From Waste to Resource Management

A DISCUSSION PAPER

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Abstract

Dealing with society's waste is one of the major environmental challenges facing the UK. A fundamental change in approach is needed if the UK is to avoid implementing less than sustainable solutions in the race to ensure compliance with both current and forthcoming EC regulations.

This discussion paper presents a new way of thinking about waste in order that the UK can use natural resources more efficiently and minimise the impact on the environment. It concludes that a new mindset is needed that focuses not on waste but on *resource* management in order to:

- mitigate the environmental impact of society; and
- maximise the associated economic development opportunities.

The paper proposes that changes in approach are needed at all levels to deliver resource management on the ground. The following practical key steps are identified as essential to success:

- Adopting a general understanding of resource and waste management that will lead to practicable and sustainable outcomes different from today's solutions.
- Engaging the process chain involved in the life cycle of goods and products at all points along the design-production-consumption–waste management sequence.
- Establishing resource recovery systems based on key resource streams, integrating the household, commercial and industrial sectors.
- Embedding land-use planning within this approach, by making implementation easier through the identification of land for 'resource parks' and undertaking property intervention where required.

Recommendations are also made concerning key actions required by the main players from national to local levels, in order to create the climate where the vision can be brought in to reality.

Engage the process chain

Establish the materials recovery systems *

Facilitate delivery on the ground
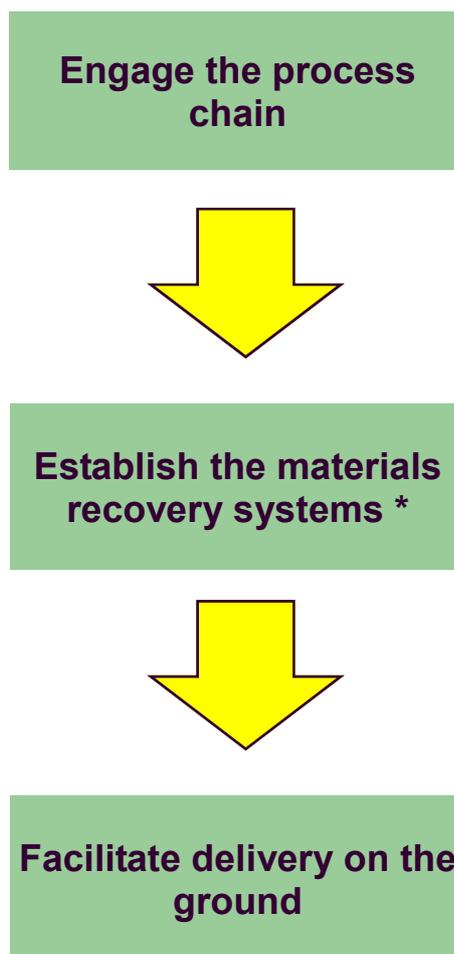
*including the waste management interface

The Resource Management Route Map

Introduction

In the 1980s the focus in waste management was on waste disposal and the UK dealt with waste mainly by landfilling. This method was cheap and flexible in meeting needs, and also well managed in comparison to other European countries. Disposal costs were very low, partly because there was not a level playing field in terms of regulation and there was no transparency in cost accounting in either the public or private sectors, both of which ignored the long-term environmental costs.

The 1990s saw action through regulation on improving environmental standards, linked to a greater recognition and awareness of the negative impact of waste. Three national waste strategies (DETR, 1998, 1999 & 2000) were published, and there was a modest shift to integrated waste management. Overall however, there was inertia leading to a lack of delivery. National recycling targets were not met and the period was characterised by polarisation of opinion and confusion among waste management 'experts' as to appropriate solutions.

We are now in the 21st century and at a pivotal time. There is no more time for debate: the UK needs to take real action now if it is to achieve national waste strategy targets in the context of the Government's wider sustainability objectives.

If this agenda is not grasped, the UK risks slipping into the lower league of a two-tier Europe as far as the management of waste as a resource is concerned. The current decade must therefore be the decade of deciding on the major changes that are needed and achieving delivery on the ground.

The Government's response (DEFRA, 2003) to the Strategy Unit report 'Waste not, Want not' (2002), accepted that waste represents one of the major environmental challenges and that improving our performance in this area is crucial to sustainable development. There is recognition that achieving the transition from waste to resource management is fundamental to moving forward, but there is no consensus to what this actually means in practice.

At the root of this debate is how we move from the mindset of ''waste' as unwanted material requiring disposal (the basis of the legal definition of waste) to one where it is routinely regarded as a raw material to be fed back into the production process as part of a closed loop system.

Environmental groups argue that radical change is needed and advocate new approaches like the Zero Waste philosophy (Greenpeace, 2001). Such concepts are very good in form and in catching the public's imagination, but lack credibility regarding the feasibility of implementation and achievement when examined closely. In contrast, the more practical models on offer from central and local Government and the waste management industry are set in conventional waste management thinking and based upon incremental change. They fail to present a convincing route-map in resource management terms and the perception in the outside world is one of 'business as usual', with a continuation of the 'throw-away' society and slow progress away from waste disposal.

This paper discusses the issues and puts forward proposals for a new approach to delivering resource management on the ground, in a way that benefits the whole community. A key aspect is examining how the more radical 'green' concepts could be linked with conventional thinking to deliver real change at a local level,

whilst offering consistency with the global and national agendas. The new approach does not recommend or exclude new processes or technologies, but instead puts forward a paradigm into which the use of resources and the generation and disposal of waste can be set. It is more a framework intended to engage designers, manufacturers, consumers and Government alike to re-orientate their thinking and attitudes to facilitate the step-changes that are needed.

The views expressed are those of the authors and reflect the experience gained in Hampshire in effecting the transition from waste disposal to integrated waste management through Project Integra, and more recently in establishing the Hampshire Natural Resources Initiative to put resource management concepts into practice (Lisney, 2002).

HAMPSHIRE NATURAL RESOURCES INITIATIVE (HNRI)

The HNRI is a multi-sector network that aims to make a real difference to the use of natural resources in Hampshire.
HNRI is based on a 'bottom up' approach using Agenda 21 principles. The objectives are to:
- Maximise the role of commerce and industry
- Promote the concept of consumer responsibility
- Reduce the impact on Hampshire's environment
- Establish the public sector as an example of best practice
- Influence change at EC/UK Government level.

For further information go to **www.hnri.co.uk**

The Resource Issue

The economies of the UK and other developed countries depend on consumption of goods and services to drive the economic growth that is seen as fundamental to meeting society's needs. The trend is one of increasing production rates and use of natural resources to provide the raw materials that are converted into the products needed to keep consumers spending. At the same time, society is producing ever-increasing quantities of waste requiring disposal. Both at global and local levels, this approach is unsustainable.

Globally, the concerns focus on the inequities in consumption between the developed and the developing world and the need to keep the overall environmental impacts of resource use within the carrying capacity of the planet. It has been estimated that the global impact of human activity will increase ten-fold by 2050 as developing countries aspire to western lifestyles and

consumption patterns. Or put another way, a tenfold average global improvement in technological efficiency is needed to prevent an increase in total impacts (Friends of the Earth, 1997).

At the UK national and local levels, ecological footprint analyses, such as that undertaken for London (Biffa, 2003), have concluded that the UK is consuming beyond its means in sustainability terms and typically a land area nearly three times greater than we have is needed to support current lifestyles.

From another angle, the impacts of increasing consumption are being brought into sharp focus by concerns about effects on local communities and their environment in dealing with the consequent waste. The emphasis may vary from area to area but the range of issues is common:
- In some areas it is becoming increasingly difficult to identify

- environmentally and/or publicly acceptable sites for major waste treatment/disposal facilities.
- There is increasing public disaffection with existing waste management approaches, leading to opposition and delays to the provision of sufficient new facilities.
- The ability of the land use planning system to facilitate delivery of the required types and numbers of new facilities is in question.
- There is a trend of increasing waste management costs to both the public and private sectors.

The political response at European Union and UK Government levels has to date been focussed on the waste management aspects of the consumption agenda. The emphasis has been on changing from waste disposal to integrated waste management based on the hierarchy of waste reduction, reuse, recycling, recovery and disposal. A range of legislative measures, such as the Landfill and Incineration Directives, will, when fully implemented everywhere in Europe, at least halve the current environmental impacts from waste (Walstrom, 2001).

Much less progress has been made on prevention of waste throughout the product life cycle, rather than dealing with it at the post-consumer waste stage. The EU is however now addressing the consumption agenda. As part of this process, the EC published a Communication on integrated product policy in June 2003 (European Commission, 2003). This sets out proposed actions to stimulate improvement in the environmental performance of products throughout the whole life cycle. The EC also intends to work with industry, business, and consumers to identify those products with the greatest potential for environmental improvement.

(The background to the resource issue is discussed more fully in Appendix 1.)

Growth in consumption is vital for the well being of society but the inevitable implication of the current approach is the increasing use of natural resources and higher waste volumes. This is unsustainable in the long term and the challenge is to find ways of mitigating the impacts by using the resource that is 'waste' to support the system and deliver environmental, social and economic benefits.

Action at Government level to create the right policy, fiscal and regulatory climate is vital, but this in itself will not be enough to provide the total solution. A 'bottom up' as well as 'top down' approach is needed to influence and manage change at a local level. There is the opportunity for all sectors to work together to map out a new 'smarter' way of doing things that will achieve the type of vision most people would subscribe to in an efficient and affordable way.

The Call to Arms

The imperative for a new resource management approach is being driven by a series of existing and forthcoming EC Directives that will impose new recycling and recovery targets on the UK and restrict the landfilling of biodegradable waste (see Table 1). These requirements, which impact on both the private and public sectors, generally ratchet up over time. They create an inescapable need for change over the period to 2010 and beyond.

There are serious legal and financial consequences if the UK fails to implement and comply with these requirements. But this is not the only issue. The danger is that a reactive response to each new regulation, as it is passed down from Europe, will result in missed opportunities and an inefficient overall solution impacting on millions of tonnes of goods and materials per annum. These legislative requirements aside, it has been calculated (Cambridge Economics, 2003) that British manufacturing could add between £2 - £3 billion to its profits if environmental best practice were made standard, wastage of raw materials reduced, and waste re-used or sold as recovered products.

Despite these imperatives for change, our current waste management approach is stuck in the mindset of managing the consequences of our consumption-based society rather than tackling the underlying issue of reducing and mitigating the impacts. In large measure this is as a result of the debate about appropriate responses being muddied and confused, resulting in a lack of clarity and certainty about the future.

The recently published Communication from the EC 'Towards a thematic strategy on the prevention and recycling of waste' (European Commission, 2003), highlights the fact that waste prevention and recycling can reduce the environmental impacts of resource use in two key ways.

Firstly, by avoiding environmental impacts from the extraction of primary raw materials. In addition to reducing mining waste, this can include air pollution, noise, soil and water pollution, effects on ground water levels, destruction or disturbance of natural habitats and the visual impact on the surrounding landscape.

Secondly, by the avoided environmental impacts from the transformation of primary raw materials in the production processes. The Wuppertal Institute (European Commission, 2003) has calculated that the following amounts of waste are generated in producing everyday products:
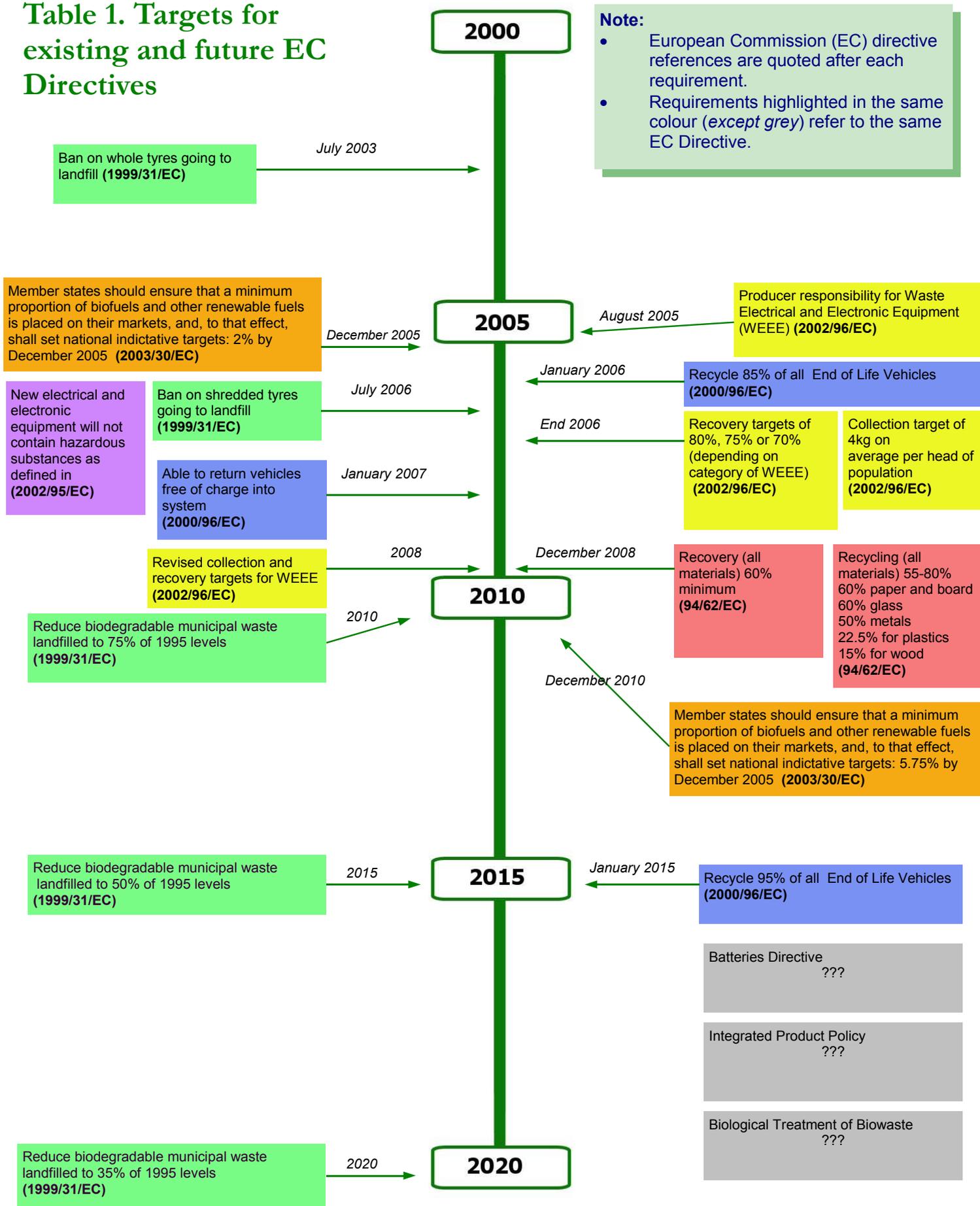
Toothbrush = 1.5kg
Mobile phone = 75kg
Personal Computer = 1,500kg

Consumption of natural resources and the associated impacts on the environment can therefore be reduced by re-using or recycling products at the end of their lives and by designing them in a more eco-efficient way. In terms of greenhouse gas emissions, it is estimated (European Commission, 2003) that recycling one tonne of paper saves 900kg of CO_2 equivalent, over the production of virgin paper. The corresponding figures for PET plastic and aluminium are 1,800kg and 9,100kg respectively.

Not withstanding the above, academic research suggests that in some cases the overall impacts from recycling certain products make this a less sustainable option than utilising virgin materials to manufacture them, or recovering the energy locked up in them once their

Table 1. Targets for existing and future EC Directives

2000

Note:
- European Commission (EC) directive references are quoted after each requirement.
- Requirements highlighted in the same colour (*except grey*) refer to the same EC Directive.

Ban on whole tyres going to landfill **(1999/31/EC)** — *July 2003* →

2005

August 2005 ← Producer responsibility for Waste Electrical and Electronic Equipment (WEEE) **(2002/96/EC)**

Member states should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets, and, to that effect, shall set national indictative targets: 2% by December 2005 **(2003/30/EC)** — *December 2005* →

January 2006 ← Recycle 85% of all End of Life Vehicles **(2000/96/EC)**

New electrical and electronic equipment will not contain hazardous substances as defined in **(2002/95/EC)**

Ban on shredded tyres going to landfill **(1999/31/EC)** — *July 2006* →

End 2006 ← Recovery targets of 80%, 75% or 70% (depending on category of WEEE) **(2002/96/EC)** | Collection target of 4kg on average per head of population **(2002/96/EC)**

Able to return vehicles free of charge into system **(2000/96/EC)** — *January 2007* →

Revised collection and recovery targets for WEEE **(2002/96/EC)** — *2008* →

2010

December 2008 ← Recovery (all materials) 60% minimum **(94/62/EC)** | Recycling (all materials) 55-80% 60% paper and board 60% glass 50% metals 22.5% for plastics 15% for wood **(94/62/EC)**

Reduce biodegradable municipal waste landfilled to 75% of 1995 levels **(1999/31/EC)** — *2010* →

December 2010 ← Member states should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets, and, to that effect, shall set national indictative targets: 5.75% by December 2005 **(2003/30/EC)**

Reduce biodegradable municipal waste landfilled to 50% of 1995 levels **(1999/31/EC)** — *2015* →

2015

January 2015 ← Recycle 95% of all End of Life Vehicles **(2000/96/EC)**

Batteries Directive ???

Integrated Product Policy ???

Biological Treatment of Biowaste ???

Reduce biodegradable municipal waste landfilled to 35% of 1995 levels **(1999/31/EC)** — *2020* →

2020

useful life is complete (Times, 2003). These arguments gain support because in most cases there is no evidence to suggest that the general supply of non-renewable mineral resources is threatened by the quantities we are consuming (European Commission, 2003). Analyses of this type are highly dependent on where the 'boundaries' are drawn, and in some cases fail to take account of the wider societal implications of materials consumption.

The reality is that in many cases scientific data are inadequate and methodologies are insufficiently well defined to reach any firm conclusions. Even when rigorous approaches are adopted, the scale, complexity and long-term nature of the issues may put the validity of the answers in doubt; and given the pressures for change, there is no time to wait while the necessary research is undertaken.

There is more uncertainty at the strategic planning level. We are strong on developing visions for the future but much less effective in engaging all sectors to agree the practical plans to deliver them. This is because there is a different responsibility for dealing just with waste and the move towards a broader resource management agenda, greatly increases the perceived complexity As a result, both the private and public sectors are faced with risks and market fluctuations that cannot be managed within existing business processes.

To make a substantial change requires sector leadership and the will to communicate across sectors (business, local authorities, community groups) involving a range of professional disciplines. They need to work out what is needed to effect a changed system that must effectively meets every party's objectives and is capable of being delivered.

There is evidence that even when decisions are taken, implementation is hampered because the land use planning system is used as a battleground to renew the total debate all over again, frequently leading to long delays, increases in costs, and in some cases abandonment of perfectly viable schemes. There is a need to harness the land-use planning system to positively aid development.

Even the private and the public sectors do not recognise that they can be a help or a hindrance to each other; all too often, it is the latter. There are major opportunities however for new networks and partnerships to deliver new solutions.

The key need is to provoke all sectors to act to create a more certain future. The way forward has to be a pragmatic approach that accepts and acts upon the general policy direction being cascaded down through European and UK Government legislation.

This is the starting point for developing the UK's response to the resource management agenda. The challenge is to develop a new resource management approach that is effective at all levels whilist complementing the regulatory and fiscal framework being implemented by national Government. We believe this can only be achieved by changing our approach to the subject.

The Change Needed

The concept of integrated waste management with its focus on waste prevention, reuse, recycling and recovery has only recently been applied to municipal waste and has largely evolved as a set of 'bolt-on' solutions such as 'bring' sites, kerbside collections for specific materials and home composting initiatives.

As a result, the upper elements of the waste hierarchy tend to be driven from a waste management perspective, without detailed analysis of the overall production cycle of goods and products, and the aspirations of consumers. Thus the links with the raw materials industries, development of markets for recovered materials, and associated societal issues are very secondary considerations in planning and decision-making processes. The outcome is that recycling and other material recovery options have a reputation of being unstable and too risky to be relied upon as core waste management options.

This situation needs to change fundamentally if resource management is to be relied upon as the predominant way of dealing with waste. The switch from landfill to new fixed capacity processing/ treatment systems (other than energy recovery options), will reduce or remove the ability to absorb a sudden collapse in markets for recovered materials, or to accommodate unplanned changes in waste volumes. Under this type of scenario, risk management must be a key factor in planning and delivery of processes.

Fundamental change is also needed in the debate about the future. This currently revolves around municipal waste, as a result of the EC Landfill Directive, and the fact that it is a public sector responsibility with a higher political profile. As the 'polluter pays' principle does not directly apply to individual domestic householders through direct economic menus, the democratic process can decide to pay more for 'greener'
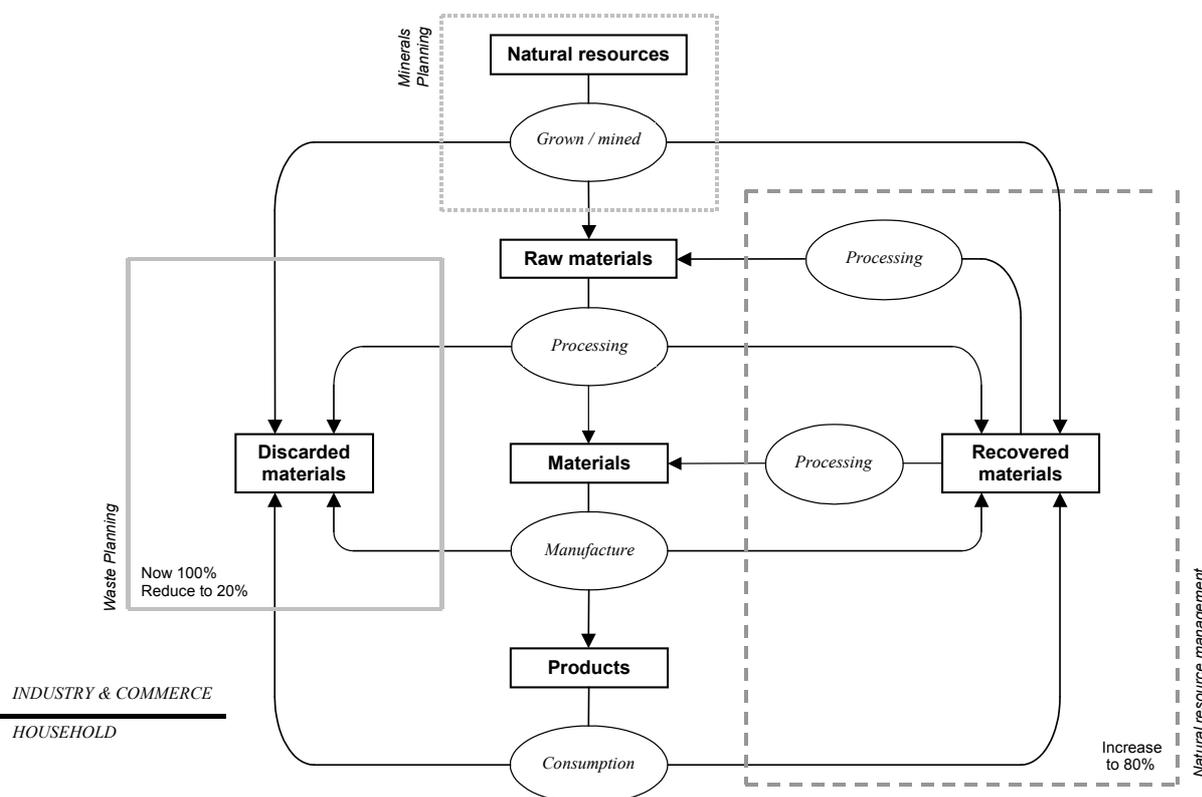

Figure 1. Product Life Cycle Material Flows

INTEGRATED WASTE MANAGEMENT

Integrated Waste Management (IWM) is based on the principle that there is no one solution to the waste problem and that a range of options based on the waste hierarchy are needed.

IWM also recognises that all the players in the waste chain must be involved in developing and implementing solutions as part of an overall systems approach.

methods from the public purse. In reality, however, post-consumer waste is only a small part of the waste arising in the overall lifecycle of products, and the greatest scope in waste prevention, reduction and recycling terms is in the pre-consumer stages. Municipal waste recovery is also dependent on the other links in the chain being engaged and incentivised.

The need is to shift the focus from waste management to a resource management concept based on the principle that recycling/recovery of waste, production of recycled raw materials and demand for recycled products are part of a managed holistic system that seeks to maximise and balance supply and demand. The stages and material flows involved with the life cycle of products are shown in Figure 1. The key objective should be to maximise the pool of 'recovered materials' and minimise the volume of 'discarded materials', regardless of which stage in the production process they arise.

This thinking is in line with EC Communication 'Towards a thematic strategy on the prevention and recycling of waste' (European Commission, 2003). This document highlights that the challenge for policy makers is to find the optimal recycling rate and the best combination of different approaches.

In theory there is a direct market incentive on business to drive recovery from the pre-consumer stages of extraction, manufacture and processing of products. This is being sharpened to some degree by economic instruments such as Producer Responsibility legislation and by increases in the Landfill Tax. Whilst these measures may drive change in large waste producers, there are barriers to this happening with the tens of thousands of small and medium sized enterprises (SMEs). The problems are in the small scale, and a general lack of information and awareness.

Crucially SMEs are often prevented or excluded from recycling because neither the private sector nor local authorities offer the required services to them. Innovation in this area, with a proactive approach to engaging SMEs, would also stimulate economic development activity through entrepreneurship in developing new products, markets and technologies in the resource management arena.

The ultimate aim should be to reach the point where decision making routinely takes into account resource management issues. For this to happen, the whole supply process chain needs to be engaged. A climate must also be created whereby the necessary investment and infrastructure is provided by the waste management industry on a planned, rather than random basis. This is not necessarily to suggest that larger facilities are needed under an integrated system, but that the required number and type of facilities should be planned at an acceptable environmental, social and economic scale to meet the overall resource management demand in a given area.

Moving forward in this direction is hindered by a lack of quality information on which to base decisions, particularly in the commercial and industrial sector.

A 'smart' resource management approach integrates the processing of household, commercial and industrial wastes to the benefit of both the council taxpayers and of commerce and industry. It aims to put in place the communications, infrastructure and systems to recover resources regardless of where the material originates. It works with all sectors to ensure stable markets and maximise economic development opportunities. For example, both a stable market for quality compost produced from bio-wastes and the processing infrastructure to produce it are needed regardless of whether the waste arises from food processing factories, hotels, restaurants or domestic kitchens. This requires a new mindset of categorising waste by resource type linked to optimum processing requirements, rather than by origin as happens now.

The data that does exist is presented with a conventional waste management focus. Waste surveys and data presentation need to be reviewed so that key resource streams are identified and assessed in a way that enables infrastructure, processing and marketing needs to be quantified.

Legislation and regulation also need to be rethought to support resource management. As an example, a product changes to a 'waste' when it is no longer required by the primary user. This may involve a product going from a totally uncontrolled status to that of being a hazardous waste, even though it is subject to no physical change. This can be a major disincentive to reuse, recycling and recovery. There is a need to introduce a new system of definitions based on the life cycle of products that recognises the levels of environmental risk at each stage and applies regulation proportionately:

- Product:- from manufacture to end of life for primary use.

- Resource:- end of life products to be fed back into the raw material chain.
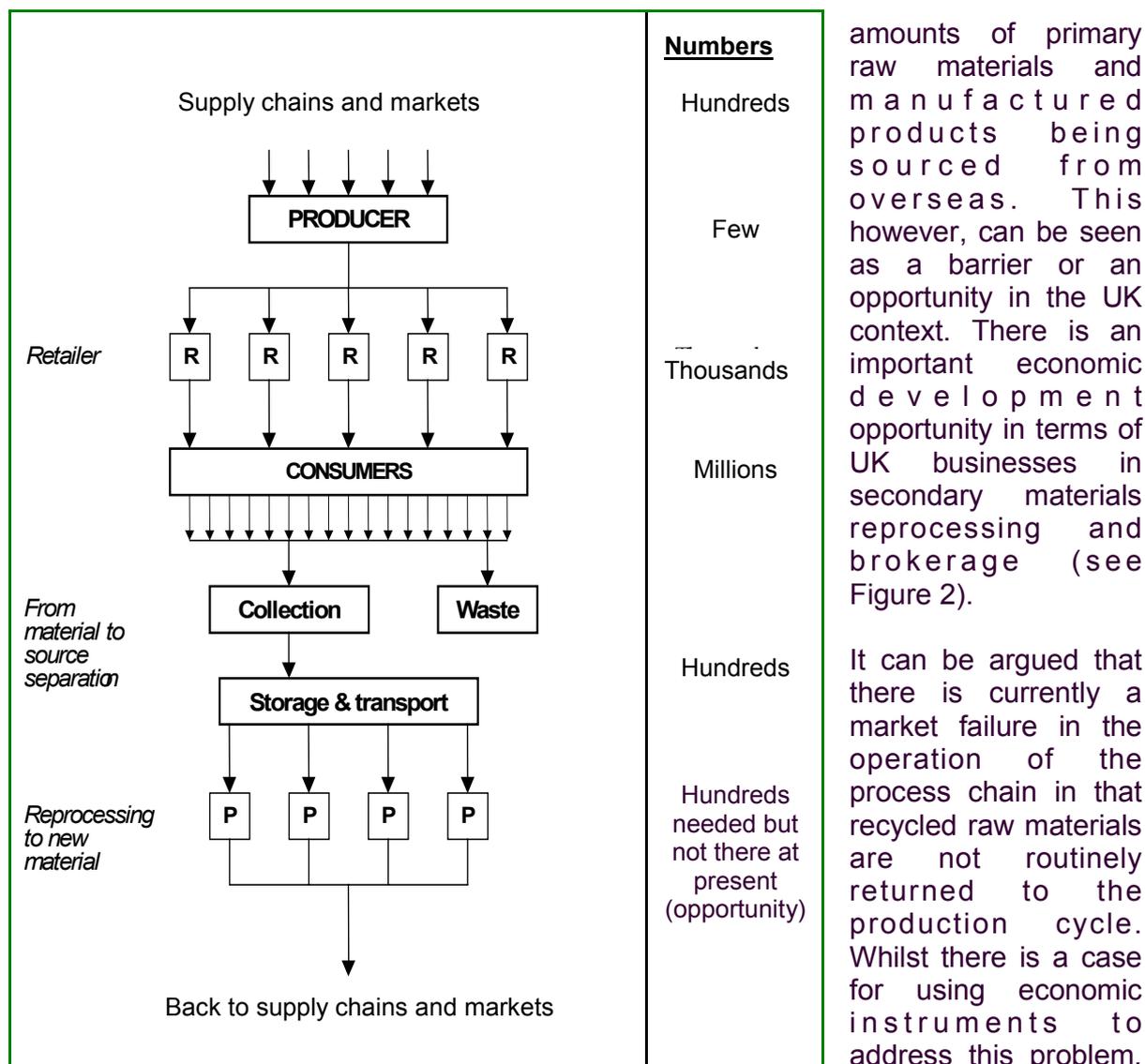- Waste:- end of life products to be handled via conventional waste management systems.

Changing legal definitions would require a fundamental revision of EU legislation which is not easy or quick to achieve. There is still scope however within existing legislation for the Environment Agency to recognise the above categories and apply regulations in a way that acts as an incentive, not a barrier to resource use.

A resource management framework developed with the involvement and support of all sectors, including the wider community would provide the foundation needed to maximise the recycling of **ALL** waste types and would offer other important advantages, including:

- Increasing the overall sustainability benefits to society.
- Helping to overcome land use planning difficulties in identifying sites and consenting facilities.
- Offering the most cost-effective solution to the council tax payers and to commerce and industry.
- Reducing the lead times and complexity of waste contracting in the municipal sector.

Resource Management is about an integrated systems approach across all sectors to improve efficiency, avoid unnecessary waste, and maximise reuse, recycling and recovery. It involves employing new skills in business development and social science to engage all stages in the production cycle to effect change and manage risks. It goes beyond the traditional waste management remit and requires a new culture and new definitions.

The Process Chain

Supply chains and markets

		Numbers
PRODUCER		Hundreds
Retailer	R R R R R	Few
		Thousands
CONSUMERS		Millions
From material to source separation	Collection — Waste	Hundreds
	Storage & transport	
Reprocessing to new material	P P P P	Hundreds needed but not there at present (opportunity)

Back to supply chains and markets

Figure 2. The Process Chain

The key to achieving Resource Management is ensuring effective operation of the process chain over the lifecycle of goods and services – sourcing of raw materials, design, manufacture and consumption. (see Figure 2). This requires the avoidance of unnecessary waste at all stages, and return of raw materials back into the system. The challenge is to ensure the chain is engaged and operating to maximum efficiency by identifying and addressing the issues relating to ends sector. At the production end, the move to globalization adds to the complexity with increasing amounts of primary raw materials and manufactured products being sourced from overseas. This however, can be seen as a barrier or an opportunity in the UK context. There is an important economic development opportunity in terms of UK businesses in secondary materials reprocessing and brokerage (see Figure 2).

It can be argued that there is currently a market failure in the operation of the process chain in that recycled raw materials are not routinely returned to the production cycle. Whilst there is a case for using economic instruments to address this problem, that in itself would not be sufficient to effect the change in culture that is needed. A comprehensive and systematic information and engagement programme is also required.

Currently a range of organisations with waste management, sustainability or economic development interest undertake work impacting on the process chain. The Waste and Resources Action Programme (WRAP) is involved in strategic market development for recyclables and there are seven local 'ReMaDe' market development initiatives. The national

'Envirowise' programme supports business in preventing and reducing and has had notable success in saving firms money in the process. The Environment Agency, Local Authorities and a range of NGO's also undertake activities which impact on the process chain. There is however no systematic approach or co-ordination between the various players.

Engaging and energising the process chain is potentially a massive task and it is essential to establish a framework that integrates action at national, regional and local levels.

The 1996 'European Sustainable City' of Graz in Austria (Graz, 1996) has shown that both environmental and economic development benefits can be achieved by the Implementation of integrated local information and support programmes. The key tasks are to identify where the greatest impacts can realistically be achieved, establish priorities, and determine at what level action is most effective in achieving change. This requires a fundamental rethinking of the traditional approaches to influencing behaviour, having regard to:

- The motivations of the different sectors, for example the pressures on the general public to consume resources to maintain economic growth.
- The engagement and communication logistics involved with the size of the target audience in each sector.
- The potential for achieving quick wins.

The issues associated with the various links in the process chain are discussed below.

Manufacturers and Producers

Given our consumption-led economy, manufacturers and producers are the key to improving resource efficiency, both in terms of minimising consumption through more efficient product and process design, and utilising recycled raw materials. Engaging this sector in new approaches to achieve 'smart consumption' is potentially a win-win situation in terms of the resource management benefits and of creating new economic development opportunities.

Certain sectors are already subject to producer responsibility regulations (e.g. packaging, electrical and electronic goods) and this is already having some impact on design of products and packaging to minimise waste and assist recyclability .

Industry is complex and diverse with different sectors facing their own range of issues and pressures. The response to the resource management agenda therefore varies from sector to sector and business to business. In general large companies are more informed and are already involved to some degree in resource efficiency measures. The big challenge is SMEs which make up the bulk of the industrial sector and are often unaware of the opportunities or consequences. For example, SMEs account for 96% by number of firms in the construction industry: a recent survey found that 86% of these companies did not think their activities were environmentally damaging (Adams, 2003). There is a need to engage SMEs in a systematic way through the implementation of local programmes, including sustainable business partnerships, to provide information and advice on the opportunities and to give support, including funding for new initiatives.

Another important area is to maximise export opportunities for secondary raw materials as well as products made from recycled materials. This is an area where the waste management industry could develop partnerships with

manufacturers and producers to maximise opportunities.

Retailers

Retailers are the second largest group in the process chain, their numbers running into many thousands. They are also crucial to achieving resource management objectives, given the influence of their marketing strategies on consumers and the impacts of the retailing sector generally.

Retailers are the interface with consumers when they make their purchases, a time when they are susceptible to messages about waste minimisation and recycling. The range of inputs they can provide includes:

- Promoting purchases that prevent unnecessary waste.
- Promoting products made of recycled materials.
- Ensuring that their commercial waste is re-used, recycled or recovered.

Larger retailers are subject to producer responsibility for packaging waste. They also have strong influence over their supply chains and can make a real difference through effective management and auditing of supply chains. Companies such as B&Q already have well developed processes for sustainability auditing when sourcing products, particularly from overseas.

As with manufacturers and producers, the challenge is to engage and influence small and medium sized retailers who may not be aware of the issues and opportunities.

Consumers

Influencing consumers (including the general public) is a major communications challenge. They amount to millions of people who need to be engaged on three key issues:
- To inform purchasing and lifestyle decisions so as to prevent waste

wherever this is practicable.
- To encourage the use of products made of recovered/recycled materials through purchasing choices.
- To ensure that waste materials are separated at source and fed back into the recovery stream.

The potential quick wins in this area are institutional consumers such as public sector bodies which can take policy decisions impacting on all three of these issues. Given their purchasing power, the procurement policies of the public sector are particularly important.

Influencing the behaviour of the general public, in the absence of financial instruments such as direct charging, is probably the greatest challenge of all. To date the local authority focus has been in the household area and this work has demonstrated the scale of the challenge in lifestyle change terms. This applies to materials recycling, as well as waste prevention and reduction. Experience in Hampshire has demonstrated that maximising domestic separation at source involves much more than just providing a kerbside collection system. The type of collection system and the way it is organised heavily influences the level of achievement, and even with the best systems less than half of the recovery potential for the targeted materials is actually realised. This is because some people do not participate whilst many others make a token or partial effort.

Experience from Europe and the USA shows that direct charging of householders for the waste they produce is the most effective lever to effect behaviour change. In the absence of such financial instruments, the 'quick wins' in recycling terms, rest with a systems approach to optimising the design, implementation and regulation of collection processes.

The role of consumers with respect to waste prevention and reduction is a more

complex issue given our consumption driven economy. Market research undertaken in Hampshire has highlighted that the public often see themselves as 'victims' of the system and feel that they are not in a position to take significant action to reduce waste themselves. This may be one reason why waste reduction initiatives tend to ignore the underlying economic, environmental and social issues and be very simplistic in nature.

Whilst the role of lifestyle change and consumer choice in reducing waste should not be overlooked, it is clearly a very major logistical challenge with little hard evidence to suggest how real and significant impacts can be achieved.

The current focus on reduction aims at both private and public sectors. In the private sector business have a plethora of advisory organisations to assist them in reducing their use of raw materials in product design and manufacture. The challenge is to communicate and influence the way hundreds of thousands of small companies who are 'time poor' and may see business survival more critical to their daily motivation than what they perceive as 'nice to have' environmental gains.

The municipal sector is the area where there is a great deal of confusion and many waste prevention, reduction and minimisation programmes are, in fact, recycling projects, landfill avoidance or statistical manipulation. An example of the latter is home composting, where waste is still generated but it is not part of the municipal waste stream for collection and processing by the local authority but done at home. This does have an advantage but does not tackle the key issue for the municipal sector which is consumption.

A more sophisticated approach needs to be considered where some material streams may inevitably lead to more waste, but the recovery system for recycling captures most of the additional material. This may be the best option for a sustainable economy. If this is so then we should be looking at the societal causes of unnecessary consumption.

Waste Collectors and Processors
Local authorities (both as client and service providers), Community Recycling Networks (CRNs) and the waste management industry operate and manage this area. The sector is well organised and relatively easy to engage and communicate with. The customers being served (the public, SMEs, institutions, corporate enterprises etc) are diverse and have a wide range of requirements and aspirations. The key needs are to establish a sustainable 'best practice' model for the provision of flexible, multi-client orientated collection systems and infrastructure, then to create the climate where the service providers/ waste management industry have the incentives, the finance and confidence to provide them.

Reprocessors and Raw Material Producers
There is a well-established core waste reprocessing industry in the UK, as well as an export market in recycled materials. It is important however, to ensure that secondary materials are not exported on cost grounds to situations where there are poor environmental working practices. A sustainability auditing approach is needed to avoid this possibility.

This industry needs to be developed significantly to support a major expansion of recycling and recovery, including meeting the challenge of new regulations on waste electrical and electronic goods, end of life vehicles, etc.

The reprocessing area represents a major economic development opportunity, and there is a strong case for it being a key focus of economic development policy and activity. WRAP has engaged in a programme to stimulate market development and reprocessing at a

strategic level and there are a handful of local ReMaDe schemes that form the UK market development network. More however needs to done regionally and locally. This should involve proactive action to engage and support entrepreneurs and new businesses, seeking to ensure that affordable land is available for resource management activities through a combination of land-use planning designation and direct property intervention.

It is vital that the process chain is systematically energized and engaged at all levels to achieve sustainable resource management. This is currently undertaken in a patchy and piecemeal way. An integrated 'top down' and 'bottom up' approach is needed linking Government actions to correct market failures with national awareness campaigns, and local engagement on a sector-by-sector basis.

The Waste Management Interface

An effective interface between the process chain and the waste management system is fundamental to resource management. The implication of the current trends is that household, and commercial and industrial (C&I) wastes will increasingly be handled through separate waste infrastructure systems.
The system dealing with household waste will be paid for by the public sector to meet with community aspirations. The system dealing with commercial and industrial waste will comply with minimum regulatory requirements and be financed by the private sector at least cost.

This situation will become more prevalent as waste disposal authorities seek to meet their obligations under the Landfill Directive by contracting for new household waste facilities on a finance, design, build and operate basis using the Private Finance Initiative or similar. The emergence of such twin-track waste handling and processing systems, by default or otherwise, is potentially not the most sustainable solution.

As noted previously, one of the current impacts is that SMEs are often unable to access affordable recycling services. The impact of this in terms of the message it sends out to the process chain is potentially much greater than the loss of recovered tonnage.

The optimum solution is a resource management system, based on the integration of recycling and recovery of resources from household, commercial and industrial wastes, by moving to a new infrastructure system based on key resource streams: a step change from the current approach that primarily looks at waste in terms of the sources that produce it.

One approach that can be adopted is to make use of the resource categorisation system developed under the Zero Waste concept. Knapp/Van Denenter (2001) have identified twelve master resource categories, into which it is claimed that all types of waste fit with nothing being left out or left over. These master categories can be sub-divided in a range of ways into sub-streams. The chief weakness of the system lies in the fact than many products are composite in nature and do not naturally fall into any one category: this has significant implications for the potential for resource recovery that needs to be addressed earlier in the process chain by looking at product design and end-of-life disassembly.

The master category concept is a useful starting point for an analysis of the key resource groupings in household, commercial and industrial waste, but by itself it is of limited use in indicating the
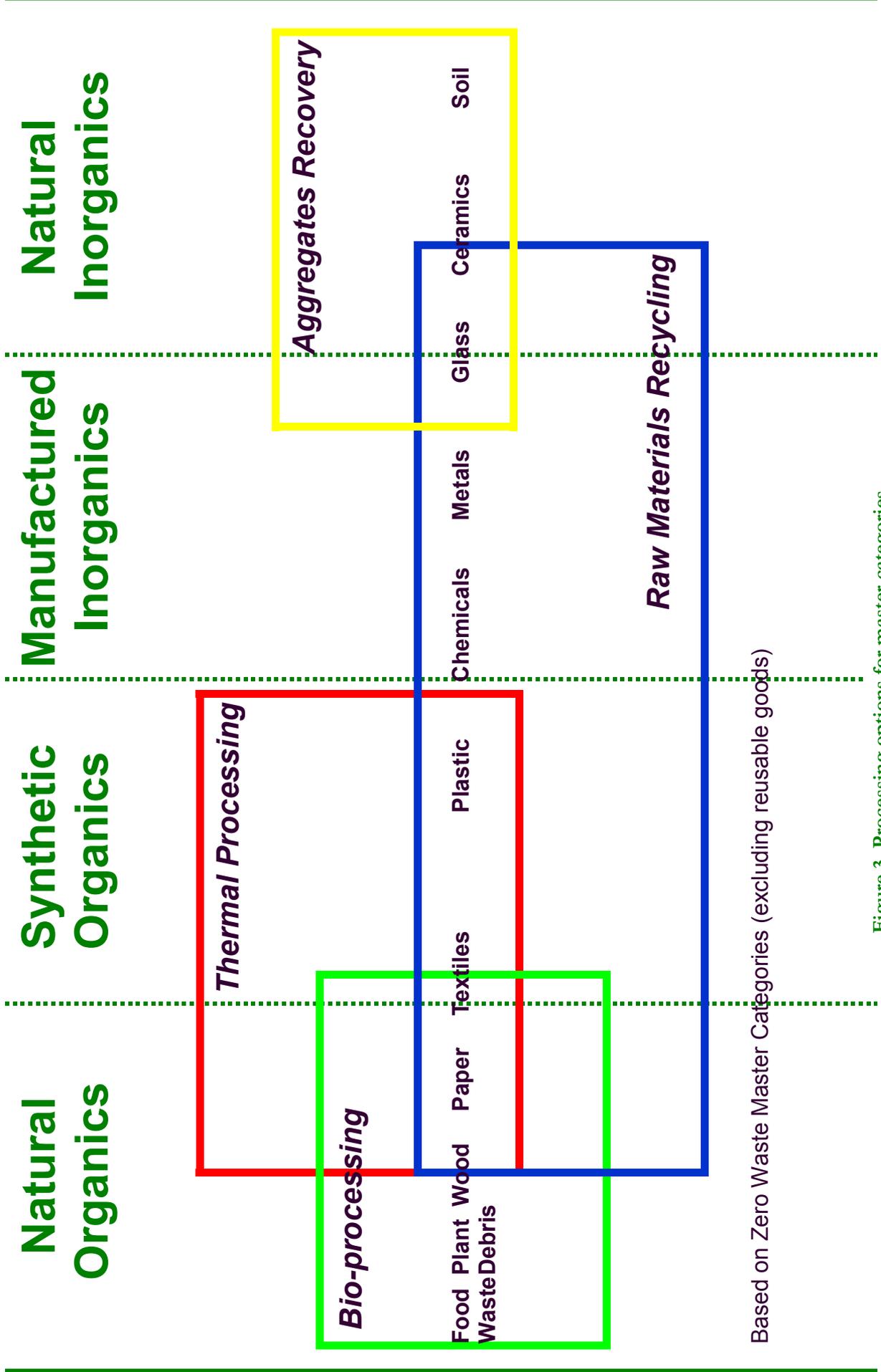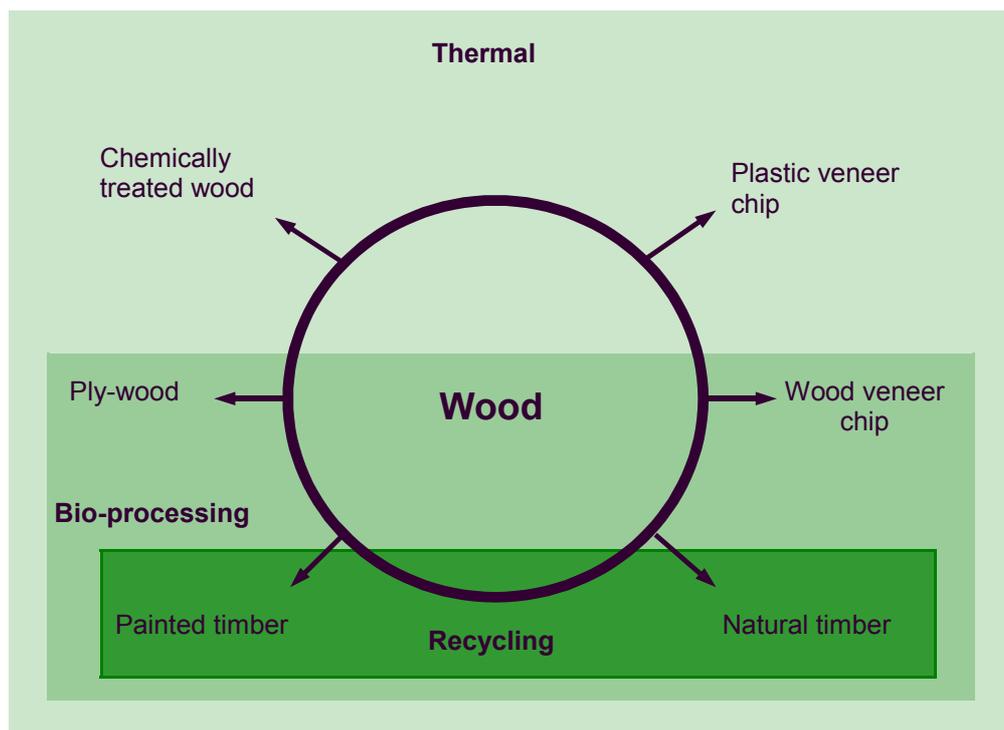
Natural Organics | **Synthetic Organics** | **Manufactured Inorganics** | **Natural Inorganics**

Food Waste · Plant Debris · Wood · Paper · Textiles · Plastic · Chemicals · Metals · Glass · Ceramics · Soil

Thermal Processing

Bio-processing

Raw Materials Recycling

Aggregates Recovery

Based on Zero Waste Master Categories (excluding reusable goods)

Figure 3. Processing options for master categories

Figure 4: Processing options for wood products

type of collection systems or infrastructure needed to maximise recycling and recovery. To achieve this it is necessary to consider how the materials can be returned in a sustainable manner to the cycle of utility, by reuse, sorting, disassembly and remanufacture, and/or re-processing on either human or natural timescales. If the twelve master resource categories are viewed from this perspective the groupings shown in Figure 3 result.

When viewed in this way, the range of options for sustainable resource management and utilisation is limited, and that once these are recognised they impose requirements on the collection system and infrastructure. Conversely, if the type of collection system is fixed then this may determine the options for processing or treatment. In principle, for example, wood can be recovered for reuse, biological or thermal processing. When the different types of wood products commonly found in waste streams are taken into consideration however, the options for each one are

more restricted. If there is only a single-route infrastructure for collection of wood products without segregation, then the only practicable processing route is thermal treatment with energy recovery. If the possibility of separate collection exists, it is necessary to look at wood in terms of its sub-groupings. As shown in Figure 4, some types may be recoverable for direct re-use, and some suitable for bio-processing. The treatment and processing options for each sub-group thus override the materials master categories, and are sufficient to indicate the appropriate collection strategy.

Taking food waste and garden wastes as another example, the optimum option for resource sustainability is bio-processing (subject to human and animal health considerations): the material is too wet to contribute energy by thermal processing, and has no reuse or recovery value without further treatment. It therefore does not make sense to mix these materials with other waste streams, where cross-contamination will interfere with the processing of both. At the other
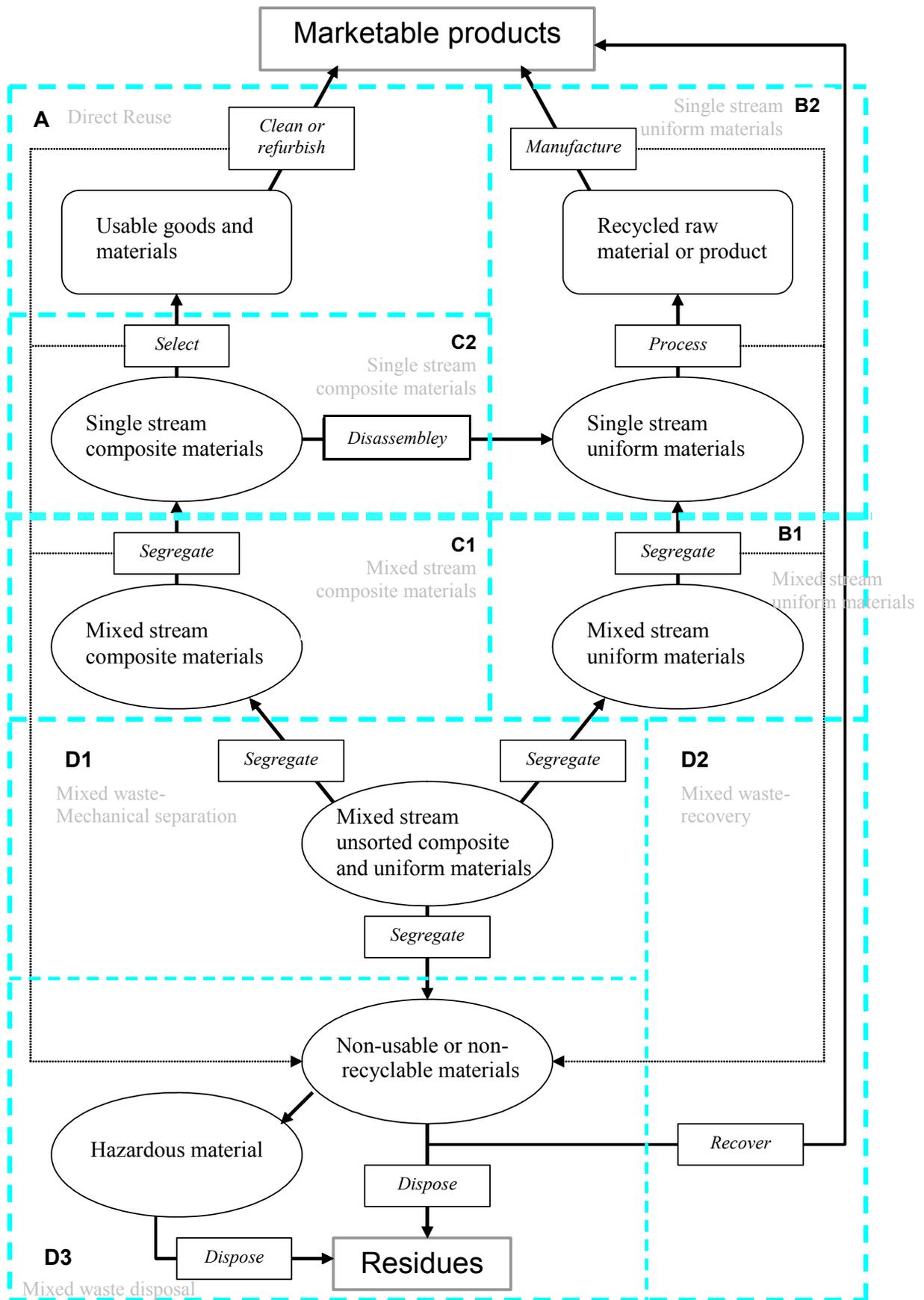
Figure 5: Waste entry point and flow options

end of the spectrum from natural organic materials are the natural inorganics, such as aggregates, ceramics and soils: since they cannot be burnt or bio-processed, raw material recovery is the only long-term sustainable option for these materials.

The area where there is most scope for interplay between developing technologies is synthetic organics such as plastics and textiles. If these are taken from fossil fuel sources, they represent a relatively limited resource. The balance between raw materials recycling and thermal processing will shift according to the development of new technological options, e.g. manufacture of new plastic materials from sustainable sources, advances in mechanical, chemical and feedstock recycling processes or changes in energy recovery technologies.

Continuing the analysis in terms of the critical role of collection and processing options, there are five main points of entry for materials into the waste resource recovery chain, as shown in Figure 5:

- As items for direct reuse (Box A)
- As mixed stream uniform materials (Box B1);
- As single stream uniform materials (Box B2);
- As mixed stream composite materials (Box C1);
- As single stream composites (Box C2);
- As mixed stream unsorted materials (Boxes D1, D2 and D3).

The above represent everything from co-mingled unsorted wastes, to single materials such as those from bottle banks.

These groupings reveal a great deal about both current and future resource management practice, as the entry point determines the degree of difficulty associated with the recovery process. The diagram is sub-divided into blocks indicating different activity types, to illustrate the current level of recovery and barriers to further progress.

Box A represents direct re-use, usually mediated through voluntary and charitable organisations, though occasionally through bulky waste collections etc: this currently represents a small market but activity could be significantly increased given support and integration between different sectors.

The main focus of government and public attention to date has been on the activities in Box B, which represents conventional single and mixed-stream recycling of uniform materials, such as paper, glass and metals; but as noted elsewhere this is only a small fraction of the total waste stream and efforts have mainly been limited to domestic wastes.

Box C represents one of the biggest challenges for the future, where the major hurdle is the requirement for a disassembly process to separate the components of composite materials into forms suitable for recovery. There are also potential large gains to be made from integrating the activities in C with those in A; but this will involve the identification or creation of much larger markets for refurbished second-hand items.

Box D represents what may be seen as traditional areas of waste management practice with co-mingled collections and bulk treatment primarily for disposal. To continue with this sort of collection practice and recovering recyclables from mixed waste, as represented in Box D1, would impose limitations on the potential levels of materials recovery, given the ability of mechanised sorting technologies to meet the material specifications imposed by the process chain. In such circumstances, where materials are deemed unsuitable for passing up either the mixed stream composite or uniform materials lines,

there is still potential for resource recovery through thermal processing with energy recovery and ash utilisation (Box D2). There is also growing interest in treatment of mixed waste streams with a high organic content through mechanical-biological treatment (MBT) and anaerobic digestion, although careful consideration needs to be given to ensuring a beneficial use for the digestate, having regard to relevant quality standards.

A number of other important basic principles emerge from the above if the resource management potential is to be maximised:

- By far the greatest challenge is recovery of materials at a grade suitable for re-processing.
- Materials for reuse and recycling need to be collected according to their resource categorisation and kept free of contamination. In the case of reuse of items such as furniture and WEEE, the collection and sorting processing methods must be such as to avoid damage and exposure to the elements.
- Hazardous wastes should be excluded from the general waste stream and handled separately.
- There is a need for a network of community recycling facilities (drop-off points) accepting wastes for reuse and recycling from householders and SMEs. This service could be an extension of that currently provided by household waste recycling centres (civic amenity sites). Innovative methods of providing and operating integrated community recycling facilities as part of larger 'resource park' type developments are worth investigating.
- The decisions as to the optimum processing/treatment option (e.g. recycling, energy recovery) need to be based on a regional/local context which will be influenced by scale of arisings, collection logistics, process chain considerations and economics.
- Potential synergies between different processes may make it desirable to group them, leading to benefits in terms of land acquisition and siting terms.

The optimum interface between waste management and resource management would be the provision of an integrated waste handling/ processing infrastructure serving the household, commercial and industrial sectors.

Societal issues, in terms of achieving segregation at source, are the limiting factor in terms of maximising recycling unless advances in technologies can meet the quality requirements of the process chain.

The Resource Park Concept

Resource management involves a significant switch to 'industrialised' waste handling and processing activities. Sites will be required for a range of new facilities including reception and storage sites, disassembly facilities, materials recovery, composting sites, anaerobic digestion and other energy recovery plants.

To complete the loop, land will also be needed for new market development industries that use the recycled raw materials and turn them into new materials and products. This will require the development of new 'resource manager' skills to identify market opportunities and place materials and products either in the UK or the global market-place.

Resource Management activities, certainly in the early stages, will be at best marginal in economic terms and a supply of low cost, affordable land is vital to pump-prime and establish the concept. Site availability is currently an obstacle since resource management developments are steered by planning policies towards prime development land, where they are in competition with other 'high value' retail and industrial uses.

An emerging solution being pioneered in the UK by organisations such as Urban Mines and the Wales Environmental Trust, is the resource park concept, where related resource management activities are clustered together. The problem is that implementation of such initiatives is not on the scale needed and there is no co-ordination. An answer to these problems is to allocate land specifically for resource management use through the land use planning system. Knapp/Van Deventer (2001) have proposed that resource management activities could be grouped together in three major business clusters; the reuse cluster, the recycling cluster and the compost cluster. A more practical and pragmatic approach however, would be to link activities based on their potential environmental impacts and the relevant planning criteria. For example:

- Activities involving open storage such as aggregate recycling, wood chipping, and end of life vehicle processing.

An artists impression of the proposed 'resource park' redevelopment at Bar End, Winchester

- Activities of an enclosed industrialised nature requiring enclosed premises, such as materials recovery facilities, de-manufacturing and repair facilities, etc.
- Activities more closely related to traditional waste treatment management like enclosed composting sites, anaerobic digestion plants and biomass facilities.

There is also opportunity to integrate functions in the wider natural resources context, e.g. linkages with energy, sewage, soil improvement and transport systems.

It is important to achieve a balance between economies of scale in facility provision, the proximity principle and maximising sustainable transport modes. The optimum solution for many situations may be a 'hub and spoke' arrangement whereby a central de-manufacturing/reprocessing facility is served by a number of feeder reception facilities.

Given the variations in land availability from area to area in the UK, the full resource park co-location concept may not always be achievable. A pragmatic approach that tailors the concept to local circumstances is therefore appropriate, for example by recognising the needs of the rural economy or the economic regeneration opportunities of using 'brownfield' sites. Activities that can be linked to agriculture and/or the processing of agricultural waste may be appropriate in farm settings, e.g. green waste composting, bio-waste treatment facilities and rural transfer facilities.

The general principle is that the planning system only prevents uses with higher levels of impacts although planning policies can be used in a general way to protect lower land value categories, for example, employment land over housing or retail. The application of this principle to resource parks would not therefore guarantee the availability sites and a degree of property intervention may be required initially. The Regional Development Agencies (RDAs) could potentially play an important role in this area by securing and making available strategic sites. The precedent for the RDAs undertaking this type of role is already established in other sectors.

The reservation via the land-use planning system of 'resource parks' specifically for resource management use is an essential part of the overall jigsaw and would send a clear message to all parties about the way things must develop.

A Concept Eco Park, as developed by the Wales Environment Trust, including the following facilities:

- Material Recovery Facility
- Energy From Waste Plant
- Composting Plant
- Green House
- SME's Manufacturing with Waste
- Visitors Centre
- Garden Centre
- Office
- Product and Manufacturing Display Area
- Play and Picnic Area

Implementation

Resource management requires changes at all levels involving upstream measures such as integrated product policy and producer responsibility to more 'end of pipe' changes to waste management systems. This sums up the paradigm shift that is needed.

But how do we make the transition at a practical level and who is responsible for initiating it? There are no rules to provide the answers to those questions. There are issues at all levels:

- There is no strategic planning framework for resource management. Who should take the lead?
- How do we get the data to forecast potential facility requirements in terms of numbers, types and locations?
- Whose role is it to engage and influence the process chain?
- What needs to happen to ensure investment in a new resource management infrastructure?
- How can the land-use planning system deliver consents for a new infrastructure on the scale required?
- How can regulatory barriers, such as the legal definition of 'waste', be overcome?

Answers to these questions are needed urgently to help ensure that the UK complies with the various EC Directives in the most sustainable way.

Providing an implementation plan for resource management is beyond the scope of this paper but 12 key actions to underpin a resource management approach are set out below:

Central Government
Achieve a joined-up approach between Government departments to:
- **Strengthen the link between**

'cause and effect' by developing an integrated national materials resource strategy covering the life-cycle of goods and products, including waste management strategy.
- **Develop economic instruments and regulations to energise the process chain to correct market failures (linked to the above strategy)**
- **Develop a multi-agency organisation to provide the essential information to support a resource management approach.**

Environment Agency
- **Apply regulation in a way that facilitates resource management. Undertake waste surveys with a resource focus and at a level that facilitates planning of local infrastructure.**

WRAP
- **Develop role as a strategic facilitator in resource management, working in partnership with the private and public sectors.**

Regional
Regional Assemblies and Development Agencies should:
- **Ensure that they influence all sectors to work together for the well being of the region, by ensuring that planning frameworks include natural resource management policies, and local market development networks are established to help industry invest and develop.**

Local Government
Establish all- party political consensus and leadership on resource management. Allocate roles and

responsibilities to ensure a more corporate approach using local strategic partnerships to:

- **Undertake strategic planning at a local level through integrated material resource strategies incorporating waste management strategies, statutory waste local plans and associated societal and economic development issues.**
- **Establish a new materials resource management function which links to Sustainable Development/Economic Development, to work with the community using Local Agenda 21 principles to influence change in the process chain.**

Industry
- **Harness the business development and expansion opportunities in materials handling, facilities management and materials brokerage.**

- **Work in partnership with the public sector to identify how entrepreneurship can be harnessed to achieve resource management objectives and achieve environmental, economic and social goals.**
- **Reassess the approach to financing new resource management infrastructure and systems.**

Academia
- **Align research to the resource management agenda and in particular to what is needed to get the process chain operating efficiently.**

Conclusion

This paper sets out an urgent call for change. It highlights the paradigm shift in thinking that is needed to achieve the transition from waste to resource management, and sets out key practical measures that need to be taken to help get there.

The keys to success are correcting market failures in the process chain, putting in place a strategic planning framework for resource management, and coordinating the various key sectors. Lifestyle and behaviour change is also a very major issue and coordinated action at a strategic level to research, develop and test effective approaches is needed.

Government has a key role in creating the overall climate for resource management and its support for the type

of approach outlined in the paper is vital. Without its leadership on this societal change agenda we fear that there will be substantial inertia, delay and inability to meet EU targets across many sectors. Further, what will be put in place will be an inefficient system that will take another 10-20 years to correct at a huge cost.

Thus, the way forward is to lift one's sights to a wider horizon and to the best means to deliver what is required.

Adoption of these concepts would require the establishment of an integrated performance and monitoring framework to set targets for the various sectors and track their achievement.

Appendix. Background to the Resource Issue

The global driver in resource management terms is concern about consumption and the inequities between the developed and the developing world.

This topic was a key theme of the 2002 Johannesburg World Summit that took place against the backdrop of deepening global poverty and worsening environmental degradation since the 1992 Rio Summit. A key outcome of Johannesburg was a better understanding of the key linkages between poverty, the environment and the use of natural resources (including energy, water, fisheries, atmosphere and biodiversity).

Johannesburg (2002) recognised that fundamental changes in the way society produces and consumes are vital to achieving global sustainable development. Developed countries have a responsibility to take the lead, with all other countries befitting from the process. World leaders agreed that a key need is to address, and where appropriate de-link, delivering economic growth and environmental degradation by improving efficiency in the use of resources and production processes and reducing resource degradation, pollution and waste. The Summit Action Plan encourages and promotes the development of a ten-year framework of programmes in support of regional and national initiatives to accelerate this shift.

Over the past 25 years European waste policy has focussed on reducing the environmental impacts of waste management, with the evolution of a number of key principles as a framework for environmental protection and sustainability. These include:

- The 'polluter pays' principle.
- The waste hierarchy (prevention, reuse, recycling, recovery and disposal).
- The proximity principle, that waste should be dealt with as close as practicable to where it arises.
- The use of the best practicable environmental option (BPEO).
- The concept of 'producer responsibility', making producers responsible for their products and goods at the end of their lives.

Identification of these principles has led to a range of legislative measures, such as the Landfill and Incineration Directives, which when fully implemented everywhere in Europe will at least halve the current environmental impacts from waste (Walstrom, 2001). Much less progress has been made on waste prevention, which impacts on most stages of the product life cycle in addition to post-consumer waste.

Resource productivity is becoming generally recognised as the key concept in the reconciliation of economic growth and the environment. Achieving this goal is dependant upon making consumption patterns sustainable, and estimates suggest that an improvement in productivity of between four and ten is needed. Organisations such as the Organisation for Economic Co-operation and Development have researched the trends in consumption and reviewed the effectiveness of different types of policy instruments in influencing consumer decision making.

Europe is starting to address the consumption issue, with the aim of European Commission (EC) policy being to ensure that the consumption of resources does not exceed the carrying capacity of the environment, and that the link between economic growth and resource use is broken. There is

increasing recognition that the environmental impacts of waste are just one element among the impacts of resource extraction, manufacturing, transport, trading and use of products.

The European agenda is therefore moving to the bigger picture of making waste and resource policy more effective in achieving the broader objectives of environmental protection and sustainability. Part of this agenda is to ensure that better use is made of the resource that is waste, by increasing recycling and closing the material loop in terms of markets and demand for recycled products. Measures such as integrated product policy and producer responsibility are seen as important drivers for technological innovation at the production end of the cycle. The EC's Sixth Environment Action Programme (European Community, 2002) includes the Sustainable Use and Management of Resources, and Waste Recycling, as two of the seven priority areas.

In the UK, waste and natural resources are reflected as key themes in the Government's sustainable development agenda.

The consumption issue was highlighted in the UK context in a report 'Resource Productivity - Making More with Less' (Cabinet Office, 2001) published in November 2001 by the then Performance and Innovation Unit in the Cabinet Office. This report highlighted the need to improve efficiency in the use of natural resources as a key issue facing the UK in overall sustainability terms. The key challenge was identified as decoupling economic growth, resource use and the production of waste.

Historically the UK has lagged behind most Northern European countries in terms of waste management practice and achievement. This is exampled by the UK's low historic household waste recycling levels and the very high

reliance on landfill for waste disposal. This situation will have to radically change over the next decade in order for the UK to comply with its obligations under the Landfill Directive and a range of other EU Directives, such as those relating to Waste Electrical and Electronic Equipment (WEEE) and End of Life Vehicles (ELVs).

In 2001 the Government asked the Strategy Unit in the Cabinet Office to identify the actions needed to achieve the aims of Waste Strategy 2000, the key focus being on achievement of the Landfill Directive targets. The Strategy Unit sought opinions from key stakeholders and reported in November 2002 (Strategy Unit, 2002). Their report stressed the reoccurring themes of action on decoupling waste growth from economic growth and increasing the level of recycling. The study also made a series of recommendations for change at Government policy level. The Government published its response (DEFRA) in May 2003 accepting the majority of the Strategy Unit's recommendations and supporting the direction or intent of many of the others. The Government had already responded in the following key areas:

- Landfill Tax to be increased by £3 per tonne in 2005/6 and by at least £3 per tonne in the years thereafter, on the way to a medium to long-term rate of £35 per tonne.
- The reformation of the Landfill Tax Credit Scheme to redirect funding into a new Sustainable Waste Management Programme for England in 2003/04, 2004/05 and 2005/06.
- A new Sustainable Waste Management Programme managed by DEFRA to improve waste minimisation, recycling and composting and to research new technologies for dealing with other wastes.
- Establishment of a new Delivery Team and Steering Group.

- Local authority funding for 2004/05 and 2005/06.

The most significant of the above measures is the increase in the Landfill Tax, which is stated to be cost-neutral to business and local government. Over time this will start to fundamentally change the economics of the various waste management options and to open the way for major new opportunities.

The Waste and Resources Action Programme (WRAP) was set up in 2001, with an initial budget of £40 million of public money over three years, to pump-prime new markets in order to support the expansion of recycling. The initial focus of this programme is on plastic, paper, glass and wood. WRAP has also taken on the coordinated funding of initiatives to support aggregate recycling, funded from the Aggregates Sustainability Levy. As part of the Government's response to the Strategy Unit report, WRAP's remit is being widened significantly to include national waste awareness and recycling development.

A regional dimension is emerging with the development of regional waste management strategies cascaded down from the national agenda. Regional strategies will have statutory status in land-use planning terms and thus be key policy documents in shaping future infrastructure provision.

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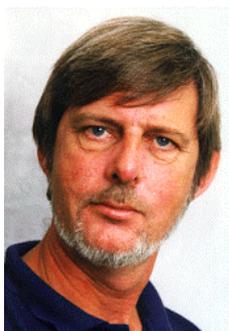
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If you would like to receive a further copy of ' From Waste to Resource Management' a discussion paper, or have any questions or queries in regards to the paper, then please contact the Hampshire Natural Resources Initiative team (*who are acting on behalf of the authors*), at the below address.

An electronic version of the full discussion paper, along with a shortened summary of 'From Waste to Resource Management' is available on the HNRI website, please see details below:

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