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POLICIES TO ACHIEVE DEMATERIALISATION

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A 'Thinkpiece' for the Project of the Sustainable Development Commission

'ECONOMY 'LITE' – CAN DECOUPLING WORK?'

Defining dematerialisation

Dematerialisation may be defined as a decrease in the quantity of resources, measured by mass, being used by an economy. It is clearly related to but is distinct from the concept of decoupling, which is a decline in the ratio of the amount used of a certain resource, or of the environmental impact, to the value generated or otherwise involved in the resource use or environmental impact. The unit of decoupling is therefore a weight per unit of value. *Relative* decoupling means that productivity/efficiency improvements have been realised, but total inputs, or pollution outputs, continue to increase as economic output increases. *Absolute* decoupling refers to the situation in which there is an overall reduction in required material inputs or pollution outputs, even while the economy grows, whether through productivity improvements or through a decrease in pollution, or a combination of the two.

If dematerialisation occurs in a growing economy, then it is indicative of absolute decoupling. If it occurs in a shrinking economy, its relationship to decoupling is unclear. Decoupling may be defined in terms of emissions and other environmental impacts as well as resource use. Dematerialisation is usually only defined in terms of resource use, although, especially in mass balance studies (see below), there is no over-riding reason why this should be so. Obviously both resource use and emissions may lead to environmental impacts, although these are normally considered as an extension to, rather than as part of, the dematerialisation concept.

Three kinds of materials may be defined in an economy. There are virgin resources, those which enter the economy for the first time after their extraction from the natural environment; recycled resources, which circulate in the economy through multiple uses; and materials for disposal (not resources at this stage because they have no economic value). The dematerialisation concept may be applied to any or all of these stages of resource and material use, depending on whether it is the use of virgin resources, the circulation of resources in the economy, or the disposal of materials, that has been reduced. The distinction between these stages of resource and material use is important, because the policies to affect the different stages may be very different.

The rationale for dematerialisation

Dematerialisation, as opposed to decoupling, is not a concept that has received any policy attention in the UK at all. There are no policies that have been introduced with the explicit purpose of 'dematerialisation'. It is therefore important, in thinking about policies that might achieve dematerialisation, to be clear about the purpose of dematerialisation. This may include one or more of the following objectives, associated with the different stages of resource and material use:

1. To reduce the depletion, and therefore extend the period of availability, of a scarce resource;
2. To reduce the environmental impacts associated with the extraction, transport, processing or use of the resource;
3. To reduce the environmental impacts of the disposal of the material at the end of its useful life.

The importance of whole-system life-cycle assessment

In seeking to achieve one or more of these objectives, the assessment or evaluation of the impact of the policy must be carried out in life-cycle terms over a system that includes all the relevant impacts. As the scoping note for this project makes clear, it is possible for a national economy to look as if it is dematerialising, when it is actually displacing to another country the resource use associated with its consumption. If this resource use was included in its inventory of resources, it might not be dematerialising at all. This is not to say necessarily that all resource use should be assigned to the final 'consumers' of those resources (producers get the benefits of producer surplus and employment from their production of exports and so arguably should be assigned some of the responsibility for the resource use), but it is to emphasise the importance of being clear about the system that is being considered, and of ensuring that the system being considered is consistent with and appropriate for the policy objective that is being pursued.

For example, if dematerialisation in one country is being sought to achieve the reduction of carbon dioxide (CO_2) emissions associated with the processing of the materials, and if what is happening is that this processing is being displaced to another country, rather than being reduced, then it is false to conclude from the dematerialisation of the first country that overall CO_2 emissions are being reduced, and of course it is overall CO_2 emissions that are important to the climate change impact associated with them. If dematerialisation is being sought in order to reduce emissions of a local pollutant (for example, sulphur dioxide), and this is achieved by displacing the emissions to another country rather than reducing them, then the policy objective may be achieved (the local environment in the first country will improve), but at the cost of local environmental damage elsewhere, and again this should be made explicit.

Again, if it is the reduction in the use of virgin resources that is being sought, in order to reduce their rate of depletion, or to achieve sustainable use in the case of renewable resources, and this is achieved by increasing recycling rates, then it is important that the full environmental impacts (for example, associated with transport or reprocessing) of the recycling are assessed in order to get a clear idea of the overall environmental change achieved through the policy.

Measuring dematerialisation and some recent results

It was noted above that the key metric for dematerialisation is mass. There has been substantial generation of data through application of the relatively new methodology of material flow analysis, and then applying mass balances through the systems being investigated. Figure 1 shows the headline results of a whole series of mass balance projects implemented in the UK with funding from the Landfill Tax Credit Scheme over the years 1998-2003.

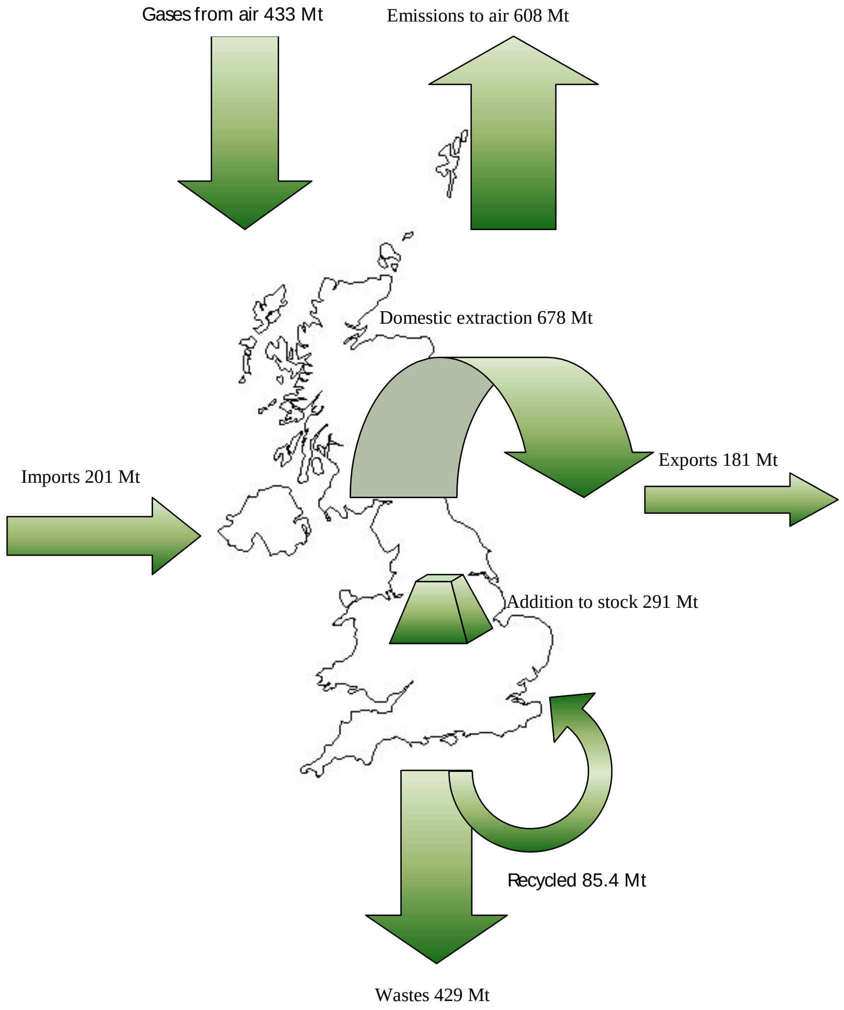


Figure 1: Resource flows through the UK economy in 1998 (Source: Linstead et al. 2003)

In terms of such a diagram, dematerialisation might most obviously be said to be taking place if either domestic extraction or the generation of wastes was being reduced. If emissions to air were reduced, this would probably signal a reduction in the combustion of fossil fuels (the major source of such emissions, which also accounts for most of the gases taken from the air), which might also be considered dematerialisation. It can be seen that in mass terms imports and exports in the 1998 were of the same order of magnitude. It is not clear whether a reduction in only one of these would be dematerialisation, but a reduction in both probably would be. If more wastes were recycled instead of being disposed of, this would strictly only be dematerialisation if this led to reduced resource use or emissions elsewhere (for example, in the use of virgin resources or the flows of energy used in processing them), again calculated on a holistic, life-cycle basis for both the recycling and the alternative resource use.

The new methods for measuring materials flows have resulted in much information organised through new concepts such as Total Material Requirement (TMR), Domestic Material Consumption (DMC) and Direct Material Input (DMI). The Wuppertal Institute has been important in developing these methods and datasets, and carried out the first such analysis for the UK, on commission from DEFRA, in 2001

(Bringezu & Schütz 2001). Through these studies it is increasingly possible to characterise material flows such that it would at least be possible to assess whether or not dematerialisation is taking or has taken place. For example, Bringezu et al. 2004 (p.120) find that, for 26 countries and with the exception only of the Czech Republic , "no significant absolute decline of direct material input per capita has been observed so far in the course of economic growth". However, useful as such studies are, it should always be borne in mind that aggregate mass flows give very little insight into the environmental impacts of these flows. What is required in any but the most headline analysis of an economy's use of materials is a disaggregation of the flows into the various substances of environmental concern.

Moll *et al.* (2003) provide a limited disaggregation into the four main materials by mass to flow through the economy (excluding water) biomass, construction minerals, industrial minerals and ores, and fossil fuels. The flow of these materials through the economies of the EU-15 countries since 1980 has been remarkably constant (Moll et al. 2003, Fig.4-4, p.35). This confirms that, while technical progress tends continuously to improve the efficiency or productivity with which resources are employed, the decoupling has in the main been relative rather than absolute. The productivity or efficiency gains have overall been outweighed by growth in the scale of the economy, and there has been a small absolute increase in a number of both resource inputs and emission and waste outputs.

The UK produced a set of decoupling indicators in 2005 (DEFRA, 2005), under a number of headings as follows:

Economy wide resource consumption

1: Material use; 2: Water use; 3: Land use; 4: Fish stocks;

Economy wide resource pollution

5: Climate change (GHG emissions); 6: Air pollution; 7: Water pollution; 8: Waste;

Household consumption

9: Household water consumption and waste; 10: Household energy; 11: Household vehicle use; 12: Embodied emissions in goods consumed by households;

Production

13: Agriculture; 14: Mining and Construction; 15: Manufacturing; 16: Electricity generation; 17: Road transport; 18: Services and the public sector

The outcomes for these decoupling indicators are shown in Annex 1. It can be seen that many of the pollution indicators are characterised by absolute decoupling, but that this is not true since 1993 for materials use generally. Moreover, the judgement is obviously dependent on the time period chosen. For example, UK CO2 emissions (the main component of GHGs) fell from 1990-2003, but rose from 1997-2007. However, the overall picture is one of generally increasing resource productivity and local environmental improvement (with some exceptions), but no dematerialisation since the early 1990s and difficulties with the reduction of CO2.

Indicator 12 of the DEFRA set relates to the emissions involved in the manufacture of UK imports. Moll et al. (2003) find that the Physical Trade Balance (mass of imports less mass of exports) of EU countries increased from 1.8 to 2.6 tonnes per capita over 1983 to 1999, indicating a shift in the structure of trade, with EU countries importing relatively more material goods. It is conjectured that these imported materials are probably associated with significant emissions in the exporting countries, and Indicator 12 is intended to capture this, but so far no robust methodology to calculate this has been implemented (although one was recommended in Wiedmann et al. 2006).More recently Peter & Hertwich (2008 forthcoming) have calculated that most industrial countries, including the UK, have higher embedded carbon emissions in their imports than in their exports (which they express as a negative Balance of Emissions Embodied in Trade (BEET)). For the UK, they calculate that emissions from production are 618.6 MtCO2, while those from consumption are 721.3 MtCO2. About 132 MtCO2 are embodied in exports, as against 234 MtCO2 embodied in imports, leading to a negative BEET of about 100 MtCO2.

This result was confirmed in the preliminary calculations of Helm et al. 2007. Figure 2 shows their calculations of carbon emissions associated with UK imports and exports, from which it can be seen that the former have grown much faster than the latter.

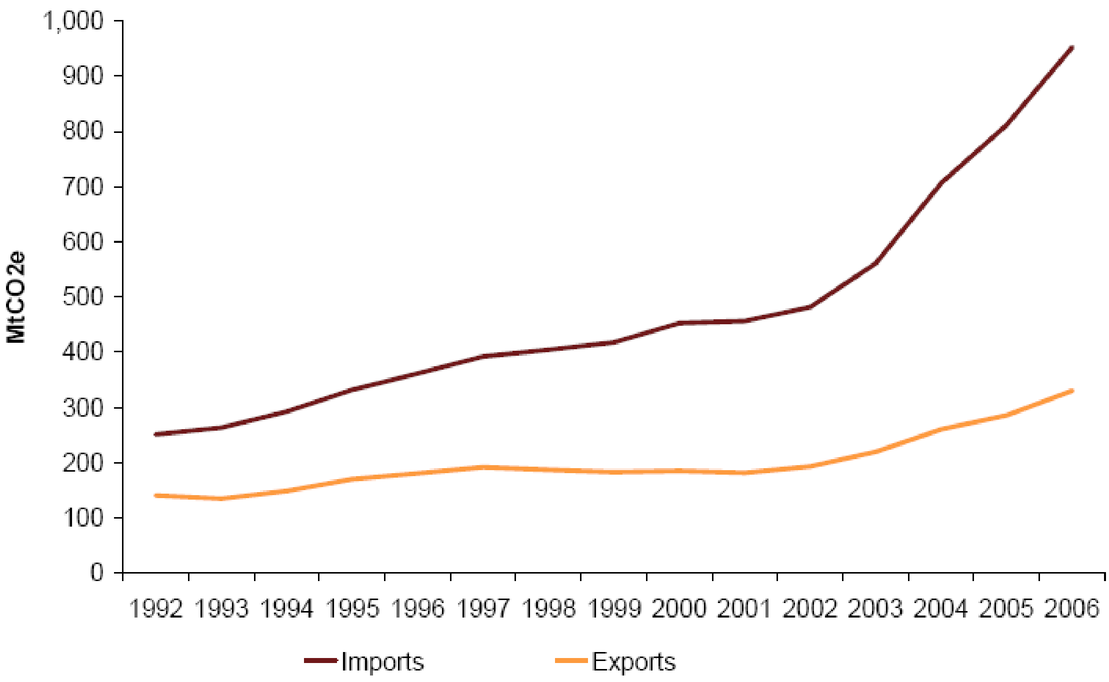
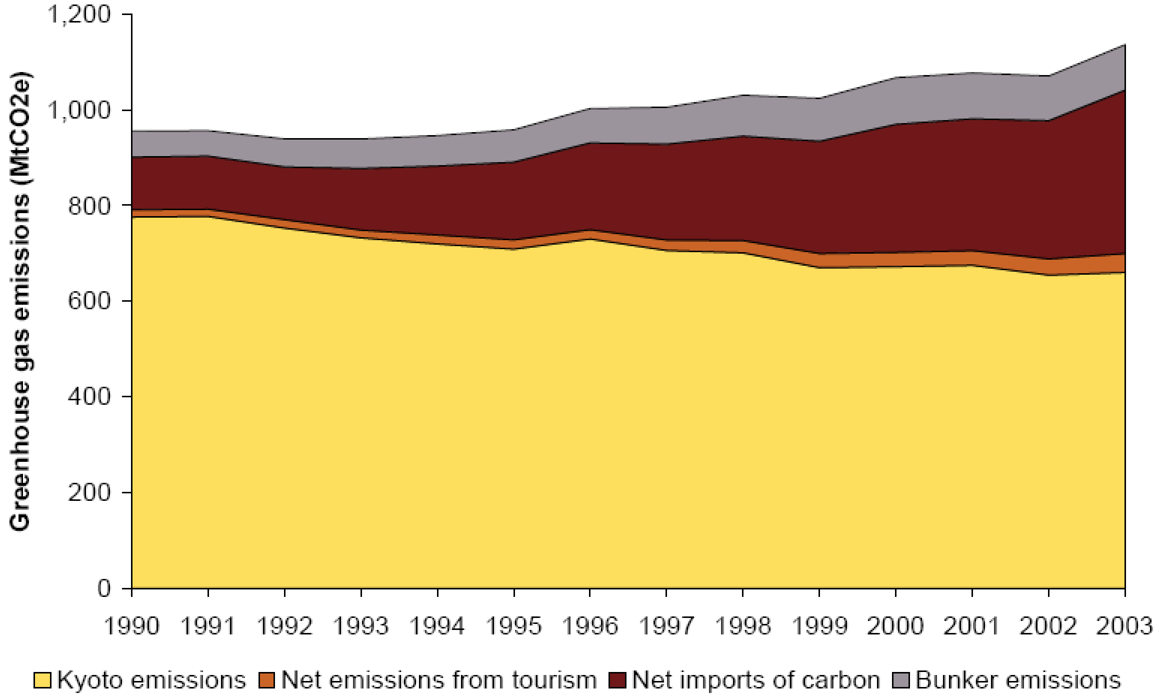


Figure 2: Greenhouse gases associated with UK imports and exports, 1992–2006

Source: Helm et al. 2007, Figure 8, p.20



Note: Bunker emissions include a radiative forcing factor of 3 for international aviation. Source: ONS (2007) and Vivid Economics

Figure 3: UK greenhouse gas emissions on a consumption basis, 1990–2003

Source: Helm et al. 2007, Figure 11, p.24

At present, for the purposes of the Kyoto Protocol, carbon emissions are attributed to countries on a territorial basis, i.e. they are held to be responsible for the emissions from their territories. Clearly shifting patterns of trade, in terms of the CO2-intensity of imports and exports, can result in changes in BEET, resulting in countries that increase their net exports of energy-intensive goods being responsible for emissions that are greater than those implicated in their consumption. Similarly, the consumption of countries whose net imports of energy-intensively produced goods increase over time is responsible for more CO2 emissions than as calculated under the Kyoto methodology. Thus, as shown in Figure 3, on a Kyoto basis, UK GHG emissions fell by 15% over 1990-2003, but on a consumption basis they rose by 19% over the same period.

However, it is not clear that a consumption basis for carbon calculation is actually more valid than the territorial basis of the Kyoto calculations (which include emissions from exports). It is clear that production (and net exports) bestow economic benefits as well as consumption, so that if the allocations of emissions from trade are supposed to reflect economic benefits, they should be shared between importing and exporting countries, but it is not at all obvious what the share of the allocations should be. Moreover, allocating emissions on a territorial basis is far simpler than calculating emissions involved in the production of exports, which requires complex input-output tables containing large quantities of country-specific up-to-date data if the calculations are to be performed accurately. However, it may well be that this is going to be a complicating issue in the negotiations for a follow-up to the Kyoto Protocol, as net exporting countries seek to reduce the emissions for which they deemed responsible.

Categorisation of environmental policies

There are various types of policy instruments which a national government can employ in an attempt to improve the environment. Such instruments may be grouped under four generic headings (see Jordan *et al* (2003), and the same categorisation may be used for policies dematerialisation:

- Market/incentive-based (also called economic) instruments (see EEA 2006, for a recent review of European experience). These instruments include "emissions trading, environmental taxes and charges, deposit-refund systems, subsidies (including the removal of environmentally-harmful subsidies), green purchasing, and liability and compensation" (EEA (2006, p.13).
- Regulation instruments, which seek to define legal standards in relation to technologies, environmental performance, pressures or outcomes. Regulation can also include the imposition of obligations on economic actors, such as the renewable and energy efficiency obligations that have been imposed on energy suppliers in the UK.
- Voluntary/self-regulation (also called negotiated) agreements between governments and producing organisations (see ten Brink, 2002, for a comprehensive discussion). Economic actors may enter into these in order to forestall the introduction of market-based instruments or regulation.
- Information/education-based instruments (the main example of which given by Jordan *et al.* (2003) is eco-labels, but there are others), which may be mandatory or voluntary.

It has been increasingly common in more recent times, as will be seen, to seek to deploy these instruments in so-called 'policy packages', which combine them in order to enhance their overall effectiveness across the three (economic, social and environmental) dimensions of sustainable development. In this paper, policies for dematerialisation will first be explored separately in the different categories, with comments where relevant about the packages in which they have been or can be deployed.

Policy principles for the management of materials

The general principle behind most materials management is that the responsibility for management derives from ownership of the materials, and the ownership of the materials changes according to the ownership of the product in which they are embodied. Thus manufacturers of products surrender ownership of their materials when the product is sold. The owners of materials have the responsibility to process or use them safely. Therefore the final consumers of the product have the responsibility for its disposal in line with the prevailing legal requirements. It is assumed that while the materials have value, their private owners will look after them (with health and safety legislation ensuring safe use of materials at work), so that the only public concern to date has been with the disposal of materials wastes, from products at the end of their lives, or from processes. The policy focus has never been on 'materials management' or dematerialisation, but on waste management.

In the UK until very recently, the presumption was that the vast majority of materials wastes, both from end-of-life products and from the processes of producing them, would be dumped in holes in the ground through the disposal practice known as 'landfill'.

The principle of owner-responsibility of materials, and the institutional arrangements that have flowed from it are an important cause of the UK's historical reliance on landfill as its principal disposal route, and its low rate of recycling compared to most other North European countries. The principle is fundamentally at odds with what has become the formal guiding principle for waste policy in the

European Union, namely the waste hierarchy. This was endorsed in a Communication from the European Commission (EC 1989), which in 1989 provided strategic guidelines for the EU's waste management legislation based on a three-tier hierarchy:

- prevention of waste by improved technologies and products;
- recycling and reuse;
- optimisation of final disposal.

Figure 4 illustrates gives a somewhat more detailed illustration of the waste hierarchy.

The waste hierarchy makes immediately apparent that the dematerialisation options (prevention and minimisation) are the most favoured in the hierarchy. These options are also effectively ruled out by the owner-responsibility principle, because once owners of materials wastes wish to dispose of them, prevention and minimisation are no longer possible. It is also the case that final consumers of products generally know least about either the products' material contents or how these materials might be re-used or recycled. So that it is not surprising that owner-responsibility has led to heavy reliance on landfill in the UK, and landfill and/or incineration in many other countries.

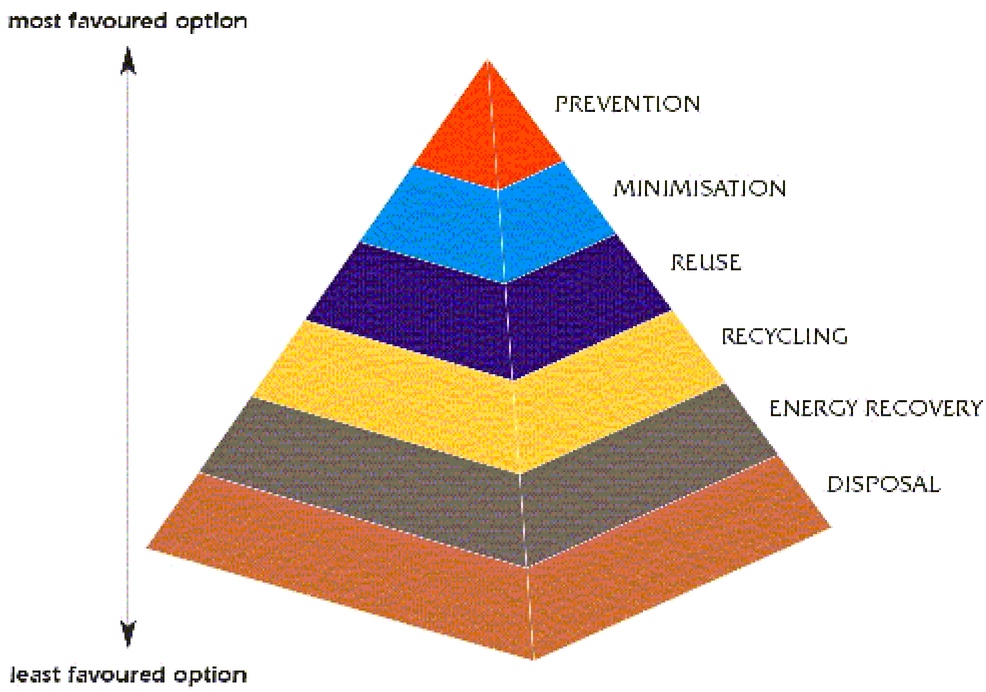


Figure 4: The Waste Hierarchy (Source: www.repak.ie/best_practice.html)

During the 1990s it became increasingly obvious that owner-responsibility for materials (or wastes) would not achieve waste prevention and minimisation (dematerialisation), and two new approaches were introduced and combined: the conceptual switch from owner to extended producer responsibility

(EPR)[1], whereby producers retain the responsibility for the management of the materials in their products when they becomes wastes; and the Priority Waste Streams Programme (PWSP), which in subsequent years has produced Directives or regulations on packaging, used tyres, end-of-life vehicles, batteries and waste electric and electronic equipment, specifying that producers of the materials in these streams have responsibility for them, and have to achieve certain minimum rates of recycling or re-use. It is hoped in this way to introduce the incentive for producers to find ways to reduce the quantity of materials in their products, and to make the products of materials and components that are relatively easier to recycle.

Different EU countries have implemented the EPR directives in very different ways, and it is beyond the scope of this paper to give a detailed review of this implementation. However, so far it is undoubtedly the case that in many countries the Directives have done much to increase the recycling rate of affected products; but there is very little evidence that they have achieved anything in terms of dematerialisation beyond what would have been achieved anyway. However, there is little doubt that conceptually EPR is a more effective materials management approach, which is more likely to lead to dematerialisation, than owner responsibility. Whether it does so depends on the detailed policies through which it is implemented.

Broader still than EPR are policy approaches that seek to link production and consumption, such as the Sustainable Consumption and Production (SCP) approach, which the UK government has been actively promoting since the middle of the 1990s. The SCP agenda featured prominently in the UK Government's sustainable development strategy *A Better Quality of Life* (DETR, 1999). After the World Summit on Sustainable Development (WSSD) in Johannesburg, the government established its SCP policy framework *Changing Patterns* (DEFRA, 2003). The objectives of the framework were intended to be accomplished by:

- "Decoupling economic growth and environmental degradation.
- Focusing policy on the most important environmental impacts associated with the use of particular resources, rather than on the total level of resource use.
- Increasing the productivity of material and energy use, as part of the broader Government commitment to increase the productivity of the nation.
- Encouraging and enabling active and informed individual and corporate consumers who practice more sustainable consumption" (DEFRA, 2003, p.6).

The rather general guidelines and principles laid out in this SCP framework were taken forward in the revised Sustainable Development Strategy (DEFRA, 2005b), which provided what might be called a national action plan for SCP, with the actions clustered in seven key areas identified to accelerate the shift towards a more sustainable system of consumption and production (see Table 1). A major objective of these actions is to decouple economic growth and resource utilisation.

[1] The 'extended' part of EPR denotes that the producer responsibility extends beyond the producer's existing responsibility for the production process

Products	Strengthening UK and international measures to improve the environmental performance of products and services, including improved product design
Production	Improve resource efficiency and reduce waste and harmful emissions across business sectors
Consumption	Influence consumption patterns, including proposals for new advice for consumers
Procurement	Sustainable procurement in the public sector, to make the UK a leader within the EU by 2009
Innovation	Support for innovation to bring through new products, materials and services
Sustainable business	Increase transparency, corporate responsibility and skill in business and other organisations
Waste	Increased emphasis on reducing waste at source and making use of it as a resource

Table 1: Key areas in the UK Government's Sustainable Consumption and Production Strategy

More general still than SCP is a policy approach that has become an important organising framework at the European level, called Integrated Product Policy, which is discussed further below.

Policies for dematerialisation

As noted above, there is no history of policies for dematerialisation, and very few such policies, and none that were introduced as such. Those that may now be described as dematerialisation policies were not introduced with dematerialisation as their explicit goal (in this they resemble policies such as fuel taxes, which are now described as environmental taxes, and also contribute to dematerialisation, but were introduced for their potential for revenue-raising rather than environmental improvement). This is at least partly because until very recently the data on material flows were so poor that it would have been impossible to tell whether a policy for dematerialisation was being successful or not. Many policies that will reduce the flow of materials through the UK economy are focused on energy, and will have the effect of reducing fossil fuel use and CO2 emissions. This is because CO2 emissions are now the environmental issue of the greatest policy concern. Similar policies could reduce the flows of other materials if it was desired to achieve this.

Policies in the UK that may have the effect of dematerialisation, irrespective as to whether that was their intention when they were introduced, will now be described in the categorisation introduced above.

Economic instruments

Many resources have to be paid for, and their price introduces some incentive for their conservation, efficient use and recycling. This is probably why, even in the absence of policy, industrial economies, at least, tend to show relative decoupling (decreasing resource use per unit of value added). Similarly, emission taxes (or trading schemes), or waste disposal taxes, may be expected to lead to a reduction in emissions or waste disposal. In the UK such instruments include:

Aggregates tax: this was introduced in 2002 at £1.60 per tonne, and in the 2007 Budget, which raised it to £1.95 per tonne, the UK Government considered that "There is strong evidence that the levy is achieving its environmental objectives, with sales of primary aggregate down and production of recycled aggregate up" (HMT 2007, p.189).

Energy taxes: the UK currently has a range of taxes on energy, most important among which are fuel duties and the climate change levy (CCL), the latter of which is estimated to reduce CO2 emissions by 3.5 million tonnes of carbon (mtc) by 2010 (HMT 2007, p.192). On fuel taxes more broadly, Sterner (2007, p.3201) estimates that the difference in fuel taxes between Europe and the USA, which results in European consumer prices of road fuels being about three times higher than those in the US, has resulted in European CO2 emissions from road fuels being about half what they would be at the US price.

Landfill tax: this was introduced in 1996, at £7 and £2 per tonne for active and inert waste respectively, very considerably increasing the cost of disposal to landfill. The active waste rate has increased steadily and by 2007 was at £24 per tonne. The 2007 Budget announced that the rate would increase by £8 per tonne per year from April 2008 until at least 2010-11, and the inert rate would also be raised (for the first time since its introduction) to £2.50 per tonne. Active waste disposed of to landfill fell by 14% between 1997-98 and 2005-06, while overall landfilled waste fell by 25%.

EU Emissions Trading Scheme (EU ETS): while energy or carbon taxes set a tax rate and the quantity used or emitted adjusts to reflect the higher price, in emissions trading schemes the policy sets the quantity and the market in emissions allowances sets the price. In Phase 2 of the EU ETS the UK Government set the number of allowances at 8 mtc below the baseline calculation, implying a saving in emissions of this amount.

Carbon Reduction Commitment (CRC): this is a new UK carbon emissions trading scheme which will apply to large commercial organisations, including the public sector. It is not yet clear what carbon emissions reduction it will seek to achieve.

Regulation

Landfill Directive: this EU Directive is the major driver of landfill reduction in the UK, to achieve the targets in which the UK Government is raising the landfill tax (see above), but also greatly increasing the resources available for local authority recycling schemes (which is a subsidy and therefore really an economic instrument). There is also a Landfill Allowance Trading Scheme (LATS) (another economic instrument) which permits local authorities to meet their landfill targets by trading waste certificates with each other. It can be seen from this example how policy instruments can be mixed together, in this case an EU regulation resulting in UK economic instruments (other countries in the EU will have sought to achieve the Landfill Directive's target through different policy means).

Renewables Obligation and Energy Efficiency Commitment (EEC): these are both obligations placed on energy suppliers to supply a given quantity of renewable electricity by a certain date, or to save a certain quantity of energy by a certain date. Suppliers will adopt their own policies (chief among them subsidies in the case of energy efficiency) in order to achieve their targets, the costs of which may be passed on to consumers. In both cases there is provision for trading of the commitments between suppliers.

Integrated Pollution Prevention and Control (IPPC): this is the major regulation controlling emissions from, and seeking to improve the energy efficiency of, industrial plant. Some, but not all, of this regulation may be regarded as a 'dematerialisation policy', because some emission control may increase the overall flow of materials (e.g. by reducing fuel efficiency, or by requiring extra materials to 'scrub' flue gases).

Voluntary agreements

Climate Change Agreements (CCAs): these are agreements with over 50 relatively energy-intensive industrial sectors that they will get an 80% discount on their CCL if they reach certain targets, normally relating to energy intensity. Budget 2007 (HMT 2007, p.192) estimates that the CCAs will deliver annual CO2 reductions of 2.8 mtc by 2010, and Ekins & Etheridge (2006) have calculated that the CCAs have probably saved more energy than a uniform tax rate on the CCA sectors, which is what economic theory would recommend, would have done.

EU Fuel Efficiency Agreements: these are agreements concluded between the European Commission and the major vehicle manufacturers that they would improve their vehicles' fuel efficiency such that by 2008 the average CO2 emissions of new cars would be 140 gCO2/km, representing a 25% reduction from 1995. By 2003 the achievement was only 12% (DEFRA 2006, p.66). In its Energy Efficiency Action Plan of 2006 (EC 2006, p. 15), the European Commission made clear that failure to reach the 'voluntary' target would trigger regulation: "Should it become clear that the voluntary commitments of the car industry to reach 140 gCO2/km by 2008/2009 will not be honoured, the Commission will not hesitate to propose legislation. To that end a Commission Communication on a revised long-term strategy to reduce CO2 from cars beyond the current voluntary commitments will be adopted …, aimed at reaching the Community objective of 120 g CO2/km by 2012 through a comprehensive and consistent approach, involving other relevant stakeholders and authorities and other instruments", and it was further specified that these 'other instruments' could include taxation. This is therefore a good example of how 'voluntary' voluntary agreements really are, and how different types of instruments are increasingly being incorporated into 'policy packages', as noted above.

Information/education

The principal information policy in the UK is related to labelling, which is now required for a wide variety of white goods and, most recently, vehicles. Labelling is a core element of what has come to be called the 'market transformation' policy approach, which seeks greatly to improve the environmental performance of different products groups. Figure 5 shows how this has worked for fridge freezers, with the most efficient A-rated fridge freezers increasing to around 80% of the market over a period of about five years.

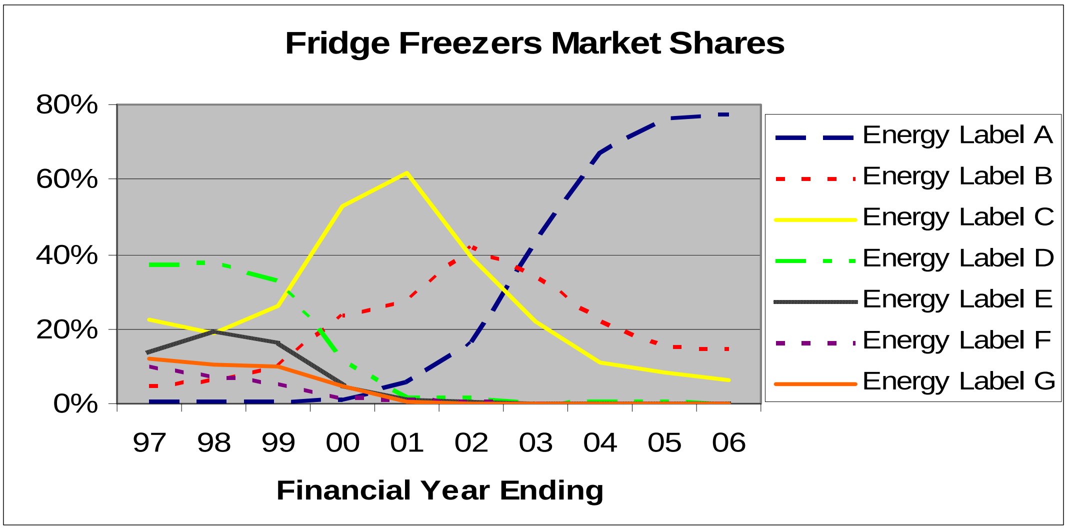


Figure 5: Development of the fridge freezer market by energy rating to end September 2005 (Source: Lees 2006)

Similar diagrams could be drawn for wet appliances and dishwashers. However, Lees (2006, p.34) stresses that such market transformation is the result of the combination of a number of policy measures (many of them informational, but also including regulation and financial incentives) affecting a number of different actors, including: EU energy labelling; marketing campaigns by the Government and its agencies, like the Energy Saving Trust; consumer advice from the Energy Efficiency Advice Centres; media coverage on climate change; retail staff training and point of sale material from the Energy Saving Trust; Energy Efficiency Recommended branding and advertising; EU Minimum Performance Standards; EEC funding for incentives for consumers to purchase the energy-efficient models. Similarly the increased uptake of condensing boilers would not have been possible (and their installation would not have been made mandatory) without prior work of information and training to ensure that installers in sufficient numbers were both aware of the technology and capable of installing it.

Policy packages

Market transformation, sustainable consumption and production and Extended Producer Responsibility are three broad policy approaches discussed above which often involve a mixture of instruments that are intended to be mutually self-reinforcing. Perhaps the most all-embracing of these approaches, which illustrates best the new emphasis on policy packages, is the European Commission's Integrated Product Policy, which is explicitly conceived in terms of a policy 'toolbox'[2], which includes: Sustainable Consumption and Production; state aid; voluntary agreements; standardisation; environmental management systems; eco-design; labelling and product declarations; greening public procurement; encouragement of green technology; and legislation in areas including waste and chemicals.

However, notwithstanding the innovation that has been shown in relation to dematerialisation and decoupling policies, and the increasingly sophisticated and complex policy approaches that are taken to

[2] See http://ec.europa.eu/environment/ipp/toolbox.htm

address them, there is no evidence yet that they are having a substantial and sustained impact on overall material use and of systemic environmental impacts such as CO2 emissions. For local pollutants such as SO2, there has, in contrast, been marked success at decoupling, which Ekins (2000, Ch.10, pp.283-315) showed to be due to a number of mutually reinforcing factors: the availability of an affordable end-of-pipe technology (flue-gas desulpurisation) and of low polluting substitute fuels (low-sulphur coal, natural gas) at little or no extra cost. The political pressure resulting from the pollution was sufficient in this case for regulators to require emissions to be reduced and for the end-of-pipe technology to be installed, and the alternative fuels to be used.

Given the absence of end-of-pipe technologies for carbon emissions (although considerable effort is now being invested in carbon capture and storage technologies), and the lack of affordable low-carbon substitute fuels (although it is hoped that investment in either or both of nuclear power and renewables will remedy this), it is not surprising that carbon emissions have been less easy to reduce. With regard to dematerialisation generally, it is not clear that there has been much policy priority in actually reducing resource use, as opposed to increasing recycling to reduce disposal to landfill, so that it is perhaps also not surprising that dematerialisation across the resource base has not occurred.

Conclusion

As environmental issues have risen up the public policy agenda, a range of policies and policy approaches have been developed in order to reduce environmental impacts, especially the emission of CO2 by reducing fossil energy use. While none of these have been explicitly conceived in terms of 'dematerialisation', insofar as the environmental impacts of concern are the result of material flows (which is often the case), then reducing the impacts will often require the reduction of the flows, i.e. dematerialisation in practice if not in objective. In order to ensure that the environmental objective is met, it is important that the full environmental implications of the flows with and without the policies are assessed.

Notwithstanding the policy innovation – conceptually and practically – that has been shown in relation to environmental policies over the last few decades, they have not yet been successful in systematically reducing some of the environmental impacts of most concern (especially greenhouse gas emissions), or of achieving the absolute decoupling between economic growth and resource use that is required for dematerialisation. While it may be that further conceptual development will help policy effectiveness, it seems likely that the main requirement for dematerialisation is more stringent application of the policy instruments and approaches that are already available and of which examples have been given above. It would seem especially important to combine measures to increase resource efficiency with measures to increase resource prices, if rebound effects and other developments to use the resources are to be avoided.

The failure, 15 years after the Earth Summit, to achieve dematerialisation, despite substantial policy development and application and innumerable rhetorical flourishes in favour of such concepts as 'sustainable consumption and production', goes to the heart of the continuing debate about the compatibility, theoretical or practical or both, between the twin aspirations for economic growth and environmental sustainability, which dates from the 1970s. One of the main protagonists in that debate, Herman Daly, wrote in 1977 of his disbelief that the economy, as measured by GNP, could be continuously dematerialised to produce what he called 'angelised GDP'. "It would be necessary", he wrote (Daly 1977, p.119), "for us to become angels to subsist on angelised GNP", which resulted in him rejecting the term 'sustainable growth' as "a bad oxymoron" (Daly 1990, p.1). Daly's arguments and conclusions were widely rejected by economists at the time, and generally still are. However, they, and the policy makers that share their analysis, have yet to prove Daly wrong in practice.

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ANNEX 1

OUTCOMES FOR UK DECOUPLING INDICATORS (DEFRA, 2005, pp.8-9)

Economy-wide decoupling indicators

Decoupling indicator for SCP Framework			
		For resource consumption	
1	Material use	Domestic Material Consumption and GDP, UK, 1990-2003 (supported by an analysis of the extraction of construction materials and construction output, UK, 1970-2003)	Absolute decoupling; no further decoupling since 1993
2	Water use	Abstractions from non-tidal surface water and groundwater sources, England and Wales, and GDP (UK) 1990-2002	No decoupling since 1994
3	Land use	Percentage of homes built on previously undeveloped land, and number of new households, England, 1990-2003	Absolute decoupling
4	Fish stocks	Fish landings in UK and % of UK fish stocks not within sustainable limits, UK, 1998-2003	Underlying trend uncertain
		For pollution	
5	Climate change	(a) Greenhouse gas emissions on IPCC basis cf Kyoto target and GDP, UK 1990-2003	Absolute decoupling
		(b) Greenhouse gas emissions from international aviation and shipping bunker fuels, and GDP, UK, 1990-2003	No decoupling (international aviation bunkers)
			Absolute decoupling (international shipping bunkers)
6	Air pollution	UK sulphur dioxide, nitrogen oxides, ammonia, particulate emissions and GDP, 1990-2003	Absolute decoupling
7	Water pollution	Rivers of fair, poor or bad chemical and biological quality, England and Wales, and GDP (UK), 1990-2003	Some evidence of absolute decoupling; further monitoring required
8	Waste	Waste arising and management of controlled waste from households, commerce and industry, UK, 1998-9 and 2000-1 estimates	No trend available yet

Decoupling indicators relating to household consumption

		For resource consumption	
9	Household water consumption and waste	Household water consumption 1992-2003 (England and Wales), UK household total waste arisings and waste not recycled 1990-2002 and UK household final consumption expenditure, 1990-2003	Relative decoupling
		For pollution	

10	Household energy	UK domestic energy use, carbon dioxide emissions and household final consumption expenditure, 1990-2003	Relative decoupling; after allowing for impact of electricity generators
11	Household vehicle use	UK household private road transport emissions, car kilometres and household final consumption expenditure, 1990-2002	Relative decoupling (CO_2 emissions) Absolute decoupling (NO_x, PM_{10} emissions)
12	Embedded emissions in goods consumed by households	Carbon dioxide emissions associated with UK household consumption and household final consumption expenditure (to be developed)	Not available

Decoupling indicators relating to production

13	Agriculture	Agricultural output, inputs of fertilisers, ammonia and methane emissions and the farmland birds index, UK, 1974-2003	Absolute decoupling (ammonia emissions, use of fertilisers since 1997) Relative decoupling (methane emissions) No decoupling (farmland birds)
14	Mining and Construction	Mining and construction Gross Value Added, carbon dioxide and particulate emissions, UK, 1990-2002	Absolute decoupling (PM_{10} emissions) No decoupling (CO_2 emissions)
15	Manufacturing	Manufacturing Gross Value Added, carbon dioxide, nitrogen oxides, sulphur dioxide and particulate emissions, UK, 1990-2002	Absolute decoupling
16	Electricity generation	Electricity consumed and fossil fuel use by electricity generators, associated carbon dioxide, nitrogen oxides and sulphur dioxide emissions, and GDP, UK, 1990-2003	Absolute decoupling (CO_2, NO_x, SO_2 emissions) Relative decoupling (fossil fuel use)
17	Road transport	Non-domestic sector road transport carbon dioxide, nitrogen oxides, particulate emissions and GDP, UK, 1990-2002	Relative decoupling (CO_2 emissions) Absolute decoupling (NO_x, PM_{10} emissions)
18	Services and the public sector	Service sector (commercial and public separately) Gross Value Added, carbon dioxide and nitrogen oxides emissions, UK, 1990-2002	Absolute decoupling (NO_x emissions) Relative decoupling; after allowing for impact of electricity generators (CO_2 emissions)