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Some inconvenient theses

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HIGHLIGHTS

- The assumption that energy problems can be solved sustainably is challenged.
- Selected areas of difficulty are briefly discussed, including limits to renewable energy.
- It is asked whether abundant energy would be desirable.
- A low energy "Simpler Way" is sketched.

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ABSTRACT

There is a strong tendency for energy technologists and policy analysts to believe that energy demand can be met and associated problems including climate change can be solved, and to focus attention on finding the best technologies to achieve these goals. They tend not to be comfortable with any suggestion that there might be insurmountable limits and insoluble problems, or that the problems they are working on require social solutions rather than technical solutions. Various contributions to this Special Edition provide illustrations. This paper explores some challenges to the dominant Promethian world view. These include a consideration of the magnitude of the energy and other problems, the possibility that renewable energy cannot solve them, the significance of energy and of declining EROI for economic growth, and the possible effects of rising resource input costs and unstable capital markets for energy investment. Finally the ultimate heresy is considered, the possibility that access to abundant energy would not be good for us. In summary, it is suggested that coercive limits to growth are being encountered and that the resulting problems cannot be solved by action on the supply side but will require a radical rethinking of social goals, systems and values.

1. Introduction

Before the Enlightenment era there was little or no concept of progress. Over the short historical period since then Western culture has come to be built on the taken for granted conviction that technical and social progress is not only possible and normal, but potentially limitless. Economists have probably done most to reinforce the faith through making economic growth the supreme and unquestionable goal of national and global economic policy, but scientists and engineers are also major reinforcers due to their astounding achievements. It is therefore no surprise that there seems to be almost universal belief that the serious resource, ecological, development, peace, etc. problems confronting us can and will be solved by technical advance.

It can be argued that the most important technical problem is energy in general, and within this domain oil and gas in particular. It is important to keep in mind that at present only around one-fifth of the world's people live in high energy consuming societies, and that by 2050 six times as many will be wanting to do so. Thus a great deal depends on continued access to ever increasing quantities of energy. The overwhelmingly dominant assumption among energy technologists and analysts is that these challenges can be met. This paper seeks to point to reasons for thinking that they cannot be met.

In my experience energy researchers and scientists are especially focused on the positive, on delivering, getting around the blockages, improving efficiency, finding better ways, and on potential, i.e., on how remarkable the breakthroughs deriving from their particular project might be. This is evident in the fact that there is almost no critical literature on the potential limits of renewable energy technologies.

The following pages offer thoughts on some of the issues which provide grounds for thinking that the major global problems we are now encountering cannot be solved within or by a society committed to the concept of progress we take for granted, that is one which assumes high material "living standards" and continual

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and limitless growth in “living standards” and GDP. The reasons for regarding such a society as non-viable range well beyond the field of energy to include for instance a financial system based on interest and debt, and the inevitably destructive effects of market systems on equity, social cohesion and values (for the wider discussions see Trainer, 2010), but the following comments will be confined to difficulties arising within the energy field.

2. The problem, the overshoot, is now too big

For more than 50 years what many regard as a now overwhelmingly convincing “limits to growth” literature has been accumulating. Its core thesis is that rich world per capita levels of resource consumption and ecological impact are far beyond levels that are sustainable or that could be made sustainable. Scarcities are already clearly or probably evident regarding food in general, fish, water, many industrial minerals and petroleum, and there are estimates that peak coal will occur within a few decades. Above all looms the prospect of climate change, setting “safe” emissions reductions targets that it will be argued below cannot be met.

The “footprint” index illustrates the magnitude of the overshoot. To provide the average Australian with food, settlement area, water and energy now requires about 8 ha of productive land. (World Wildlife Fund, 2009.) If by 2050 9 billion people were to have risen to the present Australian “living standard”, and the planet's amount of productive land remains the same as it is today (which will surely be an invalid assumption), the amount available per capita will be around 8 ha. In other words Australian's today are using 10 times the amount that will be possible for all. And yet Australia is committed to at least a 3% p.a. increase in “living standards”, economic output and GDP.

If a world population of 9 billion people were to rise to the GDP per capita Australians would have in 2050 given 3% p.a. growth in our present “living standards”, then total world economic output would be around 20 times its present volume.

In the face of such simple numerical arguments it is difficult to see how there could be any disagreement with the claim that rich countries today, and the world as a whole, are far beyond sustainable levels of resource consumption and ecological impact. The crucial point here is the magnitude of the overshoot.

It would seem that the challenges thereby set for the “tech-fix” optimist are clearly insurmountable. It is highly implausible that technical advance combined with conservation effort can supply the required resource quantities sustainably or bring those multiples down sufficiently…unless the commitment to affluent “living standards” and economic growth are jettisoned. The purpose of The Simpler Way project is to show that an alternative is available, that it would greatly improve the general quality of life, and that it could be easily achieved…if it was chosen (see further below).

3. The constraints on technical fixes

The rejection of the “limits to growth” case usually takes the form of a “tech-fix” claim. It is assumed that the problems can be overcome through the development of better technology, thus heading off any need for abandoning the quest for affluence and growth. What is not well understood is the gulf that can exist between the theoretical potential of an initiative or discovery and what it might achieve in the real world. The steps that often lead to a dramatic difference include:

- “Theoretical potential” refers to what could be produced or done without regard to any other considerations such as cost, other uses, social or environmental constraints, etc.
- “Technical potential”; e.g., what biomass energy yield might be achieved allowing for the fact that there are other demands on the theoretical potential, such as the land needed to grow food.
- “Economic potential”; i.e., what could be done within technical potential at an affordable cost.
- The net achievement. Costs must be subtracted from gains. It is possible to save a lot of the heating energy loss from buildings, but this requires energy in the form of insulation and electricity for air-conditioning and heat pumps.
- “Ecological potential”. Then there will be reductions in what might be achieved due to the need to avoid environmental impacts.
- The socially acceptable achievement. it would be possible to reduce urban transport energy markedly by greater use of public transport, but many people will prefer to continue car use.
- The Jevons or rebound effect. Often savings of energy made possible by a technical advance reduce its cost and this prompts increased consumption.

The large difference that can be made when all factors are taken into account is well illustrated by the estimates for global biomass potential. Smeets and Faiij (2007) state that the theoretical potential is around 1500 EJ, but Field et al. (2007) conclude that when all other relevant considerations are taken into account the practically achievable yield would be only 28 EJ.

Thus many technical advances which are theoretically possible are not achievable in the real world.

4. Renewable energy cannot save us

The widespread acceptance of the “Peak Oil” thesis in recent years, which can be taken as a general position on the future availability of oil and gas, has bolstered one of the most powerful technical fix assumptions; viz. that renewable energy sources can replace fossil fuels, thereby eliminating the problem of climate change, and enabling abundant energy. Many impressive reports have claimed to show that this is possible, and easily afforded. Hardly any academic literature has questioned the faith. It is not surprising that all Green agencies and political movements appear to accept it enthusiastically.

Over several years this author has published a series of attempts to analyse the potential and limits of renewable energy. Earlier attempts were hampered by challengeable assumptions and inadequate data but their adequacy has improved. The current version of the approach (Trainer, 2012a) is considerably more persuasive than the initial efforts. It is not likely to be advanced until experience with increasing renewable penetration into supply systems accumulates and until better data on output and costs becomes available, especially for solar thermal power.

The focal concern in these analyses has been the implications of the intermittency of sun and wind for quantities of redundant plant required, and the resulting total system capital cost. It is not uncommon for Europe to experience little or no solar or wind energy for 1 to 2 weeks in winter, during which time demand peaks. Oswald, Raine and Ashraf-Ball, (2008) document such an event in February 2006 and several others do so for other regions. During these periods the contributions that the wind or solar sectors normally make must be made by others. If for instance the back-up system is biomass–gas–electricity generation then the amount of this plant required at times might have to be sufficient to meet all demand except for hydroelectric system, while a large amount of wind and solar plant sits idle. The crucial question is whether the amounts of redundant plant required to cope with the winter supply task can be afforded. Here is an indication of the negative case detailed in Trainer (2012a).

The assumptions made, for working purposes are as follows. World energy demand doubling by 2050, 33% reduction in overall energy demand due to conservation and efficiency advances,15% energy loss where very long distance transmission (plus local distribution) applies, embodied energy costs for wind, PV and solar thermal of 5%, 15% and 10%, plant lifetimes of 20 years for wind and 35 years for PV and solar thermal, 60% of transport electrified, a 67% reduction in energy consumption for electric vehicles, 50% efficiency of conversion from electricity to hydrogen gas and its distribution and storage, Central Australian location for PV and solar thermal, PV efficiency 15%, winter wind capacity 38%, 16% efficiency for central receiver solar thermal plant with 6 h storage, 42% efficiency of ethanol production from biomass, the equivalent of a 700 million ha global biomass harvest plus another one-third from wastes, adding to 50 EJ p.a. of ethanol, and long term future capital costs per kW(p) of fully installed wind, PV and solar thermal plant of $1500, $2700 and $4390.

Four strategies are explored. The first is aimed at meeting the non-electrical energy demand and overcoming the intermittency and storage problem by use of hydrogen. The system capital cost comes to approximately 10% of the 2011 global GDP and is more than 14 times the early 2000s ratio of rich country energy investment to GDP (i.e., for building and maintaining plant, as distinct from purchase of energy) (Pfuger, 2004; Birol, 2003).

This figure would be far below the actual cost because several important system components could not be included mainly due to lack of data, including the cost of the long distance transmission lines from desert locations of PV and solar thermal, the probable 40% increase in cost for construction in remote areas (Lovegrove et al., 2012), the biomass and hydro components, and the cost of the hydrogen production, distribution storage and regeneration component, including storage to meet energy demand through several continual days.

Strategy 2 assumes dropping the hydrogen provision and supplying 68% of demand in the form of electricity. This reduces the capital cost sum by 23%. However this strategy is not viable as it does not provide for getting through big gap events.

Strategy 3 briefly explores use of biomass for back up purposes. This involves a severe limit set by the relatively low probable global biomass yield combined with the low efficiency of electricity generation from biomass, and another very large redundancy problem.

Strategy 4 explores the possible use of the heat storage capacity of solar thermal systems to overcome intermittency problems. Again the limits quickly become evident. Plant being built at present include c. 6 h storage but to supply through a 4 day period of little or no solar radiation would require 16 times as much. If solar thermal was normally contributing one-third of supply but at times was called upon to contribute 100% of it for 4 days the storage capacity multiple would have to be in the region of 50. The event Oswald, Raine and Ashraf-Ball documents lasted around 14 days, not 4.

The case therefore seems to be a strong one. It is not an argument against transitioning to renewable energy, which is a crucial step in The Simpler Way vision discussed below. It is an argument against the possibility of running energy-intensive consumer societies on renewables.

5. The special case of biomass potential; probably far less than has been assumed

Biomass is an especially important energy resource because it is the only major direct renewable source of liquid fuel. Short term future concerns about energy availability centre on oil and gas and the most promising replacements for these are ethanol and methanol produced from biomass. In addition biomass is the chief candidate as a back-up for overcoming the intermittency in solar and wind energy availability. The ideal contributor for this purpose is hydroelectricity but its relatively limited global potential, around 16% of electricity demand, and the limited scope for pumped hydro storage (even for the rainy UK, see Mackay, 2008) will leave a significant role for biomass electricity. However the efficiency of biomass generation both from direct combustion and via gasification is relatively low, possibly around 23% or less at present but possibly rising to 29% in future. (AETA, 2012.) This does not take into account the considerable energy cost of producing, drying and delivering the biomass, nor that of returning ash to plantations.

The second reason why biomass is very important is because at present only about 20+% of rich world energy use is electrical and all renewable sources other than biomass produce only electricity. This leaves the problem of where the other 80% is to come from, and biomass is the most likely option. In an era when the prospects for oil and gas appear to be increasingly problematic, the major problem set for renewable supply is the provision of transport fuel. If it is assumed that 60% of transport can be converted to electric drive that would still leave over 50% of all final energy demand required in non-electrical form, which means oil and gas, in the short run given renewable hydrogen's inefficiency and cost as a transport fuel. On the global scale it is not plausible that biomass can meet this demand. At present global final non-electrical demand is in the region of 375 EJ/y and the above estimate of potential ethanol derived from biomass is around 50 EJ/y.

The IPCC (2011, c. p. 13) reports estimates of “technical potential” for plantations on arable and degraded land, plus crop, forest and urban wastes/residues averaging around a total of 400+ EJ/y (of primary energy). However there are several reasons why the amount likely to be available will be well below this figure.

- As was explained above there will be a significant difference between technical potential and a realistic figure which takes into account all the social, economic, political and ecological limiting factors.
- The IPCC figures explicitly assume (p.13) no increase in the proportion of forest, grass and crop land taken for the production of food, fibre, etc. This is virtually certain to be invalid given the current and increasing food crisis. It is commonly assumed that food output will have to double. The IPCC stresses that its estimates assume very favourable future conditions for food production, and considerable agricultural technical advance. Smeets and Faaij (2007) conclude that under plausible unfavourable future conditions there would be no global plantation biomass energy potential.
- Similarly pressure on land for biological materials will increase. Normal 3% p.a. economic growth will result in a global economy in which there is three or four times as much producing and consuming taking place in 2050 as there is now, with corresponding increases in resource demands. Rising energy costs will tend to move structural materials from steel, aluminium and cement to timber. Thus the demands on land for other than biomass energy will probably greatly intensify.
- The IPCC report notes that water is a problem for very large scale biomass production, especially in view of the climate problem. Water will be removed from ecosystems in the biomass harvested, and more importantly will be transpired through plantation growth. The IPCC refers to studies finding that plantations reduce stream flow 50% (2011, Chapter 2, p. 24).
- Large quantities of carbon would be removed from soils and ecosystems. Patzek (2007) argues that over the long term carbon should not be removed as it inevitably causes soil

deterioration (see also Pimentel and Pimentel (1997)). In the coming era of probably severely limited availability of petroleum and fertilizers it is likely that agriculture will have to focus more intensively on the organic factors contributing to yields, as distinct from external and artificial inputs, meaning that maximum retention of soil carbon and therefore maximum recycling of crop "wastes" is likely to become crucial.

- The biodiversity effects are probably the most disturbing. The rapid species extinction humans are now causing is primarily due to the fact that they are taking so much natural habitat. Even in the late Twentieth century humans were taking 40% of the land NPP (Vitousek et al. 1986). This points to the urgent need to return vast areas to natural habitat, rather than contemplate taking more from nature. In addition biomass plantations focus on a few high yield species, meaning that large areas would not have natural levels of biodiversity.
- In the coming era of probably severely limited resources much less urban waste is likely to be generated. It is also likely that the half of urban waste that is biodegradable will be recycled to soils for food production. Thus current estimates of waste inputs to biomass energy production are likely to be too high.
- Biomass energy conclusions depend greatly on the assumed biomass growth yield. It would seem that the common biomass energy yield per ha assumption of c. 13 t/ha/y, (evident in the IPCC discussion) is unrealistic as an average for very large scale production. It is easily achieved in good conditions, such as willows on cropland, or forests on good soils with adequate irrigation and fertilizer applications, but very large scale biomass energy will have to use large areas of marginal and/or damaged land. World average forest growth is only 2–3 t/ha/y. A more realistic biomass-energy yield figure might be 7 t/ha/y. Even if 13 t/ha/y is assumed, i.e., 234 GJ/ha/y, a 250 EJ/y harvest (the average estimate the IPCC reports for technical potential from arable land) would require more than 1 billion ha, which is far more than is likely to be accessible.
- According to the IPCC (2011) 80% of the present 50 EJ/y harvest of biomass energy is "traditional use" by tribal and peasant people. This is labelled "inefficient" use and the report anticipates shifting this land to the much more "productive" use characteristic of modern biomass energy systems. In view of the low yield/efficiency, that area is likely to correspond to 750 million ha. However this land provides crucial services sustaining the lives and livelihoods of the poorest people on earth, the building and craft materials, food, medicines, hunting, animal fodder, water and products to sell. The greatest onslaught of the global economy on the poorest billion is the taking of the land on which they depend. To move this land into modern "efficient" production would inevitably be to transfer the resource from the poor to the rich. The operation would be governed by "market forces", meaning that the rich would get the resource because they can pay more for it. This is already happening with respect to biofuel production, especially oil palm plantations. The expropriation of native lands in colonial times was rationalised in terms of moving it to more "efficient" use.

For these reasons it is probable that only a relatively small amount of land should be put into global biomass energy production and it would seem that a plausible yield would be a small fraction of the average of the estimates the IPCC reviews.

6. Nuclear energy… in the context of the multiples and limits?

If 9 billion people were to have the present Australian per capita electricity consumption via nuclear energy then around 12,000 reactors of 1000 MW capacity would be needed, (taking into account the additional capacity needed to meet peak demand.) In view of estimated Uranium resources these would probably have to be fast breeder reactors reprocessing plutonium. In addition four times as much energy would have to be provided to meet non-electrical demand, and if this was to be produced via electricity the conversion etc. losses would mean that in the region of 80,000 reactors would be needed. There are a number of reasons why a nuclear solution on anything like this scale would seem to be highly implausible and inadvisable, notably to do with the scarcity of the minerals reactor construction requires (Abbott, 2012) the issue of wastes, and questions to do with reprocessing and proliferation.

Why analyse in terms of 9 billion living like Australians? Because this is the universal explicit or implicit taken for granted global goal of "development". Whether we like it or not we need to deal with the implications of the overwhelmingly dominant continued and unquestioned pursuit of that goal. From the perspective of the limits to growth analysis the goal is clearly impossible and a recipe for accelerating and probably catastrophic breakdown.

7. The greenhouse problem can not be solved… in or by consumer society

The 2007 IPCC report found that if atmospheric CO_2 is to be kept to a "safe" level emissions must be reduced by 50–80% by the year 2050. The easier of these targets would require about a 95% reduction in the Australian per capita emission rate. It is difficult to imagine that such a target cold be achieved. In recent years global emissions have accelerated, and the political climate has hardly moved in the direction that would enable the appropriate and painful action to be taken. This means that if and when reduction began the rate of decline would have to be very steep.

However it is increasingly being argued that all emissions must be totally eliminated by 2050. (Meinshausen et al., 2009; Hansen et al., 2008.) It now seems advisable to think in terms of a fixed total "budget" of emissions that must not be exceeded and the figures from Meinshausen et al. indicate that the budget would be exhausted by 2050 if emissions tapered from their present level to zero by then. Again it is quite implausible that such a target could be met.

Apart from adopting renewable energy, the strategy most commonly advanced for solving the greenhouse problem is carbon capture and sequestration. However this is applicable only to stationary energy sources such as power generation, meaning that most present emissions could not be dealt with, and it cannot extract all carbon from flue gases. CCS might be significant if the task was only to achieve marked reduction in emissions, but it seems that the task has to be their complete elimination. In addition Smil (2010) points to the extreme magnitude of the task, effectively having to construct plant capable of processing, transporting and burying more than three times the weight of all the coal, gas and oil produced each year.

8. Energy and the economy; Are we near the minimum ER for viability?

Conventional economists have overlooked the significance of energy for economic growth, focusing only on labour and capital and attributing the rest of the growth to technical advance. A number of recent analyses (e.g., Sorrell, 2010; Warr et al., 2009; Ayres and Warr, 2005; Murphy and Hall, 2010, p. 112) conclude that energy is more important than capital and labour and that productivity growth can mostly be attributed to the application of more energy. Ayres argues that rising energy cost is the cause of the downturn in productivity growth and he believes that energy trends could result in a cessation of growth in the near future. Murphy and Hall (2011, p. 52) report that since 1970 "… spikes in the price of oil have been a root cause of most recessions." They suspect that a general energy return on energy investment of at least 5 is the minimal viable level of complex and energy-intensive societies. The ER for ethanol from corn is around 1.4 (Shapouri etal., 2002) and for methanol from wood it is likely to be around 5 (Mardon, 2011.)

A simple ER number does not make clear some of the concerns in this area. For instance it might seem that because the energy return on investing a unit of energy in the production of ethanol from corn is around 1.4, doing this makes sense, because there is a 40% profit. What the figure does not draw attention to is the "opportunity cost" of the resource costs other than energy that are also being paid, notably the application of land, skills, chemicals, time, trucks etc. that then cannot be devoted to producing other desirable items.

Embodied energy costs constitute a potential time bomb, especially for renewable energy technologies. There is reason to suspect that these are much higher than has been thought, mainly because relatively few studies have been carried out (Murphy and Hall, 2010, p.109), and fewer still seem to have taken into account all "upstream" factors (Lenzen, 2012; Crawford, 2012). For instance the energy cost of producing PV panels should include the appropriate fraction of the energy it took to produce the plant that made the aluminium for the frames. The energy cost of producing PV panels is commonly assumed to be about 10% of their lifetime energy production. However a number of studies attempting more inclusive assessments conclude that it is in the region of 33%. (Lenzen, 1999, 2009; Lenzen et al., 2006; Crawford, 2011; Crawford et al., 2006; Lenzen and Munksgaard, 2001; Lenzen and Treloar, 2003; Hall and Pietro, 2011.)

A major concern is to do with future multiplicative interactions between many costs and availability factors affecting energy technologies. There would be little doubt that there will be steep rises in energy prices in future and these will have impacts throughout the whole economy. Clugston (2012) documents remarkable minerals and energy price rises in the few years before and during the GFC. Rising energy prices can dramatically reduce mineral reserves, i.e., the quantities estimated to be retrievable at an acceptable price. Thus the cost of all products involving the use of energy and metals etc. as inputs or infrastructures will rise, raising the capital cost of machinery and plant, and affecting the availability of capital for investment.

This is especially significant for the discussion of renewable energy. It means that all current estimates of future capital costs, including those used in Trainer (2012a) above, are likely to be serious underestimates. These typically take present production costs and apply assumptions re the effects of technical advance and mass production. Understandably none seem to attempt to take into account the effect of higher resource input costs, especially for energy. This might be impossible to do satisfactorily at present, given the uncertainty of possible magnitudes and the complex interactions and feedbacks.

Interacting with these energy, resource and plant cost issues are those determining capital availability and investment incentives. Rising capital costs for renewables will deter investment. In addition as Ayres and others argue, significant energy price rises will depress overall economic activity, detracting from the readiness to invest capital anywhere, including in costly renewable energy provision.

9. The problem cannot be solved…in or by consumer society

These inconvenient theses present some elements within a strong case against the possibility of finding technical solutions, not just to problems within the oil and gas domain, but to the general problem of the global sustainability predicament. (The core thesis in Trainer (2010) is that the problems cannot be fixed… within or by consumer society.) Sociological arguments could be added, for instance to do with the rising levels of dissatisfaction, depression, inequality and social breakdown generated by the prioritising of affluence and growth. The logic of the need for huge and radical structural change is clearest with respect to economic growth; if sustainability requires levels of resource production and consumption that are not just stable but must be far lower than at present, then it is not possible to solve the fundamental problems unless the growth commitment is completely abandoned. But that is only one element in the overall challenge which calls for historically unprecedented system change which jettisons some of the basic drivers of Western culture.

10. TSW…TINA

The Simpler Way project involves the following basic claims. The first is that the limits case shows convincingly that global problems cannot be solved within or by a society that is committed to affluent lifestyles, economic growth or allowing market forces to determine "development". These are the main factors causing the alarming sustainability and justice problems. The second argument is that there is an alternative, a Simpler Way which would defuse the problems and could be quickly and easily built…if that was the goal. A third claim is that The Simpler Way would enable a far higher quality of life for all, including people in rich countries today. Finally there is the claim that there is no other way. The problems are basically being generated by the quest for limitless affluence, which is not possible for all, so a sustainable and just world cannot be conceived other than in terms of frugal but sufficient material living standards within basically localised economies under mostly participatory democratic control by local assemblies, and within zero-growth economies operating at far lower levels of GDP per capita than rich countries have today (for the detail see Trainer, 2010, 2011).

The dollar, energy and footprint costs of living in settlements of the kind envisaged indicate that remarkable reductions could be achieved, probably to under 10% of those typical of rich countries today. Given this dramatically reduced scale energy demand could be met entirely by renewable sources.

This vision retains a role for centralised states (much reduced), for (some) large enterprises such as steel works and railways systems, some but very little international trade, an increased investment in socially desirable high-tech R and D, and for private farms and firms, mostly at the micro level of family businesses and community cooperatives.

It hardly needs to be said that at present the prospects for transition to this way are highly unlikely. However there is rapidly increasing interest in elements within it, evident especially in the Global Eco-village (GEN, 2011) and The Transition Towns Movement (2009)

11. Abundant energy would not be good for us anyway

A foundation belief underlying Western culture has been that more is better. Progress has been thought of largely in terms of becoming more able to produce and perform. Engineers and scientists are among the most ardent devotees, dedicating their lives to finding more productive technologies and firmly believing this inevitably contributes to progress and human emancipation. Those seeking to derive more oil and gas from increasingly difficult sources tend to provide good examples of this well-intentioned but rarely questioned world view.

However there is now increasing realisation that there might be peaks and sweet spots on some curves, and diminishing returns thereafter. A certain finite amount of food, or exercise or cleanliness is ideal, and one can have too much. For decades Daly (2008) has been pointing out that economic growth is now generating more costs than benefits, and a number of agencies are documenting the way rising GDP is being accompanied by declining quality of life indices (Eckersley, 2004; Speth, 2001; Jackson, 2009). The "downshifting", slow food, and Voluntary Simplicity movements are among initiatives identifying the good life with reduced consumption and more attention given to non-material sources of life satisfaction.

If abundant energy enabled all work to be eliminated, and nutritional needs to be met by taking a pill, would that enhance the quality of life? Humans need "work", things to do, purpose, and in my view our welfare would be maximised if most of the limited supply of food, goods and services we need were produced by hand crafts. The best way to get a house is not by ordering one to be laser-printed but by enjoying slowly building it by hand with friends, from mud. We have known for centuries how to make perfectly satisfactory housing, food, clothing, pottery, music, community, conversation and entertainment.

Sometimes when the books are kept properly it becomes evident that technical advance is not good for us. Global welfare is not likely to be increased by the development of an ultra cheap car all Indians can afford. Did finding out how to make nuclear weapons improve our situation? Some African tribes have decided not to adopt the settled agriculture their neighbours have moved to. It makes sense to consider carefully the degree to which we should embrace whatever technology makes possible and often the wise choice is an earlier and simpler way.

What would be the effects of a break through which provided abundant energy to consumer society? It would be used to provide everyone with a private helicopter, take holidays in space, process ore grades at crustal abundance, and hunt down the last shrimp in the sea… and greatly increase the GDP. For 20 years it has been pretty clear that as rich countries increase the GDP measures of the quality of life either do not rise or actually fall (Alexander, 2012; Speth, 2001).

When it comes to the personal and social domain there is a strong case that wealth impoverishes. It easily preoccupies, corrupts and debauches, increases greed, and undermines the capacity to appreciate. Poorer people tend to be more generous than richer people. (Eisenstein, 2012 p. 22.) Frugal circumstances tend to produce sharing and mutual care. Illich (1974) pointed to the tendency for increasingly energy-intensive ways beyond a low level to worsen equity and disadvantage. When travel is by foot, donkey or bicycle all can travel, but when it is by car or aircraft, many cannot afford to. UN indices of welfare show a similar pattern, reaching relatively satisfactory levels at quite low income levels and barely improving after that. The pursuit of ever-higher "living standards" and GDP has been accompanied by an epidemic of depression, drug and alcohol abuse, eating disorders, family breakdown, and suicide. These are "spiritual" problems and are not likely to be reduced by the provision of more energy. The main causes of the deterioration in social cohesion are to do with increasingly individualistic and acquisitive ways enabled by prioritising greater consumption of energy and resources. The solutions are to be found in moving to better ideas, values and social systems.

At the core of TSW vision is the realisation that only low levels of material consumption are necessary or desirable, and that beyond a low minimal level the quality of life is maximised by focussing on non-material goals. For instance in some alternative communities people only need to "work" for money 1 day a week and can spend the rest engaged in art and craft, community working bees, committees, education, festivals etc. Increasing their dollar incomes or the amount of energy available to them would not add to their quality of life. Consumer culture is about maximising income, status, wealth, technical sophistication, complexity, scale, output and GDP. The focal concern of the simpler way is what is sufficient or good enough. In my view a good quality of life for all requires a high level of frugality, self-sufficiency, localism, and mutual interdependence and cooperation.

This is not an argument against sophisticated technology, nor against the quest for more oil and gas. It is an argument that to assume that these are crucial in solving our problems is to have misunderstood what the problems are.

But do not we need more energy to lift people in the Third World out of poverty? This almost universally held belief reveals the mistaken acceptance of conventional "development" theory. This assumes that the only way to improve the lives of poor people is for those with capital to invest in what they believe will maximise their global profits. This will mostly benefit their shareholders and the few who shop in rich world supermarkets. Some wealth does usually trickle down to poorer people, but the situation of the poorest often deteriorates. The Simpler Way focuses on "appropriate" development, i.e., the direct application of the available and often abundant local resources of soil, rainfall, forests, fisheries, labour and skills, to the production of basic necessities, by local people, via mostly cooperative arrangements. Central in this vision is the claim that high levels of material, social and spiritual provision can be achieved with negligible dependence on financial capital, high-tech systems, heavy industrialisation, importing and exporting, or the global economy (see Trainer, 2010, Chapter 5, 2012b). Certainly access to more energy could significantly facilitate appropriate Third World development but this is well down the list of priorities. At the top of the list is recognising that the taken for granted goal of development, rising to rich world "living standards", is tragically mistaken. That goal is impossible and it produces one new Chinese coal-fired power station every week. The average per capita power consumption in my house averages around 8 W.

There is widespread acceptance that global resource and ecological problems cannot be solved without enormous social change, especially in rich countries. But the dominant "green development" vision assumes technical and lifestyle changes which reduce consumption levels while leaving intact the basic systems of consumer-capitalist society (see for instance the recommendations in Chapter 21 of the GEA report, Roy and (Lead Author), 2011). The fundamental Simpler Way premise is that to grasp the core limits to growth analysis of our predicament is to recognise the invalidity of this assumption; the magnitude of the overshoot cannot be dealt within a society in which growth is the supreme goal, profit maximisation and market forces are allowed to determine our fate, government is highly centralised, and all seek limitless personal wealth.

These have been reasons for thinking that striving for more oil, gas, energy in general, output and GDP will not solve our problems, firstly because the problems are far too great, and secondly because the core problems are not material. They are due to mistaken social arrangements, goals, systems and values, and satisfactory solutions will be associated with markedly lower levels of consumption and system technical sophistication and complexity.

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