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Does Energy Efficiency Save Energy: The Economists Debate

CONTENTS:

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1. Introduction

It has become an article of faith amongst environmentalists, seeking to reduce greenhouse gas emissions, that improving the efficiency of energy use will lead to a reduction in energy consumption. This proposition has even been adopted by the UK government who is now promoting energy efficiency as the most cost effective solution to global warming.

However in the USA there has been a backlash against energy efficiency as an instrument of energy policy. This has been stimulated partly by disillusionment with the failures of energy conservation programs undertaken by utilities, and partly by the growing influence of the 'contrarians' - those hostile to government mandated environmental programs.

The debate as to whether energy efficiency is effective (that is reduces energy consumption) has spread from the pages of obscure energy economic journals in the early 1990s to the pages of newspapers, such as The New York Times in the mid 1990s. It has recently produced such polemics as the US book by Herbert Inhaber entitled *Why Energy Conservation Fails*, which argues, with the aid of an extensive bibliography, that mandated energy efficiency programs are a waste of

time and effort.

A recent paper which gives a good, and very readable, review of this debate is by Richard Howarth (Howarth 1997). This debate has also promoted discussion among US energy analysts and the climate change community over the extent of the 'rebound' or 'take-back' effect. That is how much of the energy saving produced by an efficiency investment is taken back by consumers in the form of higher consumption. An excellent review of the literature on the rebound effect is in an as yet unpublished (Jan 1998) report by Lorna Greening and David Greene commissioned by Oak Ridge National Laboratory, USA.

Purpose of this Paper

This paper aims to inform non-economists of this mostly US debate on energy economics. It refers to the views of economists - both classical and environmental - and to the historical evidence on the effect of improving energy efficiency on energy consumption. This paper aims to refer readers to sources of information on this debate rather than rehash the arguments on each side. Hopefully it will stimulate a similar debate in the UK and encourage further research.

I believe that conservationists - who I define as those seeking to improve the efficiency of energy use in the belief that it will lead to a reduction in national energy consumption - should pay attention to the views of economists, if they want to have their views adopted by the energy industries and government. For economists are far more influential on policy formulation than conservationists: after all governments and most businesses have economic advisors, but how many have an energy efficiency adviser?

Economists who deal with energy issues, often termed energy economists, have their own professional organisations: the International Association for Energy Economists (IAEE) in the USA with national branches such as the British Institute of Energy Economists (BIEE). In contrast conservationists are weakly organised, they have no professional organisations, and their only forum is conferences such as the biannual ECEEE (European Council for an Energy Efficient Economy) conference in Europe or the annual ACEEE meeting in the USA.

This paper is not concerned with energy efficiency at the microlevel, that is by the individual consumer or firm, but at the macrolevel, that is at the aggregate or national level. Its question is 'does the promotion of energy efficiency (at the microlevel) reduce energy consumption (at the macrolevel)'? It presents arguments that the precise effect of energy efficiency decisions at the microeconomic level is impossible to quantify at the macroeconomic level. Furthermore the effects may be in the unsought direction and that this has been known (to economists) for a very long time.

This paper's context is the desire to reduce greenhouse gas emissions with the policy of improving energy efficiency being put forward as a means to reduce national energy consumption.

The paper concludes by drawing on recent work by ecological economists, such as Mathis Wackernagel and William Rees, who have written on investing in natural capital. They and others have suggested ways in which energy efficiency combined with market instruments can help achieve 'sustainable development'.

Hopefully readers will not interpret this paper as an attack on energy efficiency or those institutions struggling to promote it. High levels of energy efficiency are an essential part of a dynamic productive economy. Low economic productivity and energy inefficiency go hand-in-hand as the former Soviet Union demonstrates.

Len Brookes, the leading UK author in this debate, comments (1998):

> "*It is inconceivable that we should have had the high levels of economic output triggered by the industrial revolution if energy conversion had stayed where it was at the beginning of the nineteenth century. Energy productivity and the productivity of other factors of production fed on one another with rising energy efficiency contributing to rising productivity of other factors of production - labour and capital - and rising output contributing to rising energy efficiency by way of embodied technical progress. Without this interactive process we should not have had, in the meantime, the very large increases in energy consumption alongside large improvement in energy conversion efficiency...*"

This point about energy growth during the Industrial Revolution is also made by Inhaber and Saunders (1994) in the US journal The Sciences.

2. The Energy Efficiency Debate

Economic theory accepts (Brookes 1979, 1990; Khazzoom 1980, 1987; Saunders 1984 and 1992, Sutherland 1994, 1996), and the historical record for most of this century suggests (Schurr 1984, 1990), that increased energy efficiency at the microeconomic level while leading to a reduction of energy use at this level, leads not to a reduction, but instead to an increase in energy use, at the national, or macroeconomic level. This concept has been termed the Khazzoom-Brookes postulate.

From Jevons to Saunders

The name of the Khazzoom-Brookes (KB) postulate was coined by the

US economist Harry Saunders in 1992. This followed papers published independently by Daniel Khazzoom and Leonard Brookes in the late seventies and early eighties; although both of them acknowledge a debt to a paper by Stanley Jevons, in his classic work *The Coal Question*, first published in 1865.

Jevons argued that '*it is a confusion of ideas to suppose that the economical use of fuel is equivalent to diminished consumption. The very contrary is the truth*'. He points out that '*the reduction of the consumption of coal, per ton of iron, to less than one third of its former amount, was followed, in Scotland, by a ten fold increase in total consumption, between the years 1830 and 1863, not to speak of the indirect effect of cheap iron in accelerating other coal-consuming branches of industry*'.

The papers by Brookes and Khazzoom applied broad brush economic principles in an attempt to make judgements about long run macroeconomic effects. Saunders' papers take a more mathematical approach and argue that the KB postulate is consistent with neo-classical growth theory over a wide range of assumptions. For a full understanding some knowledge of economics is required and there is no real alternative to studying the papers themselves. However the following analogies illustrate the consequences of improved efficiency on demand from the labour markets and aircraft travel.

1. Employees are told that they must raise their productivity if they are to improve their job prospects. On the local microlevel this seems absurd, as many shop stewards (and the Luddites) once argued. However on the macrolevel the increased economic output, resulting from higher labour productivity, has lead (in the long term) to a growth in the number of employees.

2. The introduction of wide bodied passenger aircraft, to replace smaller aircraft, was forecast to reduce the number of flights. In fact the resulting lower cost per passenger led, in a competitive market, to a large increase in air travel that more than offset the increased size of the aircraft. The raised productivity per aircraft called for more aircraft, not fewer (Spare 1990).

The Khazzoom-Brookes postulate

The KB postulate may be described as those energy efficiency improvements that, on the broadest considerations, are economically justified at the microlevel lead to higher levels of energy consumption at the macrolevel than in the absence of such improvements. Saunders' paper claimed to show that postulate was consistent with neo-classical growth theory over a wide range of assumptions. It argues against the views of conservationists - those promoting energy efficiency as a

means of reducing energy consumption - that one can identify every little benefit from each individual act of energy efficiency and then aggregate them all to produce a macroeconomic total. In essence it adopts a macroeconomic (top down) approach rather than the microeconomic (bottom up) approach used by conservationists.

It warns that although it is possible to reduce energy consumption through improved energy efficiency it would be at the expense of loss of economic output. It thus argues that overzealous pursuit of energy efficiency per se would damage the economy through misallocation of resources. In other words reduced energy consumption is possible but at an economic cost.

The effect of higher energy prices, either through taxes or producer-induced shortages, initially reduces demand but in the longer term encourages greater energy efficiency. This efficiency response amounts to a partial accommodation of the price rise and thus the reduction in demand is blunted. The end result is a new balance between supply and demand at a higher level of supply and consumption than if there had been no efficiency response.

Under the economic conditions that have prevailed in the UK most of this century, of falling fuel prices and a free market approach, energy consumption has increased at the same time as energy efficiency has improved. During periods of high energy prices, such as 1973-74 and 1979-80, energy consumption fell. Whether this is due to the adverse consequences of higher fuel prices on economic activity, structural changes or energy efficiency improvements was a matter of some dispute. The lower level of energy consumption at times of high energy price may be at the expense of reduced economic output. This in turn is due to the adverse effect on economic productivity as a whole of the high price of an important resource.

Richard Howarth comments (1997):

> *Brookes' key insight is that cost-effective energy efficiency improvements may be viewed as a form of technological progress that improves productivity, promotes capital investment, and enhances economic growth. Since the demand for energy services is driven by consumers' incomes and by requirements for energy as a factor input, increased growth should, all else equal, lead to increased energy demand. If this growth effect is large enough, it might counter the direct reductions in energy-output coefficients so that improved energy efficiency actually gives rise to increased use*

Conservationist Disagree

The KB postulate is vigorously disputed by environmentalists. In the UK

the major clashes have been of Michael Grubb (1990, 1992) with Len Brookes (1992, 1993); in the USA Amory Lovins (1988) with Daniel Khazzoom (1987). Grubb and Lovins have argued that the shift towards the service economy and the large technical potential for energy efficiency (see classic works by Lovins 1977; Olivier 1983; Weizsacker 1997) will result in reduced national energy use, if market 'barriers' can be overcome.

Howarth in his review of this debate (Howarth 1997) writes that Brookes has put forward *this hypothesis as a general claim without accompanying caveats*, and that it does not hold under most conditions. Similarly he disagrees with the conclusions of Saunders' (1992) analysis, saying that *Saunders does not consider the distinction between energy use and energy services...*. The conclusion of Howarth's analysis is that *...the macroeconomic feedbacks of energy efficiency may be less substantial than Saunders' initial study suggests...*

The link between energy efficiency and economic activity lies at the heart of this debate. As Schipper and Grubb (1998) remark:

> *We conclude that feedback effects are small in mature sectors of mature economies and only potentially large in a few cases; lowering energy intensities almost always leads to lower use than otherwise. Of course, the scale of the system keeps increasing with population, household formation, and the climb of incomes and sectorial output. We may find that over a sufficient period energy use has increased even if energy efficiency has improved. Our thesis...is that the improvement in efficiency per se is only a small part of the reason why total energy use may have increased.*

There has been a long running debate over these issues between energy economists and energy efficiency supporters for the last 20 years. It was in a review of Leach's pioneering work, *A Low Energy Strategy for the UK,* that Brookes (1979) first criticised the bottom up approach to estimating national energy savings because of its failure to consider macroeconomic factors. The debate over low energy futures continued into the 1980s, with influential contributions from John Chesshire (1986), Bill Keepin & George Kats (1988), and again Gerald Leach (1991). This conservationist argument that improved energy efficiency will reduce national energy consumption in the future to less than what it would have been (even though there may still be an increase in consumption) is impossible to either prove or disprove, as there is only one future.

The debate grew more intense in the 1990s, spurred by global warming concerns. It was conducted most in the pages of Energy Policy and Energy Journal , with contributions from economists Manne & Richels

(1990, 1995), Maddison (1995) and Nordhaus (1995). The debate is inconclusive because of the language gulf between economists and conservationists, although there have been attempts to seek common ground (Sioshansi 1991, 1996). However attempts by conservationists, often physicists or engineers, to justify their programmes on economic grounds, such as market failure, have lead to their defeat at the hands of economists, who obviously have superior economic knowledge.

Most economists have not bothered entering this debate, but some top ranking energy economists have dropped remarks that reveal their thinking and convictions on this issue. These include Richard Gordon, Professor of Mineral Economics and Director of the Centre for Energy and Mineral Policy Research, Pennsylvania State University, Nathan Rosenburg, Professor of Public Policy, Department of Economics, Stanford University and Robert Solow, a Nobel Laureate famous for his seminal work on growth theory.

While Gordon may be labelled a 'contrarian' in believing that economic forces and man's ingenuity will always solve any resource shortages, Solow has issued dire warnings against running out of key resources like energy.

Richard Gordon, Winner of the 1992 IAEE prize for outstanding contribution to the profession of energy economics said in a review of measures to deal with global warming (Gordon 1994, p11):

> *Even more problematic is the claims made by energy conservation enthusiasts (Grubb 1990 and Grubb et al 1991) who insist that global warming can be cured almost costlessly by adopting energy-saving measures claimed to be socially profitable. The argument for conservation in any case is independent of global warming concerns and implausible. The only market failure that distorts energy use is underpricing of electricity by regulators, and deregulation is preferable to the conservation programs into which utilities were force.*

In rejecting Grubb, Gordon makes it abundantly clear that he rejects Grubb's microeconomic approach to energy efficiency as having anything to offer to understanding of the problem at the macroeconomic level.

A more considered view comes from a review by Hilliard Huntington (1992) of Grubb's book *Energy Policies and the Greenhouse Effect*. He singles out Grubb's economic assumption about saturation rates, which results in forecasts of low levels of energy demand. Huntington writes:

> *While saturation of individual appliances can be expected, rapid economy-wide saturation need not occur as new energy services and energy-using appliances are constantly*

> *emerging. The volume offers no evidence, historical or otherwise, for its assumptions about saturation rate.*

In the USA energy efficiency advocates have lobbied for electric utilities to invest in energy efficiency - or negawatts - as a means to reduce consumption and lower consumer costs (Hirst 1992, Lovins 1996). A review of these utility programs, entitled *What Does a Negawatt Really Cost?* by Paul Joskow and Donald Marron (1992) notes that many economists have expressed considerable scepticism regarding the more optimistic estimates of the magnitude of the net savings in both electricity and total societal resources that can be achieved by these programs.

A special issue of Energy Policy, in April 1996, was devoted to reviewing the success or failure of utility energy conservation programs. It concentrated on whether utility programs can correct the claimed 'market failures' existing for energy efficiency measures. Ronald Sutherland (1996) concluded these programs had failed due to a misconception about the existence of 'market failures'. He stated that conservation programmes do not reduce market failures but instead *may exacerbate inefficiency by increasing market or regulatory failure*.

In the UK this debate surfaced at the British Institute of Energy Economists' Conference at Warwick in December 1995. At the session on energy efficiency Eric Price, a former economist with the Department of Energy, disputed all the arguments put forward to justify Government intervention. He concluded (Price 1995) that *arguments based on imperfect market structures, imperfect knowledge, and learning curve advantages of encouraging innovative energy efficiency products are no more valid in the energy sector than elsewhere*.

Ecological Economic

Not only mainstream economists, but also those working on environmental issues, accept that improving energy efficiency does not lead to reduced energy consumption. David Pearce, the leading British environmental economist, comments succinctly when he writes (Pearce 1998):

> "*...the point is that energy conservation lowers the real price of energy and thus induces an energy demand expansion...this is a combination of substitution effects (substituting cheaper energy for other things) and income effects (cheaper energy releases income which then gets spent on other energy-consuming things)."*

Two environmental economists, Mathis Wackernagel and William Rees in their wide acclaimed book *Our Ecological Footprint*, and in a journal

article explicitly make the point that '*technological efficiency may actually lead to increased net consumption of resources*' (1997). Both in their book, in Box 4.1 entitled *Will Efficiency Gains Save Resources*?, and in their 1997 paper they extensively quote Jevons, and cite the work mentioned earlier by Saunders (1992).

Interestingly they also note that in contrast to the now current official consensus of "the gospel of global efficiency" (Sachs 1988), some leading environmental writers such *The Limits to Growth* team (Meadows et al 1972 and its follow up (Meadows et al 1992) and Lester Brown have recognised the limitations of increasing efficiency on resource use.

Lester Brown and his colleagues (1991), all well known US environmental authors, using the example of rising US gasoline consumption despite increased auto efficiency, state that '*continuing growth in material consumption...will eventually overwhelm gains from efficiency causing total resource use...to rise*'.

As Wackernagel and Rees conclude:

> *Ironically then, it is precisely the economic gains from improved technical efficiency that increase the rate of resource throughput. Micro-economic reality demands that these efficiency gains be used to short-term economic advantage. Far from conserving natural capital or decreasing ecological footprints, this leads to higher consumption. In a globally interlinked economy, the question then becomes: Can we afford cost-saving energy efficiency*

Environmental history

B W Clapp, an economic historian, who is completely outside this debate concurs with Jevons. In his book *An Environmental History of Britain* (Clapp 1994) he writes in the section entitled 'The Demand for Energy' ...*it is a regrettable fact that efficiency is never so complete as to lessen consumption. Economists from Jevons onwards have noted with perverse satisfaction that economy cheapens, that cheapness extends the market, and that measures of conservation or economy therefore increase, or at least do not diminish, the consumption of energy*.

Empirical Evidence

A number of studies have been done to determine the impact of improved efficiency on energy use. In the USA a major study, for energy processes over the period 1880-1970, was done by Sam Schurr (1960, 1983, 1990). Lee Schipper and his colleagues (Schipper 1987, 1992, 1997; Howarth et al 1991, Greening 1997) have done much pioneering work on energy trends for OECD countries on a sectorial level for the

period 1970-1995. However no similar work, to that done in the USA, exists (to my knowledge) for the UK.

Howarth stresses the importance of analysing historical data, and to thus determine long-term trends in energy efficiency and economic activity (Howarth 1997). He writes:

> *Historical data from the Unites States for the period 1929-1970 shed interesting light on this question. During these years, energy prices were falling gradually through time. One therefore may attribute the energy efficiency improvements that occurred during this period to technological change as opposed to price-induced substitution*

The main problem is in measuring energy efficiency (Herring 1996). Its two indicators, energy intensity (energy use per unit output) and the energy coefficient (the output elasticity of energy consumption), can give false signals. Schurr maintained that allying capital and labour inputs with new injections of energy into economic systems can increase the productivity of both capital and labour. This results in a fall in energy intensity due to a larger denominator in the shape of higher economic output. This can deliver a false message when in fact there have been no change in the efficiency of conversion of fuel to useful heat and work.

Nevertheless it is accepted that there is a steady long term trend in efficiency improvement in the economy, due to the 'vintage effect'. That is the tendency for new plant and appliances to be more efficient than those they replace. Thus it is limited by the rate of stock turnover and the rate of additions to stock, generally due to economic growth.

Schurr's empirical findings (1982) was that for the period 1920-1953 new technologies, often using electricity, not only raised the productivity of labour and capital but also improved energy productivity - that is reduced energy intensity. Energy efficiency improved at the same time as energy consumption rose and economic output increased. But total output grew at a faster rate than energy intensity declined, so total energy consumption increased. It was only in exceptional circumstances, such as the 1979 oil price hike, that energy productivity exceed multifactor productivity - which actually fell at that time due to economic recession.

Other work examining US energy data is by Bill Hogan and Dale Jorgenson (1991). They looked at time series data on energy intensity for large number of sectors and found that there is a trend of increasing energy intensity, once price effects are carefully taken out.

Schurr (1985) also found that energy efficiency increased more rapidly at times of low energy prices, and Brookes (1993) said this was because

technological progress of all types is likely to flourish when the availability of an important resource like energy is high enough (and price is thus low) to stimulate economic growth.

Howarth, however is sceptical. Commenting on the US data for 1929-1970 he writes (1997):

> *To accept the Khazzoom-Brookes hypothesis as an empirical generalisation, one must therefore assert that improvements in energy efficiency were responsible for a full 29% of the increase in gross national product that occurred during this period. Claims of this sort, however seem palpably implausible*

Biophysical economics

Another approach to analysing historic changes in energy intensity is by Robert Kaufman, a biophysical economist writing in the journal Ecological Economics (1992). He argues that the system boundaries used by neoclassical economists cannot be used to translate energy saved at the microlevel to energy saved at the macrolevel. He concludes "*substitution and technical change have had relatively little effect on the amount of energy used to produce a unit of real GDP in France, Germany, Japan and the UK during the post war period. Instead, most of the changes are associated with shifts in the types of energies used and the types of goods and services consumed and produced*".

Kaufman warns that "*...the link between economic activity and energy use is stronger than believed by most neoclassical economists, and attempts to reduce the environmental impacts of energy production and consumption will be more expensive than is commonly assumed*".

Energy Analysts

Energy analysts, who had previously ignored the macroeconomic effects of energy efficiency policies are now beginning to consider them. This is in contrast to the long and acrimonious debate about the extent of microeconomic effects - the consumer "rebound" effect - notably between Amory Lovins and Daniel Khazzoom in the pages of The Energy Journal .

Lovins (1988) has maintained that the 'rebound' or 'takeback' effect by consumers, of energy efficiency gains is minimal, whereas Khazzoom (1987, 1989) argues his analysis is completely mistaken, as it does not take into account macroeconomic responses to implicit changes in energy price caused by efficiency improvements.

Lee Schipper and his colleagues have conducted a major study on the energy intensities and the development of energy indicators for OECD countries, which was published in a special issue of Energy Policy. He

states that much of the change in each energy intensity is related to changes in efficiency, once structural effects are eliminated (Schipper & Haas 1997). While acknowledging that energy intensities have significantly declined since 1970 he concludes that '*...current emissions targets, expressed as a return to the 1990 level of emissions for most countries, will be hard to meet unless the rate of intensity decline approaches that of the early 1980s, which is unlikely*' (Schipper et al 1997, p671).

His colleague William Golove and he, conclude that this is because changes in the levels of economic activities have tended, all other factors being equal, to increase emissions, whereas declines in energy intensity and shifts in fuel mix have tended to restrain emissions (Golove & Schipper 1997, p803).

The role of the 'rebound effect' is acknowledged by two energy analysts, Lorna Greening and David Greene (1998), colleagues of Lee Schipper. They state in the abstract of as yet unpublished paper:

> *...gains in the efficiency of energy consumption will result in the effective reduction in the per unit price of energy consumption for both firms and consumers. As a result, consumption of energy should increase, partially offsetting the impact of the efficiency gains on fuel use*

- However after looking at extensive evidence on the microlevel and highly uncertain evidence at the macrolevel, they conclude (p44) that:

> *"...most or all of any reductions in energy use or carbon emissions are not lost to changes in behaviour. This leads us to the conclusion that the rebound is not high enough to mitigate the importance of energy efficiency as a way of reducing carbon emissions. However, climate policies that rely only on energy efficiency technologies may need reinforcement by market instruments such as fuel taxes and other incentive mechanisms. Without such mechanisms, a significant portion of the technological achievable carbon and energy savings could be lost to the rebound".*

3. British Policy Debate

There was a heated debate in the 1980s about the role of energy efficiency in national energy policy, firstly as a means of ensuring national energy security in times of high oil prices, and more recently as a means to combat global warming.

In the early 1980s Andrew Warren from the lobby groups ACE, argued that energy efficiency was the 'fifth fuel', but this concept was denounced by Nigel Lawson when Secretary for Energy. At the 1982 BIEE/IAEE Conference he said (Tempest 1983):

> *"There is a tendency to talk of conservation as an alternative to supply. But this is misleading. Conservation is in no sense a source of energy. Rather it is a lever on demand - a way for the consumer to cut his costs."*

When global warming became a political issue after 1988, economists like David Pearce argued for a cost-benefit approach. He and his colleague David Barbier, called for estimates to be made of the damage caused by global warming and for it to be offset by higher fuel prices through a carbon tax and tradeable permits (Barbier & Pearce 1990).

Regulatory Policies

Regulatory policies have been based on a mix of classical economic theory on externalities (use of taxes) adjusted to pragmatic solutions (tradeable permits). Pigou, a pioneer of welfare economics, argued that externalities should be internalised by taxes where the relevant activity caused external (e.g. environmental) damage and by subsidies when an external benefit was conferred (e.g. when public transport relieves road congestion).

Policy makers have relied on a variety of pragmatic solutions: banning or regulating practices that have adverse external implications (e.g. smoke control policies), establishing property rights and suing where appropriate, and use of market instruments, like taxes and tradeable permits.

Government Policy

The Third Conference of the Parties to the UN Framework Convention on Climate Change met in Kyoto, Japan, on 1-12 December

1997. This Kyoto Conference was the latest in a series of international conferences at which national governments put forward policies to reduce national emissions of greenhouse gases, mainly carbon dioxide (CO2).

The UK Government has a target of a 20% reduction, below 1990 levels, in CO2 emissions by 2010 and has put forward a policy of promoting the efficiency use of energy in order to lower energy use and hence reduce CO2 emissions. However the Government has no plans to introduce energy taxation, except to increase duty of road fuels above the rate of inflation.

The impact of deregulation of the domestic gas and electricity market is likely to reduce energy prices, as it has done in the deregulated industrial and commercial markets. Thus government efforts to promote energy efficiency will take place against a background of falling energy prices. Current UK policy on increasing energy efficiency is likely to be ineffective, and could possibly be counter productive as it would lead to

greater energy use, and hence more emissions.

4. Can we afford cost-saving energy efficiency?

This is the question posed by the ecological economists Mathias Wackernagel and William Rees. They write (1997):

> "*The answer is 'yes' only if efficiency gains are taxed away or otherwise removed from further economic circulation. Preferably they should be captured for reinvestment in natural capital rehabilitation."*

In other words they propose an environmental tax, which they extend to all resource use (see below).

Natural capital rehabilitation

There has been much work done by ecological economists on investing in natural capital as a prerequisite to 'sustainable development' (Jansson et al 1994). Wackernagel and Rees have played a leading part in this work with their development of the 'Ecological Footprint' method of estimating the natural capital requirements of a sustainable economy. They do not give much detail on policies to achieve natural capital rehabilitation, except to say in their paper (1997).

> *"This can only be achieved in the relatively short term through the institution of resource depletion taxes, marketable resource quotas, and other elements of ecological tax reform (including reductions in income taxes and other penalties on labour)."*

Robert Costanza and Herman Daly give some details of a natural capital depletion tax (1992). They believe that technological progress for sustainable development should be efficiency-increasing rather than throughput-increasing. Furthermore there should be high resource taxes, especially on non renewable energy sources, to stimulate this efficiency shift with the proceeds invested in renewable projects. As they comment such a resource tax would keep both energy efficiency enthusiasts and resource pessimists happy:

> *"Technological optimists who believe that efficiency can increase by a factor of ten should welcome this policy which raises natural resources prices considerably and would powerfully encourage just those technological advances in which they have so much faith. Sceptics who lack that technological faith will nevertheless be happy to see the*

> *throughput limited since that is their main imperative in order to conserve resources for the future. The sceptics are protected against their worst fears; the optimists are encouraged to pursue their fondest dreams."*

Costanza and Daly are under no illusions of the political feasibility of this taxation policy. They conclude that it "*...represents a major shift in the way we view our relationship to natural capital and would have major social, economic, and political implications. But these implications are just the ones we need to expose and face squarely if we hope to achieve sustainability*".

Some classical economists however disagree with this approach on conservation of resources. They argue that the best legacy one can bequeath to the next generation is a high level of real output per capita, and voluntarily foregoing opportunities to that end for mistaken altruistic reasons may be doing a disservice to the next generation. Anthony Scott (1973), in his book *Natural Resources - the Economic of Conservation*, commented:

> *"It is ridiculous to say then that conservation is a movement that has the welfare of the future particularly in mind: conservation will not necessarily increase the future inheritance but simply change its composition from capital goods to natural goods."*

The choice of whether to bequeath natural or (man-made) capital goods to future generations lies at the heart of the debate on 'sustainability', and 'soft' (light green) versus 'hard' (deep green) approaches to achieving it.

5. Conclusions

Many economists of all persuasions, whether pro environmentalist or otherwise, seem united in their conviction that improving energy efficiency through technological means, could by lowering the implicit price, result in increased, not decreased, energy use, an effect called the Khazzoom-Brookes postulate (or hypothesis). This conviction is the result of over a century - since Jevons in the 1860s - of theoretical discussion on resource use, and empirical evidence from historic analysis of energy use in economies.

At the microlevel, energy efficiency improvements do result in reduced energy consumption, though there is often a 'take back' of some of the savings, a process termed the 'rebound effect'. For instance, when insulation levels are improved in low income households, some of the energy savings (due to the higher insulation levels) are taken back in the form of higher comfort levels.

However simply aggregating identifiable savings at the microlevel - even after taking account of the rebound - fails to take into account many macroeconomic factors. For example there is the effect of new consumers previously priced out of particular energy services before they were made cheaper by higher energy efficiency. Overall, macroeconomic analysis leads to the conclusion that even if the economy is made more energy efficient the eventual outcome is for it to use more energy.

A dissenting voice is that of Richard Howarth. He questions both the conceptual underpinnings and the empirical evidence for this effect. According to his model *improved energy efficiency cannot give rise to increased energy use* except under implausible assumptions (Howarth 1997). His model (using a Leontieff formulation rather than a Cobb-Douglas function for the energy service sector) and hence his conclusions, will no doubt will be challenged by other economists.

To resolve this issue is no easy task. Howarth (1997) comments:

> *Sorting out the empirical dimensions of the Khazzoom-Brookes hypothesis...would require detailed models that merge engineering approaches to energy efficiency, microengineering studies of the demand for energy services, and macroeconomic models of savings and investments. The construction of such models is an ambitious task...*

Perhaps the KB hypothesis should be analysed more as history than as economics. Richard Howarth again (1998) makes some very pertinent comments, which may pave the way for future research paths, when he remarks:

> *...the Khazzoom-Brookes hypothesis is most credibly grounded on the story of the steam engine, coal and the Industrial Revolution. In important respects economic history, evolutionary economics, and institutional economics shed more light on this issue than neoclassical growth theory. One can specify growth models that account for the stylised facts surrounding this development, but in a sense the event marked a type of structural change in technologies, lifestyles, and social institutions that transformed economic relationships rather than fostering smooth change in a continuous model.*

Economic policies

This paper presents arguments that energy is only one factor of production. Thus there are no economic grounds for favouring energy productivity over labour or capital productivity. There are a number of ways to reduce consumption of fuels likely to cause long term environmental damage, if that is our goal. We could ban or regulate use

of forms of energy we find objectionable, like high sulphur, coal or orimulsion. We could ration some types of fuel either directly or through the use of tradeable permits - as is proposed for achieving greenhouse gas reduction targets between nations. Or we could impose fuel or carbon taxes.

A problem with environmental taxes, as a means of directly reducing environmental damage, is that they require the taxing authority to estimate the damage associated with energy use and incorporate it in the price. This is a near impossible task that leads in practice to a purely arbitrary level for the tax. Also for goods where the energy demand is inelastic, such as in domestic electrical appliances, the tax has to be continually raised to have any lasting effect. However taxes are very effective at raising revenue which can then be used to compensate for adverse effects.

However most governments are reluctant to introduce such taxes, for fear of political unpopularity and damaging national competitiveness. Instead there are plans in many countries to deregulate national fuel industries and bring about more competitive markets, which are likely to result in lower energy prices, and greater energy consumption.

The reluctance of governments, including our own, to introduce politically unpopular measures, such as energy or carbon taxes, to reduce national energy consumption has led them to emphasise a policy of energy efficiency. This has so far been through voluntary means - such as labelling, voluntary standards and best practice schemes - but it could include compulsory policies, such as regulation and subsidies, to alter consumer behaviour. However this paper has argued that the result of such compulsory policies could not only be an increase in energy consumption but also possibly higher economic growth (depending on the soundness of the energy efficiency measures).

Brookes (1992) argued that the best response Governments can make to a situation of energy constraint, is to allow consumer freedom to respond:

> *It is only at the level of individual consumers - including intermediate consumers producing energy-dependent goods and services - that valid decisions can be taken on how best to reallocate resources following a constraint imposed to serve an environmental end. The constraint might take the form of a physical limit on the use of carboniferous fuels or a tax on them....it would then be up to individual consumers to re-optimise their affairs subject to the new constraint and any other they were experiencing. They might well decide that the best response would be one in which compensating savings were made in unit costs of labour and capital perhaps by raising the productivity of those factors.*

Schipper and Grubb (1998) think that the emphasis given to energy

efficiency policies may be mistaken. They conclude:

> *More generally, our observations, suggest that the whole rebound debate may have overestimated the importance of energy in determining the mix of human and economic activities in an economy...*
>
> *If energy and climate matters, it seems better to internalise our concerns, however difficult they are to express as prices, in carbon and other green taxes.....*

An alternative approach

The British government is committed to 'sustainable development'. Ecological economists have for some years been working on this approach, and have identified the requirement for the maintenance of natural capital. This could be done through resource depletion taxes with the proceeds invested in natural capital rehabilitation.

This could tie in with measures to combat global warming, such as investment in carbon sinks - such as forests - and in non-fossil fuel energy sources - such as renewable energy sources and nuclear power. Carbon taxes could be recycled into natural capital investments and non fossil sources.

Role for energy efficiency

Many economists have argued that there are no economic grounds for favouring energy productivity over labour or capital productivity. Consumers may not make the optimal investment choices due to ignorance or miscalculation, or due to regulatory or institutional obstacles. Here the government, in its role as promoter of economic efficiency, has a role to provide information and to remove market barriers, so consumers can best allocate their resources. They can also legitimately foster technical progress, in the absence of private sector funding, by running national research institutes or funding University research.

Thus energy efficiency becomes a matter for the Department of Trade & Industry, concerned with economic growth, rather than the Department of Environment (now DETR), concerned with environmental protection. Government can also promote energy efficiency on non-economic grounds, such as social welfare, by providing measures to improve the heating comfort of the poor and the elderly.

Utilities, like any other business, will invest in energy efficiency to the extent that it optimises its resources. The UK electricity industry has a long tradition of investing in its own internal energy efficiency, such that the combined efficiency of generation, transmission and distribution has increased 10 fold this century. The UK Government is also supporting,

through its aid programme, modernisation of overseas utilities through efficiency investments to reduce losses.

A Personal View

The question I posed in the Introduction 'does the promotion of energy efficiency (at the microlevel) reduce energy consumption (at the macrolevel)'?, is like most economic questions, impossible to prove either way. Economists are divided over whether this is true on theoretical grounds, and in their interpretation of the historic data.

However the blanket statement, such as adopted by many environmentalists and the UK Government, that a policy of improving national energy efficiency will lead to lower national energy consumption is too simplistic and likely to prove false. A more feasible way to cut energy consumption is through energy taxes and regulation, but these involve economic costs to society. Cost-effective improvements in energy efficiency may, however, improve our economy such that we can easier afford the shift to less carbon intensive fuels, such as gas, renewables or nuclear.

Regretfully I have to end with the lame lament that 'more research is needed'. Governments should, in the meanwhile, continue to promote energy efficiency on both economic and social welfare grounds. For high levels of energy efficiency are an essential part of a dynamic productive economy with a high 'quality of life'. Low economic productivity and energy inefficiency go hand-in-hand with a low 'quality of life' as the former Soviet Union demonstrates. Encouraging efficiency, in all factors of production, will result in a higher 'quality of life' and enable us to fund the transition to 'sustainable development'.

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