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The “de-materialisation” myth

Ted Trainer

Faculty of Arts, University of New South Wales, Social Work, Kensington 2052, Australia

Abstract

Crude figures on GDP per unit of energy consumed indicate that significant reduction is taking place in the quantity of energy needed to sustain current levels of rich nation economic activity. It is argued that this effect is illusory and is due primarily to changes in the mix of fuels and to increasing importation of energy-intensive products. Some radical implications for sustainability are discussed. © 2001 Elsevier Science Ltd. All rights reserved.

A common argument against the “limits to growth” thesis has been that economic growth can continue because as economies advance growth can be “de-coupled” from resource demand. In other words, increased economic activity can take place mostly in the services and information areas and decreasingly in those sectors that involve intensive use of mineral and energy resources.

A superficial inspection of figures relating GDP to energy and resource use seems to show that considerable de-materialisation of the economy is taking place. The “energy intensity” of the developed economies has fallen in recent decades. For instance Reddy and Goldemberg [24] show that the energy intensity of the UK economy fell by 68% between 1920 and 1980. For the US economy there was an approximately 70% fall in the same period [37].

However there are four major reasons why the de-materialisation thesis is at best misleading, and probably largely false.

1. The dubious significance of GDP

The first problem with attending to changes in the ratio of GDP to energy or materials use concerns the meaning of increases in the GDP. To a considerable extent

E-mail address: f.trainer@unsw.edu.au (T. Trainer).

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these can reflect greater turnover in sectors with little or no real economic value, or which have little or no effect on real living standards, welfare or the quality of life. Much economic activity is now little more than speculative (i.e., gambling) within the financial sector [2,27]. For example, much of the foreign investment in Australia adds no productive capacity but simply takes over local firms. Much economic activity takes the form of zero-sum competition for the same limited sales opportunities. The remarkable recent inflation of share values also feeds into conventional estimates of national wealth, yet represents dubious long term real increase in national income given that there is likely to be a marked deflation of these values at some point in time.

Similarly reference could be made to many "services" of dubious real value, including those provided by many lawyers, consultancies and management professionals. The surge in these activities and their associated fees (including CEO salary rises) in recent years feeds into GDP growth without necessarily representing any real increase in goods or services produced (let alone an increase that raises the quality of life; Genuine Progress Indicators have been falling in rich countries for many years) [10].

Another relevant trend is the "monetisation" of output not previously within the cash sector of the economy. For example when functions that were once carried out in the household or performed for friends without payment are taken over by the cash economy, such as care of aged people, clothes washing, take-away food production and "counseling", the volume of sales can increase without change in the volume of goods produced.

The increasing commercialisation of functions is characteristic of our society [17]. Rarely considered is the resulting cost in loss of "social capital"; i.e., the familiarity, mutual support, trust and social cohesion that can only be built and maintained through mutual aid, obligation and gratitude. These social and moral factors are of crucial economic significance but are not taken into account by an economic theory that only deals with monetary values. Cobb says much of the growth of GDP comes from "...fixing blunders and social decay from the past, borrowing resources from the future, or shifting functions from the traditional realm of the household and community to the realm of the monetised economy" [5, p 62; 7]. Some have argued that increasing the GDP now adds more to costs than to benefits.

There are therefore reasons for thinking that a considerable fraction of the growth of GDP in recent years does not represent a net growth in production of "goods", let alone items that contribute to real living standards. If these elements could be subtracted from the official GDP figure at least the apparent divergence in the curves for materials or energy use and real living standards or welfare would be markedly reduced.

2. Changes in the forms of energy used

The dollar value produced by the use of a unit of energy can be altered by shifting to the use of forms of energy which have a higher "quality". A mega joule of energy in the form of electricity is worth more to industry than a unit in the form of coal. Electricity is much more flexible, adaptable, convenient and transportable than coal. It can easily be put to many specialised uses without conversion. It would be inconvenient and costly to use coal to perform some operations that electricity performs well, such as driving a washing machine via a steam engine. Petroleum is energy of a higher quality than coal, and electricity is of higher quality than petroleum. Gas is of high quality but it is more difficult and costly to transport than oil because of its low energy density.

Gever's analysis concludes that a surprising proportion of the apparent gain in the energy efficiency of the US economy is due to changes to higher quality forms of energy, as distinct from being due to producing more value per unit of energy used in the economy [13, pp. 23, 102]. Fleay puts the proportion at 72% [11, p. 77]. Hall, Cleveland and Kaufman [16], make the same general point. Kaufman [21] also points to increasing use of oil and gas rather than coal as the main factor. "...energy saving technical change has had little effect on the amount of energy used to support economic activity" [21, p. 35].

A second and more subtle change in forms of energy requires discussion of the energy cost of producing things, especially the energy cost of producing energy. A number of petroleum geologists and others have recently argued that an extremely serious and permanent oil shortage is likely to impact before 2010 [3,4,11,13,20]. They explain that a major reason for thinking that the problem will occur sooner than previously believed becomes evident when the energy costs of producing energy are taken into account. (Gever uses the term "Energy Return on Investment", EROI.) Odum discusses these problems in terms of "emergy" (which stands for embodied energy), a more inclusive concept taking in the biological as well as the physical energy costs within the chain of production leading to the item under discussion [23]. For example when a dam is built to supply energy, energy is used to produce the cement, but there is also a huge energy cost in the lost biological production from the drowned forest. Crude figures on GDP per unit of commercial energy consumed in an economy do not take into account these more subtle components of the actual total energy cost.

Energy accounting can make significant differences to estimates of potentially recoverable resources. Gever's analysis of the increasing energy cost of producing oil from depleting fields indicates that before 2010 it could be costing the US more energy to find and retrieve a barrel of oil than there is in a barrel of oil. When this point is approached production will cease even though there will be much oil left in the ground. (It can make sense to use a larger quantity of cheap energy such as coal to produce a smaller quantity of more valuable energy such as a liquid fuel, although this is complicated by the fact that some 40% of the energy needed to produce coal must be in liquid form.) However the important implication for the present discussion is that if energy costs rise then the volume of energy resources it will pay to retrieve will tend to be considerably less than the volume the geologists currently state under the heading of "potentially recoverable resources".

The significance of this energy cost factor for the discussion of de-materialisation is firstly that we must take into account the biological component in the emergy of imported goods, and secondly that the fossil fuel costs of the economy are being kept artificially low through the accelerating consumption and therefore depletion of biological resources of many kinds (e.g., the depletion of soils in agriculture.) Obviously to produce as much as we do while maintaining soils and forests in their present condition would require much more energy than we now use. The fossil fuel energy bill is therefore being increasingly subsidised by accelerating decline in the ecological account. Thus the real amount of energy used in the economy is higher than the volume taken into the conventional GDP/energy ratio (because of the rising but unaccounted biological and ecological energy input subsidies). To put it another way, energy costs would be much higher if the current volume of production was being carried out in ecologically sustainable ways.

3. The increasing importation of goods that were once manufactured domestically

Figures on changes in the energy and materials intensity of an economy can be quite misleading because they fail to take into account the extent to which the economy has shifted from production of the goods it uses, to the use of goods produced overseas and imported. A shift by a country to greater use of imports reduces the quantities of raw materials and energy used in that country to produce goods it consumes. These quantities are the only figures taken into account in the usual energy intensity indices but the quantities used overseas to produce some of the goods actually consumed are not included.

For example if refrigerators sold in Australia and manufactured from steel produced in Australia begin to be manufactured from steel imported from Taiwan the energy cost of producing the steel ceases to be tallied in Australia's energy consumption. If the refrigerators begin to be imported the energy use figure declines further. Manufacturing accounts for considerable energy and as globalization has gained momentum there has been a strong tendency to relocate it from rich to "developing" countries. Labor is very cheap in the Third World (...shirt producers in Bangladesh receive 15 c per hour; [38]) and environmental and other restrictions on corporations are often lax. There is therefore less incentive to produce in resource and environmentally efficient ways, and therefore it is not likely that the energy efficiency of producing export goods in poor countries is as high as it would be if they were produced in rich countries. That is, the energy cost of the imported goods is likely to be higher than if they were manufactured in the country consuming them.

This is again to affirm the importance of attending to "embodied" energy. For example when only dollar costs are considered it can seem economically sensible to import oranges into Australia from Brazil, or to use aluminium in preference to timber in house framing, but the energy costs of these more "economically efficient" options is far greater.

However an indication of what is happening can be derived from basic trade figures taken from the Statistical *Abstract of the United States* [34, pp. 492, 747, 861]. Between 1980 and 1994 US economic turnover increased 29% in deflated terms.

However the dollar value of US manufacturing increased only 21.6% in deflated terms in this period, meaning that manufacturing activity declined as a proportion of total economic activity. The volume in dollar terms of some of the most energy and materials intensive import categories increased greatly in this period. Imports of non-fuel merchandise increased 94% in deflated terms. Imports of industrial supplies and materials declined in deflated terms, again consistent with a shift to manufacturing overseas. The increase in automotive imports, another energy and materials intensive item, was 179% compared with the 29% increase in GDP. Non-food consumer goods imports increased at 183% in deflated terms, 1.5 times the average rate of increase for imports as a whole. Imports of capital goods, probably the most energy-intensive category, increased 271% in deflated terms, i.e., approximately 10 times the rate of increase in US manufactured goods. Kelly [22] reports similar conclusions for the 1973–1984 period. US imports of energy-intensive goods almost doubled to 7% of GNP.

These figures seem to leave little doubt that in the 1980–1992 period there has been a marked increase in the volume of imports of the most energy and materials intensive items into the US economy. Given that the value of the energy and materials intensive categories of imports (non-food consumer, capital goods, merchandise and automotive) almost trebled in this period, it is plausible that this shift has considerably increased the amount of energy and materials embodied in the goods consumed within the US, and that this quantity is significantly underestimated by figures on the volume of raw energy used in the US.

Along with the relocation of manufacturing has been the transfer of various energy intensive activities to the Third World, especially steel production and ship building. Schipper, Meyers and Richard [25] report that one quarter of the fall in OECD energy intensity is due to decline in location of energy intensive industries in the rich countries.

Adriaanse’s [1] concept of Total Material Requirement includes the embodied resource cost involved in the production of various items. He found that in general 35–75% of Total Material Requirements are located outside the country in which the material is consumed. In other words there is a considerable foreign resource cost that is overlooked if attention is only given to materials consumed within a particular country. Adriaanse concludes that over the past 20 years per capita materials consumption has increased, and therefore “meaningful dematerialisation... is not yet taking place”.

A full emergy accounting would also take in the energy costs of the increase amount of transportation of goods that now takes place, including the transportation of components to and from many locations during the assembly of final products. Because most manufactured goods and commodities end up being consumed in rich countries most of the energy used to move them between Third World countries during their production and assembly should be accounted to rich countries. However much of this energy probably appears in the accounts of the Third World importing and exporting nations, and the many shipping firms registered in the Third World.

4. Garbage is increasing

Possibly the most impressive argument against the dematerialisation thesis is given by the simple fact that a good indicator of materials and energy entering the economy and consumed within it is the volume of material thrown out, and it is not the case that the volume of garbage being generated is falling. In fact in most rich countries it is increasing so fast that there are serious problems in finding sufficient landfill sites

In the period 1960–1993 the per capita volume of municipal waste generated in the US has grown from 2.7 lb per person per day to 4.4 lb, a 63% increase [34, p. 236]. In the E.C. municipal waste increased 13% between 1986 and 1991 [14, p. 87]. Per capita solid waste in Sydney increased 30% between 1970 and 1990 [10, p. 24].

The real situation is likely to be considerably worse than these figures indicate, firstly because of the increase in the amount of waste material recycled in recent years, and secondly because the figures do not take into account the large volumes of materials and energy inputs into production that do not enter the waste stream in the short term. For example some will have been built into houses, transport equipment, urban development, roads, infrastructures, appliances and durable goods still in use. These volumes have increased in recent years so the fractions of them that will become waste at some future time have increased. Current municipal waste figures are therefore likely to understate the actual trends in the per capita material and energy consumption rate. Total US new material use p.a. is actually around 40 times the volume of municipal waste [39]. When the "rucksack" concept is also taken into account the multiple is far greater. ("Rucksack" refers to the volume of earth, water, air etc that must be used to produce one tonne of material. To produce one tonne of gold 350,000 tonnes of other substances must be processed.)

5. Putting the issue in context

These four lines of argument would seem to confirm that graphs depicting the energy intensity of rich world economies are seriously misleading regarding dematerialisation. Indeed from the discussion of trends in waste volumes it is not at all clear that any dematerialisation of the US economy is taking place.

Even if clear evidence that materials and energy use per unit of output were falling concerns about the limits to growth would not have been put to rest. The limits to growth case indicates that the volumes of materials and energy presently consumed in rich countries would have to undergo enormous reductions before they reached sustainable levels. The following elements selected from the limits case [32] are briefly noted in order to indicate the magnitude of the overshoot which the limits analysis points to, and therefore the magnitude of the dematerialisation that would have to take place before problems of resource scarcity had been resolved. (The point here is not to argue the limits position but to indicate that if it is valid dematerialisation would have to achieve huge reductions.)

At present the rich one-fifth of the world's people are consuming some 75–80%

of world resource production. If all people alive today were to have rich world per capita oil consumption world oil production would have to be about 5 times what it is today. If all the people likely to live on earth soon after 2050, around 9–10 billion, were to have the present rich world per capita oil consumption then annual output would have to be around 10 times as great as it is today.

If we attempted to increase resource production to those levels, all estimated potentially recoverable resources of fossil fuels and one-third of the basic 36 mineral items would be completely exhausted by about 2040 [28, Chap. 1; 31]. As has been noted above, the situation with respect to oil is especially disturbing. Petroleum is likely to become very scarce in the next few decades. Campbell [3] concludes that world oil supply will peak before 2010 and by 2025 will be down to half the present amount, that prices will jump and remain high as soon as the peak is reached, and that resort to unconventional resources such as oil shales and tar sands will make no significant difference to the situation. A number of other authors come to much the same conclusion [9,11,13,16,20]. Campbell argues that the problem cannot be solved by use of unconventional oil in shales and tar sands. If Campbell and others are correct, by 2025 world oil supply will be only 1/15 of the amount that would be required to provide the present rich world per capita average consumption to all people likely to be living then. If the highest current estimates of petroleum resources are taken, those of the US Geological Survey [40], the peak is delayed by only about a decade.

The Intergovernmental Panel on Climate Change [19] has concluded that if the amount of carbon in the atmosphere is to be prevented from increasing any further then fossil fuel use must be cut by 60–80%. If it were to cut by 60% and shared between 9 billion people the average amount available per capita would be only 1/15 of the amount people in rich countries use today.

According to the "footprint" analysis developed by Wachernagel and Rees [36]. It has been estimated that to provide one person living in Sydney with water, settlement area, energy and food requires at least 4 to 5 ha of productive land. Therefore if 9 billion people were to live as we do in Sydney we would need about 40 billion ha of productive land. However this is approximately 6 times all the productive land area of the planet.

Humans are appropriating about 40% of the biological productivity of all the planet's land area [35]. Possibly the most disturbing ecological problem is the loss of species. This is essentially due to the loss of habitat. If so much habitat is presently being taken to provide rich world lifestyles to about 1 billion people, how much habitat and how many species will be left if 9 billion were to live as people in the developing countries do today? (The argument that the environment problem cannot be solved without transition from industrial-affluent-consumer society to simpler lifestyles in a zero-growth economy is detailed in Trainer [31].)

These and other lines of argument within the limits to growth case indicate that the "living standards" and the economic system taken for granted in rich countries today are far beyond sustainability. However to these considerations must be added the implications of the commitment to growth. If rich countries were to average a 3% p. a. rate of growth in output and 9–10 billion were to rise by 2070 to the per capita level of consumption rich countries would then have, total world economic output would be 60 times its present volume, and it would be doubling every 23 years thereafter. For a 4% average growth rate the multiple would be 120. (Note that there are good reasons for thinking that the present volumes of production and consumption are well beyond sustainable levels, meaning that the factor reduction required could be two or three times the multiples stated here.)

These multiples also put into context the claims of technical fix optimists such as Weiszacher and Lovins [37] or Hawken, Lovins and Lovins [18]. These authors argue that the energy and resource intensity of the economy could be reduced by a factor of four to ten. The above multiples implied by the commitment to growth show that this would be far from sufficient to enable all to live in industrial-consumer society. The most difficult task for the technical-fix optimist is to explain where the necessary quantities of energy are to come from. A considerable case can be made that renewable energy sources are not capable of providing the quantity of electrical or liquid energy needed to sustain industrial-affluent society, even at its present scale, let alone assuming continued economic growth [30]. For instance when the large energy losses involved in storage, transport and conversion are taken into account, photovoltaic plant to supply electricity to Europe in winter, assuming reasonable technical advance (e.g., cells operating in the field at 20% efficiency) would be at least 30 times as expensive per kW as coal-fired or nuclear plant. (This figure does not take into account several factors that would increase it markedly, including the energy cost of plant construction, the cost of capital, and the need to pay for construction produced by energy from the new sources, which would be much more expensive.)

Similarly it is often assumed that the threat of limits will be avoided by the economy becoming predominantly concerned with the production of services. However service industries are in general rather energy-intensive. They account for more than one quarter of Australia's energy consumption [6]. Some either directly involve, or rely on, large-scale energy use, such as travel, transport, tourism, construction, retailing and advertising. For example much of the insurance and advertising industries depends on the production and sale of material goods, as does much legal, consulting and marketing activity. It is therefore not plausible that 3–4% p.a. economic growth could continue indefinitely without considerable growth in energy use.

The foregoing argument has been that there are persuasive reasons for concluding that concerns about the "limits to growth" are not satisfactorily countered by the dematerialisation thesis. If this is so radical a change of direction in thinking about the global predicament would seem to be called for. A considerable literature now argues that a just and ecologically sustainable society cannot be achieved unless there is transition to a fundamentally different socio-economic system, one in which the core principles are simpler lifestyles, small and highly self-sufficient local economies, primarily participatory and cooperative arrangements, and a zero-growth economy. (For a detailed argument in support of this "Simpler Way" thesis see Trainer [28,29,33].) It does not need to be said that the probability of such change being undertaken would appear to be slight, given that it would require immense cultural change as well as economic and structural change. However within the last two decades a Global Alternative Society Movement has emerged in which people have begun to build and experiment with communities that manifest The Simpler Way [8,12,15,26].

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Ted Trainer is a lecturer in the School of Social Work, University of New South Wales, Australia. His main interests have been global problems, sustainability issues, radical critiques of the economy, alternative social forms and the transition to them. He has written numerous books and articles on these topics, including Abandon Affluence,1985, The Conserver Society; Alternatives for Sustainability,1995, Saving the Environment; What It Will Take,1998, and What Should We Do?, (In press). He is also developing Pigface Point, an alternative lifestyle educational site near Sydney.