature, how energy is conserved may involve undefined physical processes rather than equations, but energy is still neither created or destroyed by them. In not having a way to apply energy conservation rules to undefined processes we appear to have been treating the lack of a formula as repealing the laws of nature, though. In the equations of economics "energy" is an "externality" to the money process. Consequently energy processes and their consequences are represented as not being conserved, nor even represented in the equations. To some it might seem physicists are being overly polite in refraining from comment. From a physicist's view, though, they simply have no basis. All the conservation of energy means in practical terms is that to have an energy conservation policy the earth's energy budget needs to add up. Neither the economists nor physicists approach it that way. The ecologists who try mostly don't connect energy budgets to money using the natural organization of the physical systems of commerce that do it (King, 2010). That leaves the job up to someone else.

Using a global energy budget is how I discovered this interesting series of departures from reality. The budget used was elementally simple. It was based on the necessity that the total energy should equal the sum of average values for all the parts. I used the average energy use per dollar of GDP, now ~6000btu/$ worldwide, to estimate the energy use and CO_2 production figures. I compared estimates of energy use with those others were making for various sorts of high impact products or projects. The estimates of others varied from 50% to 90% below average. (Henshaw 2007). One of the first rules of statistics is that not everyone's performance can be well above average. Then I looked at world energy use, and the efficiency and growth trends for how the averages would need to change to alter the trend of increasing impacts. That immediately showed how improbable that would be (Figure 3).

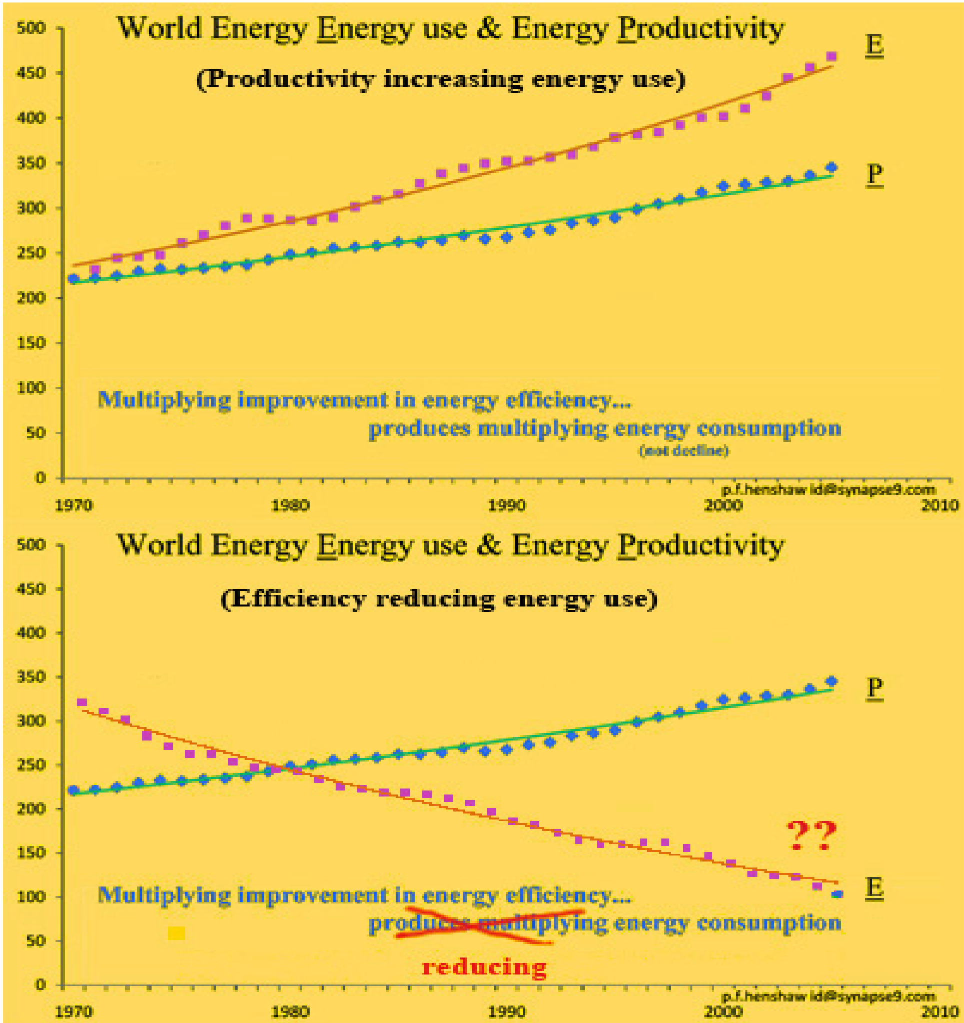

Figure 3 Instead of energy use increasing, could we have productivity make energy use decline? [On top is same data as Fig. 2, and below energy use is turned around to show ever declining need for resources to produce growing wealth, as the "absolute decoupling" idea assumes]

As far as I know this world energy budget approach has not yet been part of the reasoning behind resource conservation policies, and no one adds up the total. From my somewhat broad experience since the early 70's the main objective is only "let's do our best", assuming that efficiency would be the best way to do it. There are even quite sophisticated models of world energy technology choices integrated with economic models (Argonne 2008) but these seem mainly used to help industrialists see which investments are going to be the most profitable. That facilitates the efficiency of allocating resources, but it doesn't save energy or create resources. It creates ways to meet the projected energy demand, not to see how we could limit the explosion of impacts of increasing energy use.

It's becoming necessary to better understand complex systems that we won't ever have formulas for. That suggests going back to basics in understanding what changes in the scientific method would help. The basic question of science is not: "What are the logical implications of the rules we hope nature is following?" or even "What rules can I find in my data?" After "I wonder how that works?" comes "What can I say with confidence when I realize I don't know much?" That seems to be what Newton and Copernicus asked. One thing you can discover about natural systems and know with confidence is that some can be identified as working as a whole, which makes them somewhat explorable and to have boundaries and outside connections for which energy budgets need to add up.

For sustaining a complex society on earth most of the world is genuinely relying on having resource uses of all kinds continually accelerate as a way of conserving the resources needed. That does indicate major rethinking is in order. That can't happen overnight. It would take a developmental process starting with small steps. The tool we seem to need for connecting the terms of our different languages seems to lie in the gaps between them. What would connect them, as well as help expose our real choices with the world, is recognizing the signs of natural organization in the systems within or on which we are operating, and make that the common subject of discussion. Then everyone's different way of explaining them would in some way be naturally connected.

Being curious about small things that others leave unexplained and so obviously expect you to brush off without thinking too, is another part of this group of problems was discovered. For many years, myself included, we have been betting our whole future on the physical world working according to a long discredited but popular theory of change. Realizing that efficiency improvements have two effects, letting you do less of one thing so you can do more of another, says you are working within a system having both upstream and downstream connections. As in crossing a street you should look in both ways. It's upsetting to recognize that we haven't, but also hopeful in exposing the possibility of finding more useful ways to understand our place and choices. You don't know what you'll find, of course, but we'd only find them if we look too. It would be worth the trouble if it turns out that these gaps in our understand hold discoveries leading to worlds of opportunity we've been missing.

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