Dealing with Rebound Effects

Conference or Workshop Item

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Abstract

Energy efficiency has failed to deliver its promised savings. This is mainly because of the rebound effect. Whilst there has been some energy savings on the micro level (rebound is less than 100%), on the macro level energy use has continued to increase despite large increases in energy efficiency. This is because we choose to convert the financial savings from energy efficiency into greater consumption. However energy efficiency still has an important role, in that we can use its financial gains to fund renewable energy sources. This requires an integrated approach, whereby consumers are sold a package of efficiency and domestic renewable energy measures, often termed micro-generation. This paper first outlines the rebound effect and an anthropological approach to energy consumption that focuses on values of comfort, convenience and cleanliness as the drivers for consumer energy demand. It then presents ongoing research from the Open University on the feasibility and popularity of low-carbon living in the UK. It concludes that the emphasis should be on low carbon life-styles for communities rather low-carbon houses for individuals.

Introduction

Since its first Summer Study in1993, eceee has dedicated itself to creating a more prosperous and energy efficient Europe. Eighteen year later, eceee can feel pride in its achievements, Europe is much richer and use energy more efficiently. While eceee cannot take credit for the former, it can feel a sense of accomplishment for the latter; for its assiduous participation in the policy process has resulted in a whole host of European Directives that have greatly improved the efficiency of buildings and appliances. But there is one area where eceee has not achieved success: that is in reducing European (EU-15) energy consumption, which has increased by over 10% in the last two decades.

Furthermore, it is in the very sectors where our efforts have been concentrated, that energy use has unfortunately risen the most: that is the household, service and transport sectors. In the household sector, since 1993 (to 2008), both electricity and gas use has risen by over a quarter. Surprising, in road transport the growth is less, up about 12%, but aviation use has grown by over 70% giving an overall increase in transport use of 18% (EuroStats 2011). Of course, the reasons for these increases are complex, and include population growth, rising per capita income, technological changes such as greater use of IT, and greatly increased world trade and travel.

Increased energy use would not be a problem if it were not for the threat of ‘global warming’ and the adverse climate changes (expected to be) bought about by our increased emissions of carbon dioxide, from the burning of fossil fuels. Although the European Union takes this problem very seriously, and has set targets to reduce it, progress has been painfully slow with greenhouse gas emissions down by only 5% in the EU-15 countries by 2007 (EuroStats 2010a); although given the current recession we are likely to meet our 8% target by 2010. What is most worrying about this reduction so far, is that only about half the fall is due to cuts in carbon dioxide emissions (the major greenhouse gas). Europe has been most successful in cutting emissions of the minor gases (that constitute less than 20% of green house gases), with methane emissions down by over a quarter, nitrous oxide by nearly a third, and halogens and fluorocarbons by over 90% (EuroStats 2010a). These results for methane and nitrous oxide have come mostly from changes in the waste and agriculture sectors, and in industrial processes.

Thus Europe has made pitifully slow progress in cutting carbon dioxide emissions from our fossil-fuelled vehicles, appliances and buildings in the last 20 years, and has no hope of reaching its 20% target by 2020 unless there is a radical shift in thinking about energy consumption. The old simplistic idea that just improving energy efficiency will (under free market conditions) leads to lower energy consumption needs to be challenged. This paper takes up this challenge and argues that, due to the 'rebound effect', much (if not all) of the energy savings on a micro-level are lost at the macro-level. However rather than abandoning energy efficiency (and winding up eceee!), we should instead use energy efficiency as a tool to finance the transition to a low-carbon Europe. On a micro-scale this requires an integrated policy approach. For instance, consumers are sold a package of efficiency and domestic renewable energy measures, the latter often termed micro-generation. The financial gains from the efficiency measures being used to subsidize the micro-generation. On a macro-scale there could be a carbon tax, used to finance large-scale low-carbon generation.

In the hundreds of papers from the previous nine Summer Studies there has been hardly any mention of the rebound effect (apart from this author in Herring et al 2007). Thus he greatly welcomes the opportunity to formally discuss this topic, and hopes it will stimulate debate and further reading.

What is the rebound effect?

In the last five years there has been a great deal written on the 'rebound' (or 'takeback') effect. There was a major five-volume report by the UK Energy Research Council, which really legitimized the current debate, particularly in government circles (Sorrell 2007; Sorrell et al 2009). Two books then followed that presented evidence from a wide group of authors (Herring & Sorrell 2009; Polimeni et al 2008). This year there will be a comprehensive review from the Breakthrough Institute in the USA (Jenkins et al 2011) and a policy report for the European Union (Bio 2011). There is also an increasing amount of academic literature, dating back to 1980s when the debate was referred to as the 'Khazzoom-Brookes Postulate' (Khazzoom 1980; Brookes 1990; Saunders 1992; Herring 1999). This paper does not intend to discuss the evidence for, and the nature of, the rebound effect, which has been done to great effect by the above authors. Rather it will outline the concept and focus on the implications for a low-carbon society.

The rebound effect is concerned with the question 'Do improvements in resource productivity lead to lower consumption?' That is if you make something more efficient –use less resources for the same output—does you consumption of resources decline on the macro or national level. Of course on the micro –or local level—resource use declines otherwise you would not make the investment. If an energy efficiency investment does not produce savings then you can rightly feel a victim of fraud or incompetence, but is this true on the national level? The debate over the impact of resource efficiency dates back to the mid nineteenth century or even beyond. The debate by the early economists was over the impact of industrialization: craft workers were indeed being made redundant by new steam-powered technologies, so did unemployment rise because of these labour saving inventions? This debate again surface in the 1970s with the rise of computers: mass unemployment was forecast by some as automation took over. However, that labour debate is now over, and we accept that labour-saving inventions or greater labour productivity leads to increased prosperity and more employment.

However for energy the debate is still being waged, and has been since the 1860s and the publication of Stanley Jevons' famous book 'The Coal Question' in which he argued that economy in energy use leads not to a reduction but an increase in energy use, an observation often termed the 'Jevons paradox' (Alcott 2005). This observation we now call the 'rebound effect'. But most governments and environmentalists still believe that the way to reduce national energy use and hence reduce carbon emissions (and save the world) is to be more energy efficient. But what is the different between energy and labour (or capital or land) as a resource? Why do we accept for everything but energy, the observation --- grounded in centuries of data—that improved efficiency leads to greater resources use?

Rebound effects are a normal occurrence in economic life. Improvements in efficiency due to technical change makes goods and services cheaper, so we can and generally do buy more of them. Think air travel, the arrival of low cost airlines, like Easy Jet, or Ryanair, has lead to an explosion of short break holidays overseas. The same with energy. If the cost of energy services, such as heating falls, we can afford to use more, by heating our rooms to higher temperature, or for longer periods or heating more of the house (the direct effect). Or we could also use the money saved to buy other goods and services that use energy (the indirect effect). The saving on heating can be used for a holiday with Easy Jet (Gillespie 2009)! Here are diagrams from the UKERC Report of these direct rebound effects for car travel and for a steel producer (Herring & Sorrell, 2009, 6):

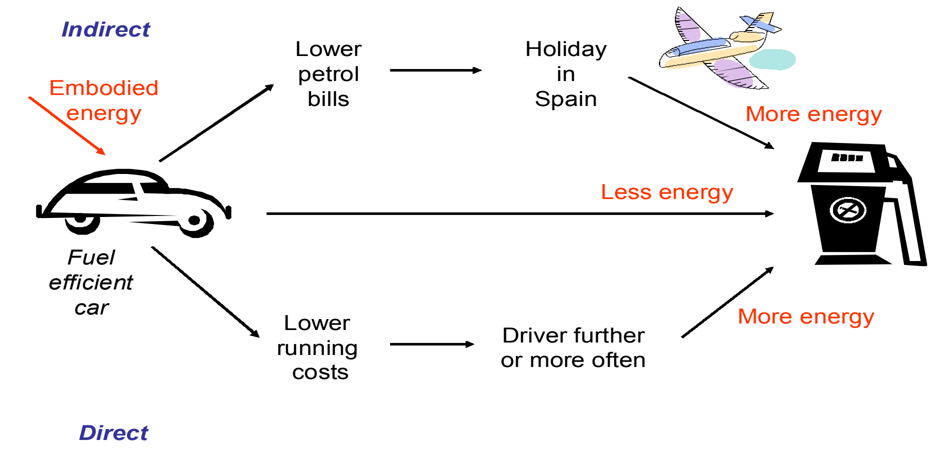

Figure. Illustration of rebound effects for consumers

For producers more efficient production processes (such as in a steel industry) result in both a lower cost commodity (cheaper steel), and for products made from that commodity (e.g. cars). Cheaper steel results in greater sales, and hence more production; cheaper cars result in more car sales and greater car travel. The end result is greater energy use (in the long run) that can outweigh the original efficiency savings.

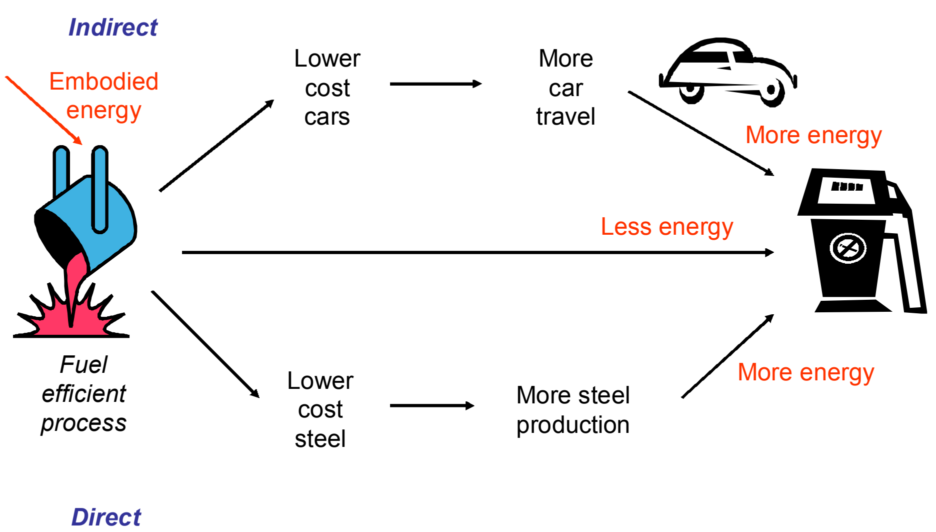

Figure. Illustration of rebound effects for producers

So we take back some of the savings. But how much? That is the key question, do we use only part of savings (rebound of less than 100%) or does efficiency encourage us to consume more energy than we would have done, a rebound of more than 100% or called ‘backfire’. The rebound effect is linked to the big policy question: why does energy use continue to grow despite large increases in energy efficiency? Is energy efficiency a credible policy to reduce energy use, and hence carbon emissions? Is it we have not promoted efficiency enough--the view of most greens lead by Amory Lovins and Ernest von Weizsacker (1997; 2009) or is promoting efficiency a mistaken policy (argued by Len Brookes 1990)? Or do we not understand enough about how we use energy, a point made by numerous authors in their papers to the ‘Behaviour’ Panels at eceee Summer Schools, and well articulated in a classic paper by Hal Wilhite and his colleagues (2000), and later by Benoit Lebot and his colleagues (2005). Or should energy efficiency be promoting energy conservation or sufficiency, rather than growth, a debate that is just starting on the eceee website (Calwell 2010; Nilsson 2010).

Like most economic questions there is no definitive answer! It all depends on the technology and energy services you are dealing with. But it is clear that energy efficiency has an impact on economic growth, and that it is very difficult to decouple energy from economic growth. So unless we have a very drastic change in energy-efficiency policies, and given we want more economic growth, in the future it is very likely we will be using more energy than now. So what can we do about it? Can we really have ‘sustainable consumption’ through changing our consumption lifestyles, by its three strategies of consuming more efficiently, consuming differently or consuming less (Jackson 2006)?

This third strategy, consuming less, is called ‘sufficiency’, or in the US ‘simple living’ or voluntary simplicity’, or more generally ‘downsizing’. That is to voluntarily decide to consume less (and generally differently), generally by deciding to earn less. The story is that we quit our highly stressed and well-paid job as a financial traders earning 100Ks Euros and become organic farmers earning 10K Euros. We swap money and hedonism for leisure and simplicity. If enough people did it, the argument goes, then the UK and global consumption of resources would fall.

Why consume

But first before I talk more about these energy strategies of efficiency and sufficiency, I would like to pose the question of why do we consume energy? And here I am going to take an anthropological approach to the question of consumption, which is influenced by the works of Mary Douglas and her colleagues, and subsequent ‘energy-anthropology’ writers like Hal Wilhite (2005), and also the socio-cultural approach of Elizabeth Shove (2004). So why do we consume? As Mary Douglas observed (Douglas et al 1998, 202):

> A person wants goods for fulfilling personal commitments. Commodities do not satisfy desire: they are only the tools or instruments for satisfying it. Goods are not ends. Goods are for distributing, sharing, consuming or destroying publicly in one way or another. To focus exclusively on how persons relate to objects can never illuminate desire. Instead research should focus on the patterns of alliance and authority that are made and marked in all human societies by the circulation of goods. Demand for goods is a chart of social commitments, graded and timetabled for the year, or the decade, or the lifetime.
>
> …The main objective of consumption is the desired pattern of social relations. The material objects only play an ancillary role; goods are battle standards; the draw the line between good and evil; and there are no neutral objects.

A completely different interpretation to the standard economic model of people as rational profit (or utility) maximising individual. Rather people as social beings located in a particular culture

And I interpret their writings in the following diagram:

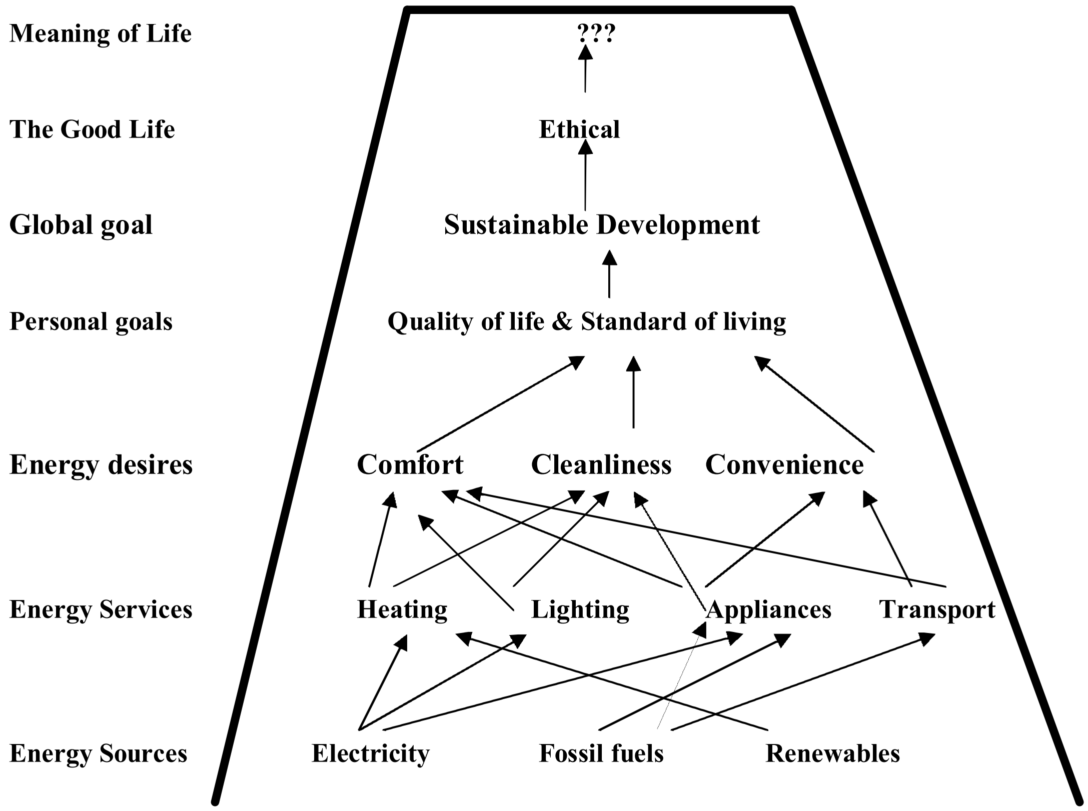

Figure. Diagram of the hierarchy of energy needs.

As many energy authors have pointed out people want to consume energy services rather than energy sources. That is we want better heating, hot water, refrigeration or lighting rather than more electricity and gas. But fewer authors ask why we want energy services; what are the reasons for our desire for heating or hot water? One who has is Elizabeth Shove, and she groups the ultimate purpose of energy services into the trio of comfort, cleanliness and convenience. These are not only physical factors, but also psychological and ethical ones. And, going further we can ask why we want more comfort or convenience? Is it to improve our 'standard of living' or 'quality of life'? The former is a more objective concept and can be expressed in physical or monetary terms, while the later is more subjective and is heavily influenced by environmental and ethical concerns. And above this desire for a good quality of life may be ethical or religious concerns, our search for the meaning in life.

Comfort and convenience can be seen as individual, materialist values, heavily promoted by a consumer culture. But cleanliness is more a cultural or social value, and plays a major role in religious teachings, with their notions of purity in food and behaviour, especially sexual. It also plays a major role in environmental thinking, with its concept of man-made pollution versus natural purity. Hence the relevance of Mary Douglas' famous work *Purity and danger: an analysis of the concepts of pollution and taboo*. The worst insult you can level against people is that they are 'dirty', and this is, and has been used, to justify discrimination and persecution of social and ethnic groups. It is also heavily marketed by energy companies: clean electricity versus dirty coal, or by greens: clean solar against dirty nuclear. So the concept of cleanliness (and pollution) is a key battleground in the public acceptance of energy sources.

So to influence or change our demand for energy requires knowledge of people's intermediate and ultimate concerns. Do more efficient light bulbs fit in with people's desire for greater convenience? Do solar water heater tally with people's desire for greater cleanliness? Do government adverts advising people to turn down the thermostat by 1ºC resonate with our desire for comfort? Do appeals to consume less strike a chord with people wanting to improve their quality of life?

Comfort, cleanliness and convenience

Once this hierarchy of motives is accepted, then paradoxical energy efficiency actions can be more easily understood. Installing double-glazing in the UK has been more popular than cavity wall or loft insulation despite its higher cost and worse economic return. This can be explained by the (perceived) comfort and cleanliness it brings, the convenience of installation, and its visible social prestige--again another source of comfort. Again with solar-water heating, an important factor in its installation is its (perceived) cleanliness: that is the hot water comes from solar energy considered as a non-polluting and green energy source compared to electricity or gas, as the work of Sally Caird & Robin Roy (2008; 2011) shows.

These three concepts of comfort, cleanliness and convenience are, I believe, powerful ways to analyse and explain energy behaviour. Unless we are a fanatic, we are unlikely to trade two values for the sake of improving one. Doing the weekly shopping at the out-of-town supermarket by bus, instead of by car, is a completely unappealing proposition—it is far less convenient and comfortable for only a little gain in cleanliness (less environmental pollution). A more appealing alternative is to use the internet- far more comfortable and convenient and its un-cleanliness is hidden from us.

Another example, loft insulation is inconvenient, if it is hard to find a contractor and you have to clear the loft of your junk, for a little gain in comfort and cleanliness. Hence something you are likely to postpone to a more convenient time, such as when moving in. And again, people are not comfortable about living next to a nuclear power station, despite its clean rhetoric. It inconvenience for investors (long pay-back time and high uncertainty), so results in the public and investor ambivalence. Hence few get built, compared to wind farms that are more convenient for investors, and more comfortable for the public.

Rebound in practice

So with these concepts in mind lets get back to the rebound. Here is a diagram from the UKERC Report (reprinted in Herring & Sorrell, 2009, 8):

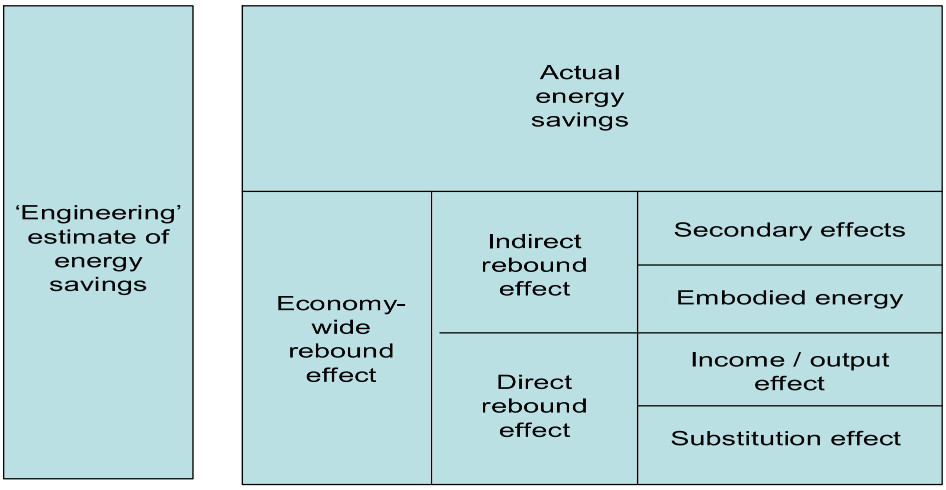

Figure. Classification scheme for rebound effects

The direct rebound effects are the most easy to measure, and unless energy demand has been constrained, are about 10-30%. Only if energy demand has been constrained due to lack of appliances, and there is pent up demand, as occurs with those previously living in fuel poverty, or people living without access to electricity supply, will there be rebound of > 100% or backfire. So where demand is saturated, or we have (nearly) enough, like the house is warm enough and lights bright enough, rebound will be low. So efficiency improvements targeted to rich consumers will be more effective than to poor ones.

The indirect rebound effects are far more difficult to measure. They are estimated using various econometric models, producing a wide range of results including backfire, generally in developing countries. For the UK one model shows economy–wide effects of 30-50%, with rebound declining over time. However like all models the results are sensitive to assumptions made (see Herring and Sorrell 2009, Chpt 4).

So to sum up, with a lesson from history from a great book, *Heat, Power and Light* with its 700 years of data on energy services in Britain (Fouquet 2008). In the last 500 years, the price of energy services has fallen dramatically due to more efficient technologies, and consumption has risen the most where efficiencies have increased the greatest And the one service where prices have fallen nearly a hundred fold, in the last century is today the service where further falls are still expected due to new technologies. That is in lighting. So are we using less lighting due to this incredible achievement in efficiency, with further increases expected from LEDs? (Tsao et al 2010) No not at all, during the 20th century, lighting efficiency increased nearly 70 fold, while consumption per capita has risen over 75 times in a period when GDP per capita increased only 5 fold (Herring & Sorrell 2009, 140). Lighting is now so cheap and ubiquitous that some people complain about 'light pollution'–so much street lighting that they are not able to see the stars at night. And in the UK domestic electricity use for lighting, has increased by over half in the last 30 years, despite the widespread use of compact fluorescent bulbs, which are 75% more efficient. (Everett & Herring 2007)

So in conclusion, the rebound effect is real and significant. In policy formulation allowance should be made for its effects, and there is a need to target policies better on saturated energy services and richer income groups. However promoting energy efficiency on its own is unlikely to lead to an absolute reduction in national energy use unless we have a steady-state (or no-growth) economy.

Low-carbon living

In the UK, the Government plans to achieve an 80% reduction in greenhouse gases emissions by 2050 on 1990 levels. Currently UK homes use nearly a third of delivered energy and produce over a quarter of total CO_2 emissions. If personal transport is included the figure rises to about 40% of total CO_2 emissions. If consumption of goods and services (including imports) is added, UK households are estimated to account for three-quarters of national CO_2 emissions. The remaining emissions are due to government expenditure (11%) and capital investment (13%). These figures are based on a number of studies of the composition of personal and household carbon footprints, by the RESOLVE group at Surrey University, the Design Innovation Group at the Open University and the Carbon Trust (Druckman and Jackson 2009, Roy 2009, Carbon Trust 2006).

These UK studies have been summarised by Robin Roy at the Open University who estimates that the main elements of an average carbon footprint in industrialised societies are (Roy 2011):

- Transport (especially personal car travel and holiday air travel) – about 24% of an average total personal or household carbon footprint;
- Domestic space and water heating – about 20% of the total;
- Provision and use of services (insurance, finance, medical, recreation, hotels, education, water and telephone, etc.) – about 18%;
- Food and drink consumption (including agriculture, processing and distribution, catering, food imports and exports) – about 12%;
- Purchases of consumer goods (clothes, shoes, domestic appliances, furnishings, books, newspapers, etc., etc.) – about 12%;
- Domestic electricity use (for powering lights, appliances, electronics, etc.) – about 8%;
- Housing construction and maintenance – about 6%.

Angela Druckman and Tim Jackson of RESOLVE highlight the significance of travel, with about 10% of the total carbon footprint due to holidays. Two elements stand out with each roughly a quarter of the total: recreation and leisure activities (including holidays), and food and catering (eating in and out).

Eco-homes

While the UK (and other) governments have made many plans for steep reduction in emissions, national progress has been very slow. The most dramatic achievements over the last decade in living a low-carbon lifestyle have come from pioneering individuals, communities and housing providers. These are illustrated in the Open University course U116 (Roy 2009). For individuals the first step in leading a low-carbon lifestyle is in (super) insulating their existing home and installing solar heating: the energy bills is often halved. Other measures include reducing car use or shifting to a hybrid car, buying local food and generally consuming less. However the lure of international travel is difficult to resist, and in some cases the carbon saving from eco-renovating their home is 'spent' on long distance air travel. Generally the lifestyle of these green pioneers—often led without a car or foreign holidays—is considered too extreme for the general public to accept.

More acceptable are new 'green homes' and there are several developments by house builders. Millennium Green, near Newark, Nottinghamshire, was one of the first developments built in 1999-2000, and comprises 24 houses and a business centre for residents. Although the houses are conventional looking, they incorporate many environmental features. Construction materials were chose to minimise environmental impacts, such as sustainable timber, locally sourced bricks and clay drainage pipes. Insulation levels include 150mm insulation in walls and floors and 300mm of recycled newspaper in the roof space, and argon-filled, double-glazed timber windows. Energy demand was further reduced through south-facing windows and installing mechanical ventilation with heat recovery and solar water heating systems. However, despite their low heat demand the houses all have gas condensing boilers and radiators because local estate agents told the developer that potential customers would not buy a house without central heating; and this view was supported by at least some of the early buyers (Roy 2009).

The homes are equipped with a rainwater harvesting system comprising an underground water tank large enough to supply over two weeks supply of water for toilet flushing, washing machines and gardening. To help reduce the need for commuting, high-speed internet connections were provided in the houses and an on-site business centre offers office space to enable residents to work from home. The homes cost about 10% extra but this has not deterred buyers, many of whom were attracted by the green features.

Hockerton

Another early pioneering project was the Hockerton housing project, near Southwell, Nottinghamshire, which is a small community that aims to share some of the cost and effort of living sustainably. The project's five family homes were completed in 1998. The distinctive looking homes have conservatories along the south-facing terrace at the front, which collect solar heat. The interiors are light and modern and stay warm all year with no artificial heating because of the passive solar design, triple glazing and super-insulation, and mechanical ventilation with heat recovery. In 2002, after overcoming opposition from nearby residents, a 5 kW wind turbine was erected, and this, together with a 7.6 kW photovoltaic array on the roof, supplies electricity for lighting and appliances. This allowed each household's energy demand to be reduced to 10 per cent of the UK average (Roy 2009).

There is heavy emphasis on community self-sufficiency, and Hockerton residents produce over half of their food, including vegetables, fruit, honey, eggs and some meat. Each household is only allowed one conventional car, which they try to share, while bicycles and an electric car provide local personal transport. Each household is expected to provide 300 hours per year to work for community activities such as maintenance and growing food. In other words, the project aims to be socially and economically as well as environmentally sustainable. Despite some initial scepticism and opposition to its first wind turbine, over time the project has changed attitudes in the local area. In 2006 a group of Hockerton villagers, helped by project members, got together to raise finance to buy a community-owned wind turbine. A second-hand 225kW turbine was eventually installed on local farmland and in its first year of operation in 2010 generated enough electricity to nearly meet the village's total annual use.

BedZED

Perhaps the most famous ‘green homes’ development is BedZED (Beddington Zero Energy Development), in South London and completed in 2002. It houses about 200 people in 82 houses, flats and maisonettes, each with its own small ground level or roof garden. As many as possible of the construction materials were locally sourced or reclaimed to reduce environmental impacts. The housing uses passive solar designs with south-facing solar conservatories and super insulation. The result is no need for conventional central heating systems, only a towel rail/radiator in the bathroom. One of the most distinctive features of the project is the brightly coloured roof-mounted ventilators that turn into the wind and draw in fresh air and expel stale air from the home and workspaces via a heat exchanger. PV cells on the walls and roofs above the conservatories provide some electricity. With all these energy technologies, monitored BedZED households use less than 20% of the heat and just over 50% of the electricity of an average local resident (Hodge and Haltrecht 2009). Although the rooms are rather small, BedZED’s bright contemporary interiors, conservatories and gardens have proved very attractive, and people are willing to pay about 15% extra for BedZED’s design, cost saving and green features.

A green transport plan was part of the project from the start. Residents’ average car mileage has been cut to a third of the local average by locating the development near bus, rail and tram routes, by restricting and charging for parking spaces, providing onsite workspaces and covered bicycle parking, and having a car-sharing club. However, it has been found that BedZED occupants fly more than average, so that their transport footprint is slightly higher than the average local resident.

BioRegional, a sustainability charity, developed BedZED with the green architect Bill Dunster, and given its success, many of its principles termed ‘One Planet Living’ are being used, elsewhere in the UK, such as in ‘One Brighton’ (in Brighton, Sussex) and ‘One Gallions’, part of a massive redevelopment scheme, east of London called Thames Gateway (BioRegional 2011). These developments were stimulated by the UK government announcement in 2007 that by 2016 all new homes should be ‘zero-carbon’, meaning that over a year each dwelling or development should produce net zero CO_2 emissions. The strategy for achieving zero-carbon is the Code for Sustainable Homes (CfSH), which sets CO_2 reduction targets, and awards points for other features including water saving, low-impact building materials, and waste recycling.

Naturally, there have been technical problems in these developments, and some of the novel features such as heat pumps and wood chip boilers have proved too costly or complex to operate and have been replaced. Even in more mainstream ‘low-carbon’ homes there are problems with construction, that results in heat loss being much higher than expected, and with heat pump performance (Bell et al 2010). A recent analysis of low-carbon homes showed that reducing carbon emissions can be achieved at much lower costs through an approach that enables sustainable lifestyles, rather than focusing purely on energy efficiency measures and renewable energy (Broer and Titheridge 2010). More valuable to the local residents and the wider local economy was good low-carbon transport provisions (walking, cycling, public transport and car-share schemes); access to jobs, amenities and low-carbon consumables; convenient recycling facilities, and a sustainability officer who supports implementation and community cohesion. The last UK government supported the creation of new ‘eco-towns’ and this increased academic interest in low-carbon communities and also in policy circles (Vaze et al 2011). Research has been led by RESOLVE, with many of the leading contributors being published in a book (Peters et al 2010), and a special issue of *Energy Policy* (Mulugetta et al 2010). As one the papers in this special issue states succinctly ‘Without working together, individuals stand little chance of seriously reducing their carbon emissions’ (Heiskanen et al 2010). Thus the creation of low-carbon communities centre around shared interests, practices and structures, but these communities need not be geographical but can also be sector-based, interest or even virtual.

This academic research also overlaps with the more ‘alternative’ longstanding schemes for ecological living as expressed through intentional communities banded together in the global eco-village network. The most famous of these in Britain is at Findhorn in Scotland where four wind turbines (each of 750 KW), produce 100% of the communities needs, with excess power exported to the grid. These intentional communities encourage low energy and material consumption through local production of food, energy and goods, often using a local currency, which encourages strong social bonds and a low consumption ethos (Mulder et al 2006; Herring 2003). These communities are widespread in Northern Europe, and two German eco-villages are estimated to have a 60-70% lower carbon footprint than the national average (Lockyer 2010, 212). They (together with fears about 'peak oil') have inspired the Transistion Towns movement, which started in the UK in Totnes in 2005, and aims to convert existing towns (and urban communities) into low-carbon ones through local action (Hopkins 2008).

As homes get more efficient, the proportion of total emissions from it decreases rapidly-- only 11 per cent of the energy used by a typical UK resident living in a new home is used to heat and light the home (Desai 2004) Thus living in a 'zero-carbon' home is no guarantee of living a low-carbon lifestyle, and emphasis should be switched to tackling problems caused by consumption and travel--especially international air travel (Shorrock & Henderson 2009).

Is sufficiency a solution?

So is it possible to cut consumption? Should we indeed be proposing that we consume less of carbon-intensive goods and services, like foreign holidays? Would the widespread adoption of 'sufficiency' have any impact on global resource or energy use? Remember its goal is not personal but global salvation. Once again the rebound effect has an impact, a point forcefully made by Blake Alcott (2008). He argues that the widespread impact of reducing demand for a commodity (like energy) would be to lower its global price, and allow greater consumption by (marginal) consumers. He remarks 'what was "saved" through non-consumption is consumed after all—merely by others' and that 'The sufficiency rebound then amounts to a passive, rather than intentional, transfer of purchasing power to marginal consumers'.

So would our renouncing of consumption merely allow poorer consumers elsewhere to enjoy a higher standard of living? Energy, especially oil and gas, is a global traded commodity, with a high elasticity of demand, so shifts in trade are easy. Therefore the sufficiency rebound is likely to be very high. Given the lower environmental standards in developing countries, a shift in energy demand from rich to poor countries could result in greater environmental pollution—a point made often by supporters of the Environmental Kuznet Curves. If we use less electricity from our clean coal power stations, will China and India use more in their dirty ones? A complex debate that has only just started.

The sufficiency strategy not only implies earning and consuming less but also consuming differently. Sufficiency, of necessity, brings a change in lifestyle. Energy services will be met in different ways reflecting changed incomes and time availability: travel by bike and bus instead of by car, eating fresh food instead of take-away or frozen meals; washing and cleaning by solar water heaters instead of gas boilers; room heating with wood stoves instead of electric fires. There will be many choices to be made as to how best to satisfy our desires for comfort, convenience and cleanliness—as have been made by the low-carbon pioneers discussed earlier.

Conclusion

Governments are heading, somewhat slowly in the right direction and beginning to acknowledge the links between efficiency and consumption, even if they can't yet face the policy implications of the rebound effect. In a recent EU report, it describes the rebound effect without explicitly naming it (EuroStats 2010b: 55):

> In recent years, reductions in particular forms of energy consumption often tend to cause an increase in other forms of energy consumption, resulting in a volume of consumption that outweighs any gains made through the improved energy efficiency. The increase in consumption is caused in these cases by an increase in the use of goods due to their higher efficiency; or, because energy efficiency results in financial savings for a household, money is available for other consumption and can involve some additional (direct or indirect) energy consumption, offsetting the initial reduction to some extent.

The UK government, since the UKERC report in 2007 on the rebound effect, has started schemes to integrate efficiency and renewables. This ties in with consumer interest in and enthusiasm for domestic renewable or micro-generation schemes (Roy et al. 2008). An innovative approach is PAYS (Pay As You Save) which gives households the opportunity to invest in energy efficiency (such as solid wall insulation) and micro-generation technologies (such as solar panels) in their homes with no upfront cost. Householders make repayments spread over a long enough period so that repayments are lower than their predicted energy bill savings; meaning financial and carbon savings are made from the beginning. The two-years pilot scheme was launched in 2009 for around 500 homes. A variety of measures have been installed including external wall insulation, solar photovoltaic panels, cavity wall insulation and boiler upgrades (EST 2010). Thus the money savings from insulation are being used to subsidize renewable energy (rather than spent on greater consumption), and hence achieves lower emissions.

So to conclude energy efficiency is a good thing, but we must choose wisely how to use its financial benefits: on more consumption as present or for a more sustainable future? And what, you may ask, is this 'sustainable future'? I can't give a clear answer but it is one where we have different notions of comfort, convenience and cleanliness, a world perhaps a bit slower and with less emphasis on personal choice and more on community consumption. And this is initially the work of voluntary organisation and social movements, with governments later providing a regulatory framework. For instance the slow food movement is trying to get us to change our ideas of convenience--faster and quicker is not better--while car clubs challenge conventional ideas about what is comfortable, as do low-carbon housing projects. The message learnt is that recycling is not inconvenient, you can be comfortable not owning a car, and that changes to a green lifestyle are socially acceptable. But the common thread to all these lifestyle changes is the importance of community and social links, and of fashioning a community, rather than an individual, low-carbon lifestyle.

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