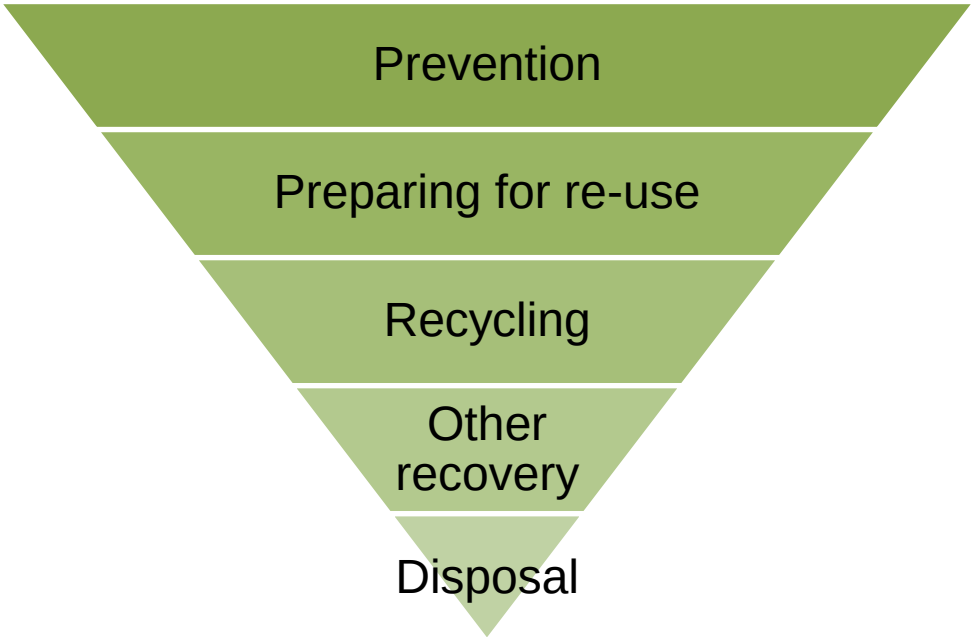
Question 7: We would welcome views on:
(a) the coverage,
(b) the ease of use and
(c) the substance of this guidance;
(d) the way Section 2 of Part 2 (*Switching to better options: ideas and sources of support*) is organised. Would users prefer to have it laid out by material (so it goes through the steps of the hierarchy for each material in turn), or the way it is now, which is designed to allow users to look at the same activity for several materials at a time?

- CONSULTATION DRAFT -

GUIDANCE ON APPLYING THE WASTE HIERARCHY



[Made under powers given to the Secretary of State in relation to England by section 34(2D) of the Environmental Protection Act 1990, as inserted by paragraph 3(4) of Schedule 4, Part 1 to the Waste (England and Wales) Regulations 2010.]

TABLE OF CONTENTS

QUICK USERS' GUIDE

This document summarises current research on the environmental impacts of various waste management options for a range of materials and products.

Businesses and public bodies can use the guidance when they make decisions on options for dealing with waste – including preventing it arising in the first place.

This guidance is designed to help you understand what measures are available to you to apply the hierarchy. **We suggest you read in particular pp. 7, 9, 15, and 16-26.**

If you are:

- any person who imports, produces, carries, keeps or treats waste, ***or*** a dealer or broker who has control of waste,

- ***and*** you are responsible for the transfer of waste

then you are legally required to take all measures as are reasonable in the circumstances to apply the waste hierarchy when you transfer waste, taking this guidance into account.[1] Other considerations, such as technical feasibility, economic viability and wider environmental protection may also apply.[2]

Part 1 is about what the document is for, who should read it, and how to use it.

Section 1.4 (p.7) sets out ***questions which may help***.

Section 2.1 (p.9) ***explains each step of the hierarchy in more details***. It also highlights when it makes sense to ***depart from it***.

Part 2 is about how the hierarchy applies to common materials and products.

The ***'60-second summary' on p.16*** lays out the order of environmental preference in a visual form that is quick and easy to follow.

Section 2 (pp.16-26) provides ***ideas for managing resources and waste more sustainably,*** with links to sources of further advice and help.

[1] section 34(2B) and (2C) of the Environmental Protection Act, inserted by paragraph 2(3), Part 1, Schedule 4 to the Waste (England and Wales) Regulations 2010.
[2] The qualifications are set out in full in Article 4(2) of the revised Waste Framework Directive, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:EN:PDF.

Section 3 (pp.27-55) explains in more detail the ***scientific evidence*** which underpins the order of environmental preference.

Finally, Part 3 and the Annexes contain links to further sources of advice, and references to the research used.

PART ONE – PURPOSE AND METHODOLOGY

1. What this document is for

1.1 Background

In the first consultation on transposing the revised Waste Framework Directive, many respondents asked for help on how to apply the waste hierarchy included at Article 4 of the Directive to the waste materials and products they commonly have to deal with.

This guidance fulfils this request for England. Separate guidance will be issued by the Welsh Assembly Government, Scottish Government and Northern Ireland Executive.

1.2 Who should read this guidance

This document aims to assist people who create or manage waste – local authorities, businesses, and their contractors - in preventing more of this waste, and in dealing with waste sustainably.

If you are:

- any person who imports, produces, carries, keeps or treats waste,
  or
  a dealer or broker who has control of waste,
- ***and*** you are responsible for the transfer of waste

then you are legally required to take all measures as are reasonable in the circumstances to apply the waste hierarchy when you transfer waste, taking this guidance into account.[3] Other considerations, such as technical feasibility, economic viability and wider environmental protection may also apply.[4] You must confirm that you have complied with the duty in the transfer note required under section 34(1)(c) of the Environmental Protection Act.[5]

This guidance is designed to help you understand what measures are available to you to apply the hierarchy.

[3] section 34(2B) and (2C) of the Environmental Protection Act, inserted by paragraph 2(3), Part 1, Schedule 4 to the Waste (England and Wales) Regulations 2010.
[4] The qualifications are set out in full in Article 4(2) of the revised Waste Framework Directive, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:EN:PDF.
[5] Regulation 34(1)(d) of the Waste (England and Wales) Regulations 2010.

1.3 What the guidance covers

This document summarises current research on the ***environmental impacts*** of various waste management options for a range of materials and products. It is not designed to be a comprehensive list, but covers the most common types of waste arising. All the research we have used is referenced in the text and at the end of the document (Section 1 of Part 3).

The application of the hierarchy to ***hazardous waste*** will be set out in separate guidance that will follow the Strategy for Hazardous Waste Management in England.

1.4 How it should be used

Businesses and public bodies can use the guidance when they make decisions on options for dealing with waste – including preventing it arising in the first place.

It may be helpful to look at the following questions in turn, and to discuss them when you negotiate waste management contracts:

What is the waste you create or handle made of?	→ The guidance looks at waste by material, and includes a section on residual waste too.
How can you prevent any of this waste?	→ The guidance provides tips and pointers to more detailed waste prevention tools
What's the best environmental option for dealing with it?	→ The guidance ranks the options according to their environmental impacts. It indicates where this ranking departs from the waste hierarchy, and why.
How can you or your waste contractor(s) make your waste suitable for use in a better environmental option than the one you are using now? o Could it be prepared for re-use? (eg by sorting, cleaning) o Could it/more of it be recycled? (eg by sorting it better) o Is there anything else that could be extracted from my waste (energy or product)?	→ The guidance indicates where factors such as quality and sorting make a difference to the use of the waste, and gives pointers to quality advice etc.

This guidance only covers the environmental impacts of the generation and management of waste. In line with life-cycle thinking, it indicates when a departure from the waste hierarchy produces a better environmental outcome.

We recognise that other factors will come into play in making decisions about waste generation and management, such as technical feasibility, economic viability and environmental protection.

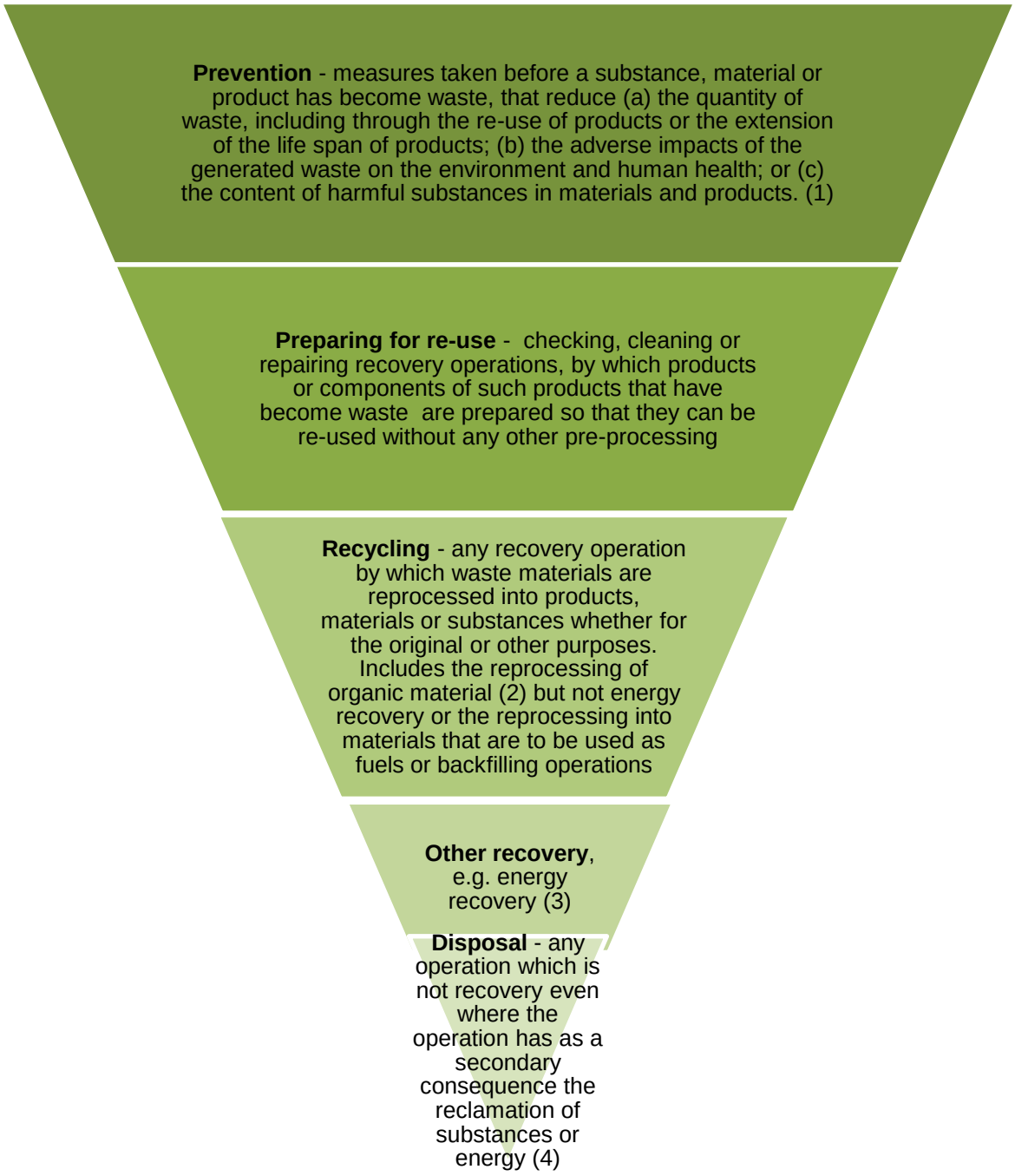
2. How this document was put together

2.1 The waste hierarchy

Article 4 of the revised Waste Framework Directive, due to be transposed into the UK law by 12 December 2010, sets out 5 steps in dealing with waste. *Figure 1* below sets these out and provides examples of what they mean.

Like all Member States, the UK will need to apply this hierarchy as a priority order in waste prevention and management legislation and policy.

Figure 1: the waste hierarchy



Notes:

(1) Prevention includes *avoidance* (buying fewer items, reducing process waste or using less material per unit), *reduction* (keeping products for longer, designing them so they last longer), and *re-use* (selling and buying used items).

(2) e.g. composting, so long as it meets PAS/Quality Protocol standards.

(3) e.g. combustion with energy recovery, anaerobic digestion, processes including gasification and pyrolysis which can produce energy (fuels, heat and power) and materials from waste, etc. This category also includes backfilling operations.

(4) e.g. landfill, incineration. The revised Waste Framework Directive sets a threshold above which energy efficient municipal waste incinerators can be classified as recovery facilities, and below which they continue to be classified as disposal facilities. Where energy recovery in municipal waste incinerators is discussed in this document, it is assumed that the option considered is above this threshold.

Departing from the waste hierarchy

Article 4(2) of the Directive allows Member States to depart from the hierarchy for specific waste streams in order to deliver the best environmental outcome. However, this has to be justified by life-cycle thinking on the overall impact of generating and managing these waste streams.

For four materials - Life Cycle Analysis evidence suggests that **waste management options which are not in keeping with the waste hierarchy are better for the environment**:

- for **food** and **garden waste**, anaerobic digestion is better than other recycling and recovery options – see sections 3.2 and 3.3 in Part 2 for more details;
- for **lower grade wood**, energy recovery options are more suitable than recycling – see section 3.5 in Part 2;
- for **tyres**, energy recovery in cement kiln or pyrolysis is better than open loop recycling (but less beneficial than closed loop recycling) – see section 3.10 in Part 2.

Other considerations - namely the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts – can also be taken into account[6]. These other factors are better considered on a case-by-case basis and are not covered here.

[6] in accordance with Articles 1 and 13 of the Directive

2.2 Environmental impact indicators

We have selected four environmental impact indicators against which to compare waste management options:

Climate change	Climate change, or global warming, refers to the increase in the average temperature of the Earth's surface. This is caused by emissions of greenhouse gases including carbon dioxide, nitrous oxide and methane. Direct emissions from waste management contribute to all of these, and when emissions from the whole life of materials and products are included, the contribution of waste management, including prevention, becomes significant. Climate Change is an issue of global concern. In the UK, the Climate Change Act 2008 sets out an objective to reduce carbon dioxide emissions 80% by 2050 against a 1990 baseline.
Air quality (incl acidification, ozone creation, toxicity (human and aquatic)	Acidification has direct and indirect damaging effects, such as nutrients being washed out of soils, increased solubility of metals into soils, and damage to stone buildings. Photochemical Ozone Creation Potential (also known as summer smog) is implicated in impacts such as crop damage and increased incidence of asthma, for emissions of substances to air. Waste management options can affect acidification through emissions from energy use, and emissions of nitrogen oxides and hydrocarbons lead to summer smog.
Water quality (incl eutrification)	Eutrophication is the addition of organic or inorganic fertiliser to land or water. Excessive growth (and death) of plants and algae can lead to decreased oxygen levels in water, creating conditions which cannot support diverse life. Eutrophication may be caused by leachate or effluent from waste disposal systems.
Resource depletion	Resource depletion is the decreasing availability of natural resources. These may be renewable (e.g. wood) or non-renewable (metals). As economies around the world grow, demand and competition for finite resources – including raw materials and fuel - also increases. Many of these resources could potentially be reduced to unacceptable

levels[7]. This will have a range of environmental and economic impacts.

Alternative options within the waste hierarchy have the ability to reduce our demand for resources and extend the life of resources.

It is worth noting that the impact of transport of waste material (including collection from the kerbside) has been taken into account in our assessment. Generally, emissions from transport of recyclable materials are a very small fraction of the total impacts, and they are dwarfed by the benefits of recycling. There are some exceptions to this, in particular aggregates, where due to low emissions associated with production and disposal, transportation becomes more significant.[8]

The way different EU countries apply the waste hierarchy may differ because of their energy mix (the CO_2 emissions associated with a kWh of electricity vary across Europe, depending on the mix of fuels used and the efficiency of production); extent of landfill gas capture, and nature of the avoided materials.

2.3 How this guidance fits with other tools

This guidance gives an order of environmental preference for waste management options, but in general it does not quantify their environmental impacts. Some figures are provided which are representative of impacts at a UK level, but actual impacts will vary according to the markets to which recyclates are sent, the efficiency of energy recovery facilities used, etc. However, the overall hierarchy of options will not be affected by such variations.

The Environment Agency has developed ***WRATE***[9], a piece of software which allows businesses and public bodies to calculate the environmental impacts of their systems, including waste management impacts. This guidance reflects the key assumptions in WRATE, and we recommend that businesses and public bodies use WRATE to make decisions based on this guidance but more finely tailored to their circumstances.

The Environment Agency is also developing a set of tools (known as ***Resource Efficiency Appraisal Development*** (READ)) which businesses and organisations will be able to use to benchmark how well they manage resources such as materials, waste and packaging, and the biggest opportunities to improve. These tools will be available on the Environment Agency and WRAP websites from Summer 2010.

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[7] Turner, R. K., Morse-Jones, S., and Fisher, B. (2007). *Perspectives on the 'Environmental Limits' Concept: A report to the Department for Environment, Food and Rural Affairs..* CSERGE, Norwich. Defra, London.

[8] http://aggregain.wrap.org.uk/

[9] http://www.environment-agency.gov.uk/research/commercial/102922.aspx

The ***"duty of care" Code of Practice***[10] is a statutory document which explains how all holders, producers, carriers, importers, brokers, dealers and processors of waste can meet the legal duty set out in Environmental Act 1990, section 34 to manage that waste correctly to enable its safe recovery or disposal without harming the environment.

All waste holders will still have to have regard to their statutory duty of care, in addition to the waste hierarchy. The Code of Practice will be revised to refer to the waste hierarchy guidance, which will remain a separate document because of its different scope and level of details.

This guidance goes ***beyond current local authority National Indicators***. National Indicator NI 185[11] (CO_2 reduction from local authority operations) covers waste collection, but excludes the emissions or savings associated with waste management, including prevention, recycling, energy recovery and landfill. This guidance covers precisely these areas.

2.4 Reviewing and updating this guidance

Inevitably, this document reflects a snapshot of current research. Over time, the efficiency of alternative options will change, as will the background energy mix. Both of these will influence the relative environmental impacts of waste management options.

To take account of such changes, this document will be reviewed on an annual basis and updated as appropriate. Section 1 of Part Three explains how to put forward new evidence for consideration.

[10] http://www.defra.gov.uk/environment/waste/controls/documents/waste-man-duty-code.pdf
[11] http://www.defra.gov.uk/corporate/about/what/localgovindicators/documents/ni185-guidance-2008.pdf

PART TWO – ORDER OF ENVIRONMENTAL PREFERENCE

This section of the guidance includes:

- a visual summary of the way waste management options are ranked in order of environmental impact for each of the materials and products covered by the guidance;

- a list of the key organisations which can provide support and information to businesses and public bodies who would like to switch to more environmentally beneficial options; and

- a more detailed look at individual materials and products, which summarises the evidence behind the ranking.

1. A 60-second summary

Most environmental benefit

Paper and Card	Food	Garden Waste	Textiles	Wood	Glass	Metals	Plastics±	WEEE	Tyres	Residual 'black bag'
Prevention	Prevention	Prevention	Prevention	Prevention	Prevention	Prevention	Prevention	Prevention	Prevention	Prevention
Re-use			Re-use	Re-use	Re-use	Re-use	Re-use	Re-use	Re-treading	
Recycling	Anaerobic Digestion	Anaerobic Digestion	Recycling	Recycling; energy recovery♦ (preferable to recycling for lower grade materials)	Recycling in a remelt process	Recycling	Closed loop recycling	Recycling (esp. suitable for metals and high quality plastic)	Closed loop recycling & use in road surfaces	
	Composting; other energy recovery technologies	Composting; other energy recovery technologies			Other recycling		Other recycling		Energy recovery in cement kilns	
Energy recovery♦ (esp. suitable for short fibres or contaminated materials)								Energy recovery♦ (esp. suitable for non-hazardous mixed plastic)	Energy recovery through pyrolysis	Solid recovered fuel derived from MHT or MBT, where it replaces coal*
			Energy recovery♦			Energy recovery♦	Energy recovery♦		Open loop recycling (eg drainage fill & sea defences)	Combustion with energy recovery*
					Energy recovery♦				Gasification/ incineration with EfW	MBT or MHT outputs used as fuel (but do not replace coal) or landfilled*
Landfill	Landfill	Landfill	Landfill	Landfill	Landfill	Landfill	Landfill	Landfill	Microwave treatment	Landfill

*the impact of CHP technology, which can improve the efficiency of each of these options, is not illustrated here

± the hierarchy may be different for some forms of bio-based plastics, see section 3.8

♦'energy recovery' covers a range of technologies, some of which will be more environmentally beneficial than others. Future versions will differentiate between technologies as more scientific evidence becomes available.

2. Switching to better options: ideas and sources of support

2.1 Prevention

Waste prevention can take many forms. Businesses, public bodies and householders all have a role to play in preventing waste, and the opportunities to make a difference are enormous.

Key sources of support

A simple summary of the benefits for all businesses of sustainable waste management, starting with waste prevention, can be found on the ***Business Link*** website[12].

Designing products with sustainability in mind is one way of preventing waste (eg by using less input material, designing products to last longer, etc). WRAP's Business Resource Efficiency Programme (previously provided through Envirowise) provides a free ***eco-design tool*** to help businesses with this.[13]

WRAP's ***Industrial Symbiosis Programme*** (previously provided through NISP) aims to help businesses become more resource efficient by bringing together traditionally separate industries and organisations from all business sectors to foster physical exchange of materials, energy, water and/or by-products together with the shared use of assets, logistics and expertise. Membership of the programme is free. It has a network of 12 regional teams across England, Scotland, Wales and Northern Ireland. Further details can be found at www.nisp.org.uk.

For local authorities, ***WRAP's Waste Prevention Toolkit***[14] offers interactive guidance that allows users to develop or review their waste prevention plan. It contains help on:

- planning and implementing a waste prevention programme
- individual activities to encourage the changes in behaviour needed to reduce waste arisings, along with examples of promotional materials, and advice on monitoring;
- examples of how to measure the impact of waste prevention activities or campaigns

Sector-specific guidance which covers all the levels of the waste hierarchy can be found in ***Section 1 of Part Three*** of this document.
Some products are subject to legal eco-design requirements. For example, packaging must be designed to minimise its weight and volume, make sure it can be recovered, and contain minimum levels of hazardous substances.[15]

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12 http://www.businesslink.gov.uk/bdotg/action/detail?r.s=sc&r.l1=1079068363&r.lc=en&r.l3=1079427402&r.l2=1079363672&r.i=1079427949&type=RESOURCES&itemId=1079427453&r.t=RESOURCES

13 (http://www.envirowise.gov.uk/uk/Our-Services/Tools/EDIT-The-Eco-Design-Indicator-Tool.html).

14 http://www.wrap.org.uk/applications/waste_prevention_toolkit/restricted.rm

More specific ideas and sources of information are listed below.

Material	Examples and sources of information
Paper	• businesses can use less cardboard packaging • businesses can reuse packaging etc. • Individuals and businesses can reduce paper use by printing less, double-sided printing, etc. • Individuals can be encouraged to reduce the direct mail they receive by signing up to the Mailing Preference Service (http://www.mpsonline.org.uk/mpsr/) and mydm.co.uk which reduces the amount of unaddressed mail delivered.
Food	'Love Food Hate Waste' is a UK-wide campaign providing information and advice on how to reduce food waste, via a website, and through media campaigning and events. Businesses, local authorities and community groups can be partners in this campaign – see http://www.wrap.org.uk/love_food_hate_waste/partners/. WRAP are also piloting initiatives on reducing food waste in schools. Businesses and other organisations can donate good quality edible food which would otherwise be wasted to organisations such as FareShare, who distribute surplus 'fit for purpose' product from the food and drink industry to organisations working with disadvantaged people - see http://www.fareshare.org.uk. Edible food that goes to rendering plants for authorised uses as non-waste (eg as pet food) can be seen a form of re-use. Increasing the amount of material which rendering plants process for these uses would be environmentally beneficial.
Green waste (garden waste)	Gardens can be designed to minimise their environmental impacts while keeping the benefits they provide. Wildlife Trusts (www.wildlifetrusts.org/) and other organisations publish advice on low maintenance and low water use gardens, which can be used by businesses and local authorities (in their communications with residents).
Textiles	Both businesses and individuals can: • retain and use items for longer • sell unwanted items, or donate them to charity shops • buy good quality textiles which are likely to last longer and save money over time. • hire rather than purchasing certain items The DirectGov website contains guidance on choosing greener clothing

[15] More details about these Essential Requirements can be found at http://www.netregs.gov.uk/netregs/63268.aspx . This includes links to relevant BSI standards.

	(http://www.direct.gov.uk/en/Environmentandgreenerliving/Greenerhomeandgarden/Greenershopping/DG_064424). Individuals can be encouraged to: • offer items for swapping or give them away through community websites, friends and family. • buy second-hand and vintage items, or take them for free from community events/websites etc. Businesses who use corporate clothing can make re-use easier by not using branding on the clothes themselves. There is a thriving secondary market for corporate clothing.
Wood	Both businesses and individuals can: • retain and use items for longer • refurbish items • sell or donate unwanted items • buy second-hand and vintage items, or take them for free from community organisations etc Businesses may also considering leasing rather than purchasing certain items.[16] A number of organisations throughout the UK collect and reuse or resell surplus clean wood (details from the National Community Wood Recycling Network at www.communitywoodrecycling.org.uk). The 'BuilderScrap' project allows SMEs in construction to sell surplus stock (including wood). It can be accessed at: http://builderscrap.com/ Individual local authorities can publicise the options available locally on their website and in their communication materials.
Glass	Businesses can use returnable bottles, a feature of doorstep milk delivery and of some drinks supplied to licensed premises. Such opportunities depend on manufacturers and distributors. For ideas on reducing glass waste in the construction sector, see www.wrap.org.uk/construction/how_do_i_reduce_waste/index.html. Individuals can be encouraged to re-use glass containers for storage, home cooking etc. Containers can also be offered on re-use websites, sold or auctioned.
Metals	Lean production and product lightweighting can make a big difference in waste prevention, as can re-use. As an example of the latter, businesses can use re-useable intermediate bulk packaging and make sure that they are re-used rather than disposed of. There are a number of bodies which promote and disseminate innovation for manufacturers, designers and materials users, which

[16] WRAP (2009) *Meeting the UK climate change challenge: The contribution of resource efficiency*. Report prepared by Stockholm Environment Institute and University of Durham Business School, WRAP

	can help resource efficiency. For example, the government-funded Manufacturing Advisory Service (MAS) (http://www.mas.bis.gov.uk/) can assist manufacturers to improve and streamline their processes, by reducing waste, becoming more energy efficient to improve their business. Free initial services and grants are available.
Plastics	Businesses can: • consider design options to reduce the amount of material their products use, • use returnable transit packaging (eg crates, sleeves) or refillable packaging, rather than single-trip packaging. However, businesses will need to look at transport distances, the number of uses, loss rate and cleaning requirements for the particular format they are considering, to make sure this does make environmental sense compared to single-use alternatives. Individuals can be encouraged to: • re-use plastic packaging more (including carrier bags), • use durable plastic containers (eg to store or carry food they have prepared) rather than disposable packaging, • choose products in refillable/returnable packaging. • Sell or donate (and in turn, buy) plastic leisure products and toys.
WEEE	Businesses, public bodies and individuals can reduce waste electrical equipment by increasing its lifetime, through: • retaining and using items for longer, • selling or donating unwanted items, and in turn purchasing second-hand items; • leasing rather than purchasing certain items.[17] There are big opportunities for more re-use: 59% of office machinery and computers disposed of by businesses are re-usable without repair. 49% of audio-visual, photographic and computers, calculators etc of by households is re-usable without repair.[18] A WEEE Reuse standard is being developed by the WEEE Advisory Body. Meanwhile, people can have WEEE they want to sell or buy tested for electrical safety through Portable Appliance Testing (PAT). For more information and a directory of service providers, see www.pat-testing.info/. Government is working on a series of projects to encourage manufacturers to design products to last for longer, and can be repaired more easily.

[17] WRAP (2009) *Meeting the UK climate change challenge: The contribution of resource efficiency*. Report prepared by Stockholm Environment Institute and University of Durham Business School, WRAP

[18] Cooper, T. (2004) Inadequate life? Evidence of consumer attitudes to product obsolescence, *Journal of Consumer Policy*, 27, 421-449

Tyres	Businesses and public bodies can consider their transport and logistics practices and maintenance programmes to maximise the life of their tyres. Tyres can be re-used in several ways if they are still in good enough condition. Tyres which still have enough tread can be re-fitted on vehicles if they have been inspected and marked appropriately. Re-treaded tyres avoid the need for new tyres to be manufactured.

2.2 Preparation for re-use

'Re-use' and 'preparation for re-use

In this document (as in the England and Wales Waste Regulations 2010 and the Waste Framework Directive), when we speak about '*re-use*', we mean using again a substance, product or material that is not waste.

'*Preparing for re-use'* relates to checking, cleaning or repairing activities which allow waste to be re-used without any other pre-processing.

It is not always easy to make a distinction between what is waste and what is not. There is no definitive list; it depends on specific circumstances. To help, government has published guidance on the legal definition of waste and its application [insert link when published.]

Key sources of support

The ***Construction Waste Platform (now part of WRAP)*** provides practical services and support to the construction industry to become more resource efficient. More information is available at http://www.crwplatform.co.uk/conwaste/ and http://www.wrap.org.uk/construction/

WRAP's ***Programme for Reuse and Remanufacturing*** is an online resource aimed at organisations and businesses interested in the reuse and remanufacture of products. Further information is available at http://www.remanufacturing.org.uk/.

Local authorities can support local re-use organisations with ***re-use credits***[19].

More specific ideas and sources of information are listed below.

Material	Examples and sources of information
Textiles	Research done as part of the Sustainable Clothing Roadmap shows that the best way to promote re-use is to organise separate collection of textiles (including clothing, footwear, and furnishings), in the case of households at the kerbside, in a way that allows re-use (eg through information about the kind of cleanliness/wearability that is expected, protection from the elements and other contamination etc).[20] Information and contacts at the local level can be found from SortUK (www.sorttextilesuk.org) and the Textile Recycling Association (www.textile-recycling.org.uk/). For carpets, there are specialist refurbishment businesses throughout the UK; a list can be found at

[19] See section 6.2 *ff* of the Defra guidance, www.defra.gov.uk/environment/waste/localauth/partnerwork/documents/recyclingcreditscheme-guidance.pdf

[20] http://www.defra.gov.uk/environment/business/products/roadmaps/clothing/documents/reuse-recycling.pdf

	www.carpetrecyclinguk.com/downloads/specialist_carpet_recyclers_feb2010.pdf.
Wood	Many wooden items can be refurbished or repaired. This is common for wooden packaging (e.g. pallets) and furniture. Wood waste separately collected from demolition sites can also be reused (e.g. flooring). Wooden furniture and fittings from businesses can be repaired and sold on. To find out how to donate or obtain re-used furniture, please use the search tool of the Furniture Re-use Network at http://www.frn.org.uk/donate.asp. In London, projects such as Greenworks (http://www.green-works.co.uk/) collect and refurbish wood products and other office furniture for resale or provision to educational facilities in developing countries.
Metals and plastics	The reconditioning of intermediate bulk containers has a well established and effective international infrastructure for ensuring the re-use over multiple cycles. This is supported in international law through regulations governing the manufacture, testing, filling, carriage and reconditioning methods currently in use. The Industrial Packaging Association provides a list of businesses which manufacture and recondition bulk containers (http://www.theipa.co.uk/download/members.pdf)
WEEE	To maximise activities which prepare WEEE for re-use, collection methods must avoid (further) damage to the equipment. Good practice guidance on the collection and treatment of WEEE is due for release by WRAP in June 2010. [update in final version]. Involving voluntary/community organisations in collection and re-use/refurbishment of WEEE – often for resale to disadvantaged in community - offers opportunities to increase the re-use. WRAP is exploring opportunities for increased WEEE collection through a trial at Civic Amenities sites. ***Public sector bodies and businesses which allow contractors access to WEEE for the purposes of refurbishment or recycling must satisfy themselves that these businesses operate legally, and in particular that WEEE is not exported illegally outside the OECD.***[21]

[21] http://ec.europa.eu/environment/waste/shipments/pdf/correspondents_guidelines_en.pdf

2.3 Recycling

Key sources of support

WRAP (www.wrap.org.uk) has a wealth of information and advice on recycling, for public sector organisations, businesses in various sectors and the general public.

The ***NetRegs Waste Directory*** (http://www.wastedirectory.org.uk/) offers a search engine that allows businesses to find out where they can recycle different types of waste.

More specific ideas and sources of information are listed below.

Material	Examples and sources of information
Food	Municipal food waste collection and recovery are priority areas for WRAP's ROTATE advisory service for local authorities. For guidance and advice, please see http://www.wrap.org.uk/local_authorities/support_funding/collections.html. Local authorities can support home composting through provision of composting bins and appropriate advice on composting techniques. WRAP provide advice on home composting to local authorities via the ROTATE team and to individual householders through the Recycle Now website[22]. Businesses who are considering using or investing in anaerobic digestion find advice at http://www.biogas-info.co.uk/. Businesses who are considering sending their food waste for composting (or anaerobic digestion) can find basic information and further pointers on http://www.businesslink.gov.uk/bdotg/action/detail?itemId=1081282627&type=RESOURCES. WRAP's 2009 report on de-packaging options[23] contains useful guidance for retail or catering businesses which generate large amounts of packaged food waste. ***There are legal requirements on the treatment of food waste***, as well as quality standards. Both are summarised at Annex A.
Textiles	Local authorities, other public bodies and businesses can make sure that they or their contractors set up arrangements with a carpet recycler. Household Waste Recycling Centres (HWRCs) could be more geared towards providing a collection infrastructure for domestic carpets for re-use or recycling. Carpet Recycling UK provides a list of carpet recyclers and other information at www.carpetrecyclinguk.com/downloads/specialist_carpet_recyclers_feb2010.pdf.

[22] http://www.recyclenow.com/home_composting/index.html

[23] http://www.wrap.org.uk/downloads/Food_waste_depackaging_equipment_FINAL_REPORT_April_09.e8e53f38.6989.pdf

Wood	To maximise both the quantities of wood recycled and the benefits of doing so, wood should be graded according to the end markets it is suitable for where possible. The Wood Recyclers' Association (www.woodrecyclers.org) has developed a grading structure for non-virgin wood for recycling into products, feedstocks and fuels. It can be found at Annex B of this guidance.[24] WRAP has published guidance[25] on how to identify and separate wood streams for different markets as well as a tool[26] to identify local wood recyclers.
Plastics	In order to maximise the environmental benefits of a recycling scheme, the system should deliver plastics with low levels of contamination to allow ready sorting of polymers. The Advisory Committee on Packaging is due to develop guidance on how to achieve this by 2011 [update before publication]. In 2008, WRAP trialled a variety of technologies for sorting and recycling mixed plastic packaging. [27] These activities were shown to have environmental benefits, though the technology is not currently widespread in the UK. Uncontaminated plastics from the building and construction sector (which accounts for 23% of the plastics market) can be readily recycled. Contaminated plastics can be suitable for recycling after additional processing. Recycling facilities for PVC waste from construction and demolition can be found from www.recovinyl.com. More information is available from the British Plastics Federation[28] and WRAP[29].

[24] A quality protocol for waste wood (PAS 111) is being developed by the BSI. This will further improve waste wood recyclers' and users' confidence in the material.
[25] www.wrap.org.uk/downloads/WoodGuidancePoster.40a2e65e.3130.pdf
[26] http://recyclewood.wrap.org.uk/
[27] WRAP (2008): *Domestic Mixed Plastics Packaging Waste Management Options*
WRAP (2008) LCA of Management Options For Mixed Waste Plastics
[28] http://www.bpf.co.uk/Sustainability/Plastics_Recycling.aspx
[29] http://www.wrap.org.uk/construction/construction_materials/plastic/index.html

2.4 Energy recovery

There are many different energy recovery technologies – including combustion with energy recovery, anaerobic digestion, processes including gasification and pyrolysis, advance biorefinery technologies. They deliver a variety of products. You can find an illustration of the options at Annex D.
For more details, please go to Defra's new technologies webpages (http://www.defra.gov.uk/environment/waste/residual/newtech/).

The revised Waste Framework Directive sets a threshold above which energy efficient municipal waste incinerators can be classified as recovery facilities, and below which they continue to be classified as disposal facilities. Where energy recovery in municipal waste incinerators is discussed in this document, it is assumed that the option considered is above this threshold.

Energy recovery is a better alternative to landfill for residual 'black bag' waste, and is also generally better than landfill for most materials. In addition, it is more environmentally beneficial than recycling for food and garden waste, and wood. Some energy recovery technologies are better for tyres than some types of recycling (see the table in section 2.1 above, and section 3 below).

Renewable energy, including energy from biobased waste, is key to our low carbon future as well as the security of our energy supply. The EU's Renewable Energy Directive requires the UK to generate 15% of its energy from renewables by 2020. It also sets a binding UK target of 10% energy from renewable sources in transport by 2020. These are ambitious targets, which the UK is fully committed to meeting. The Government has committed to introducing measures to promote a huge increase in energy from waste, through anaerobic digestion.

Key sources of support

Information on anaerobic digestion can be found on the biogas portal: www.biogas-info.co.uk. Please note that ***there are legal requirements on the treatment of food waste*** (including forms of energy recovery), as well as quality standards. Both are summarised at Annex A

The European Recovered Fuel Organisation's webpages give detail of technologies and quality standards (http://erfo.info/Quality.6.0.html).

Defra's ***Waste Infrastructure Delivery Programme*** (WIDP)[30] was established to support local authorities to accelerate investment in the large-scale infrastructure required to treat residual waste, without compromising efforts to minimise waste and increase recycling levels. WIDP provides local authorities with high quality comprehensive support, including:

- Dedicated "transactors" give guidance and support to individual Authorities procurement projects - both PFI and non-PFI.
- Generic guidance to help all waste infrastructure projects, which covers planning, options appraisal, project governance, prudential borrowing,

[30] http://www.defra.gov.uk/environment/waste/residual/widp/

output specification and payment mechanism. Other modules are under development for publication.

Financial incentives

Both local authorities and private investors can benefit from financial incentives aiming to increase the supply of renewable energy.

- Different EfW technologies are eligible for varying degrees of Renewables Obligation Certificates[31] and Renewable Transport Fuel Certificates (RTFCs)[32]..

- The Government also plans to introduce Renewable Heat Incentives in April 2011. This will allow generators of renewable heat to claim financial support for that heat.

The Renewable Obligation Certificate (ROC), RTFCs and potential Renewable Heat Incentive (RHI) entitlements are complex and variable, depending upon the route selected and need to take account of the practicalities of demonstrating to Ofgem the biodegradable content in a mixed waste stream.

Alongside planning consent, proven technological efficacy, the financial strength of contracting entities and eligibility of schemes for ROC, RHI and ECA benefits are the principal determinants of plant deliverability. There are a series of intermediate technologies which should be chosen with care depending on main technology used and location, and end use of outputs. Some technologies are promising but as yet unproven in the UK at the commercial scale. If they are to be included in a 25-year waste management contract, the financial and technical risks associated with the technology will need to be borne by the waste contractor as counterparty to that long term contract.

The Waste Framework Directive[33] establishes a formula for calculating when thermal treatment is a waste disposal practice and when it can be deemed recovery. Therefore when planning new energy recovery installations, it is essential that waste management companies and local authorities maximise the energy recovery potential. This will require consideration of the technology, waste streams, and infrastructure.

One issue to note is that different waste materials have different calorific values. This means that a different amount of energy could be recovered from burning 1 tonne of plastic than 1 tonne of food. As an increasing proportion of recyclables are removed from waste over time, this will affect the calorific value of the residual waste, altering the energy generation potential.

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[31] The banding is at p.16 of the document at: http://www.decc.gov.uk/media/viewfile.ashx?filepath=what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/policy/renew_obs/key_stages/ro_consult/file46838.pdf&filetype=4

[32] The banding is at p.16 of the document at: http://www.decc.gov.uk/media/viewfile.ashx?filepath=what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/policy/renew_obs/key_stages/ro_consult/file46838.pdf&filetype=4

[33] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

3. Individual materials/products: a closer look at the evidence

3.1 Paper and card

In 2008, the UK used 13.2 million tonnes of paper and card products[34]. 8.8 million tonnes of paper and card were collected for recycling. Almost 40% of this was collected from the municipal waste stream, with the remainder coming from commercial and industrial (C&I) sources.

Prevention

Preventing paper waste, by reducing the use of paper in the first place or re-using paper, has significant environmental benefits in terms of greenhouse gas emissions, resource use and energy consumption[35].

Preparing for reuse

We are not aware of any such activities for paper and card.

Recycling

The majority of published studies indicate that recycling is preferable to other waste management options with respect to greenhouse gas emissions, resource depletion, acidification, ozone creation, and water savings [36].

Recycling paper and card is much more environmentally beneficial than allowing it to biodegrade in landfill. The available data suggest that recycling is preferable even when the recovered paper or card is transported to China to be recycled[37]. The benefits of recycling paper and card vary with grade; the higher the quality, the greater the benefit of recycling. The different grades of recovered paper and card are defined in EN 643 European List of Standard Grades of Recovered Paper and Board. Local authorities and waste management companies should ensure their collection schemes meet the quality requirements of their chosen markets[38].

Many recycling plants in the UK use sludge from the recycling process (fibres which are too short to recycle) to generate energy via Combined Heat and Power (CHP), which in turn is used to power the recycling process[39].

Paper and cardboard may also be composted. There is some Australian research covering the impacts of composting paper and card, but neither it nor

[34] WRAP (2010): Realising the value of recovered paper: An update
[35] WRAP (2006): Environmental Benefits of Recycling
[36] WRAP (2006): Environmental Benefits of Recycling and 2010 update
[37] WRAP (2008): CO_2 impacts of transporting the UK's recovered paper and plastic bottles to China
[38] See BSI PAS 105: Recovered paper sourcing and quality for UK end markets, http://www.wrap.org.uk/manufacturing/specifications.html
[39] Dunster, A. (2007): Paper sludge and paper sludge ash in Portland cement manufacture, DEFRA

other studies have included comparisons to other waste management options.[40] So we are currently unable to advise on where it fits in the hierarchy.

Research consistently shows that more energy is saved by recycling paper and card (and thus avoiding the use of virgin fibres) than by using waste paper products to replace fossil fuels in energy production. Typically twice as much energy is saved as would otherwise be produced[41].

Energy Recovery

Paper and cardboard used to generate energy are classed as renewable fuels. They offset the use of fossil fuels, so it provides some environmental benefits in terms of avoided resource use, and reduced contribution to acidification relative to landfill.

Where paper is contaminated (e.g. with grease from food) it is less suited to recycling and more suited to energy recovery.

Landfill

Paper and card should be diverted from landfill wherever possible. As they degrade in landfill, they can emit methane. Even where some or most of these emissions are captured for flaring or energy recovery, the overall impact is still negative. [42]

[40] ROU (2007) *Life Cycle Inventory and Life Cycle Assessment for Window Composting Systems* ROU, University of New South Wales; Australia
[41] WRAP (2006) Environmental Benefits of Recycling
[42] WRAP (2010) *Environmental Benefits of Recycling - 2010 update*

3.2 Food

Of the estimated 18-20 million tonnes of food waste created in the UK each year, around 8.3 million tonnes comes from households. [43] The majority of this is still sent to landfill, where it breaks down and releases methane. A further 5 million tonnes is lost in the supply chain, and more still through the catering sector (restaurants etc).

Prevention

A considerable amount of food waste (up to 80% for households and schools, for example) can be avoided.[44] Wasting food wastes the resources which have gone into growing, processing and transporting that food. On average, preventing 1 tonne of food waste avoids over 4 tonnes CO_2 equivalent[45]. Preventing food waste saves far more than any of the options for managing this waste.

Recycling and other recovery options

Options for the treatment of food waste include, in order of environmental benefit (greatest benefit at the top):

- anaerobic digestion
- composting (in-vessel or home/local composting)
- incineration with energy recovery.

Please note that food waste must be treated in accordance with the relevant legislation (see Annex A for more details).

We do not currently have comparative information on the environmental benefits of landspreading or rendering (see below). Landspreading of food waste is subject to the controls described at Annex A.

Anaerobic digestion (AD)

In anaerobic digestion, food waste is microbiologically broken down in enclosed containers in the near absence of oxygen. The outputs produced are *digestate*, which can be used instead of fossil fuel-intensive fertilisers, and *gas*, which can be used to generate vehicle fuel, heat, electricity, combined heat and power, or refined and directly injected into the gas grid[46]. Each of these has a different degree of environmental benefit, and may be more or less feasible depending on plant location.[47] For restrictions on the use of digestate, please refer to the Quality protocol for Digestate.[48].

The combination of both outputs means that AD is environmentally preferable to composting, and is the best currently available

[43] WRAP (2009): *Household Food and Drink Waste in the UK* report.
[44] Ibid. 'Avoidable' and 'potentially avoidable' food waste which includes potato peels, bread crusts etc, i.e. things that could be eaten but people choose not to.
[45] WRAP (2008): *The Food We Waste* report.
[46] As part of the Defra AD Demonstration Programme, work on technology which would enable gas to be injected into the grid is being progressed.
[47] For more information, see the biogas portal: www.biogas-info.co.uk
[48] http://www.environment-agency.gov.uk/business/topics/waste/114395.aspx

treatment option for food waste. **This departs from the waste hierarchy.**

Composting

'In-vessel' composting (IVC) allows collected food waste to be composted on a large scale. It can produce composts meeting quality standards[49] which can be used as an alternative to inorganic fertilisers and peat-based products.

IVC is not considered as environmentally beneficial as anaerobic digestion.

Businesses can compost on site – but even if they don't move food waste to or from the site, they must comply with relevant legislation - see http://www.defra.gov.uk/environment/policy/permits/guidance.htm.

In addition to commercial composting, composting on a small to medium scale may be carried out by voluntary/community/environmental organisations and social enterprises, who collect and compost food and garden waste from local houses and businesses. The Community Composting Network is the overarching body for voluntary/NGO/community composters (www.communitycompost.org).

Many types of food waste collected by local authorities and private contractors are not suitable for windrow composting. Only where food premises process strictly vegetables only, or have for example a dedicated vegetable processing line with a strict HACCP agreed with the local authority to guarantee complete separation from all products of animal origin can this food waste be composted in the open air. See Annex A for more details.

The relative positions of composting and energy recovery options other than anaerobic digestion depend on the compost being used in place of fertiliser or peat. Composting and energy recovery are broadly similar in terms of greenhouse gas emissions. Energy recovery can avoid more air pollution since burning food waste avoids the use of fossil fuels, but composting avoids more water pollution where use of artificial fertilisers are avoided[50]. Only one data source has been identified which considers resource depletion[51], which assumed that fertiliser supply was unlimited, an issue on which opinion has since changed[52]. Insufficient data is available on this issue to assess the relative merits of composting and energy recovery.

Home composting can also be an effective means of dealing with food waste.

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[49] BSI PAS 100:2005 – see Annex X for further details

[50] WRAP (2010): *Environmental Benefits of Recycling – 2010 update*

[51] Finnveden (2000) *Life cycle assessment of energy from solid waste*; Sweden

[52] Cordell, D., White, S., Drangert, J.-O., and Neset, T.S.S., (2009) Preferred future phosphorus scenarios: A framework for meeting long-term phosphorus needs for global food demand. 2009, *International Conference on Nutrient Recovery from Wastewater Streams*, Vancouver, 10-13th May, 2009. Published by IWA Publishing, London, UK

It has the potential to offer high environmental benefits[53]. Amateur gardeners accounted for 69% of peat use in the UK in 2007[54]. Compost from home composting can provide a potential alternative to peat-based composts.

Home composting can potentially divert up to 150kg of waste per household per year from local authority collection [55]. Local authorities should therefore consider promoting home composting alongside any collection schemes. This does not mean that composting comes above other options in the waste hierarchy, but it should complement them.

Not all domestic food waste is suitable for home composting, eg cooked food or foodstuffs of animal origin, which attract vermin.For guidance on these please see DirectGov[56] and Recycle Now[57]. Other systems are able to handle wider ranges of foods, including anaerobic digestion, in-vessel composting, and Greencone.

Other energy recovery options

Food waste is combustible, but its high moisture content means that it is best suited to anaerobic digestion. As a renewable material, it replaces the combustion of fossil fuels when energy is recovered, and so even in incineration facilities which only recover electricity, it offers some environmental benefit. Available research suggests that composting remains preferable to combustion with energy recovery[58].

Segregated and non segregated food waste may also be a suitable feedstock for the production of renewable transport biofuels, renewable heat power and/or renewable chemicals through advanced biofuels and biorefinery technologies. These can often provide greenhouse gas savings and reduce demand for resources. There is currently limited evidence of their benefits relative to other technologies; this is being gathered.

Rendering

Rendering is a treatment process through which food waste and other animal by-products are ‘cooked’ at high temperature, sometimes under pressure, to remove moisture and until the fat (tallow) can be separated from the protein material. The tallow can be used to produce tyres and paint; small amounts may also be used in feedingstuffs, fertilisers, or as a fuel. The protein element can be dried to produce meat and bone meal which can be used, subject to animal by-product controls[59], as a protein source in pet food manufacture and as a fuel.

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[53] WRAP (2007): Biowaste Cost Benefit Analysis Report and Appendices
WRAP (2009): Update to Biowaste Cost Benefit Analysis Report
[54] DEFRA (2008): *Monitoring of peat and alternative products for growing media and soil improvers in the UK 2007*
[55] WRAP (2009) Home Composting Diversion: District Level Analysis
[56] http://www.direct.gov.uk/en/environmentandgreenerliving/wasteandrecycling/dg_064369
[57] http://www.recyclenow.com/home_composting/
[58] WRAP (2010): *Environmental Benefits of Recycling*
[59] http://www.defra.gov.uk/foodfarm/byproducts/legislation.htm

There is currently no research into the relative environmental merits of rendering compared to other processes. Some work is underway at Harper Adams University College.[60]

Landspreading of catering food waste is another recovery option. We do not at present have evidence of its environmental benefits relative to other waste management methods.

Landfill

Food should be diverted from landfill wherever possible. Food waste degrades over a short space of time in landfill. This gives rise to methane emissions. Even where some of these are captured for flaring or energy recovery, the overall impact is still negative. [61]

[60] Ramirez, A. (undated) Development and application of a life cycle assessment toolkit for the rendering industry http://www.harper-adams.ac.uk/postgraduate/research/research.cfm?ID=36
[61] WRAP (2010): *Environmental Benefits of Recycling*

3.3 Green (garden) waste

There is no clear picture of how much garden waste currently arises, or how much is being collected. We may start to have more information, from household waste at least, as local authorities are now able to enter information on collections of green garden waste and mixed garden and food waste into WasteDataFlow.

There is no specific data on the benefits of **preventing** garden waste.

Preparation for reuse is not a feasible option for garden waste.

Recycling and other recovery options

Separate collection of food and garden waste provides businesses and local authorities with the widest choice for dealing with the collected material.

Garden waste collected together with food has to be treated to the same standards as food waste (see Annex A for more details).

Anaerobic digestion (AD)

In anaerobic digestion, garden waste is microbiologically broken down in enclosed containers in the near absence of oxygen. The outputs produced are digestate, which may be used as an alternative to fertilisers or for land remediation. For restriction on the use of digestate, please refer to the Quality Protocol for digestate.[62].

Anaerobic digestion also generates a gas, which used as gas for injection into the grid, or to generate vehicle fuel, electricity, combined heat and power. Each of these has a different environmental benefit, and may be more or less feasible depending on plant location. [63]

The combination of both outputs means that AD is environmentally preferable to composting, and is the best currently available treatment option for garden waste. **This departs from the waste hierarchy.**

Garden waste requires a dry AD system to break down effectively (because the presence of wood makes it longer to degrade). There are currently very few of these types of plant in operation in the UK.

Composting

Composting can be carried out at home or commercially. Commercial and community operations may be windrow (garden waste only) or in vessel (food and garden waste).

[62] http://www.environment-agency.gov.uk/business/topics/waste/114395.aspx
[63] For more information, see the biogas portal: www.biogas-info.co.uk

Amateur gardeners accounted for 69% of peat use in the UK in 2007[64]. Where use of compost reduces the use of peat, it offers significant environmental benefits.

The relative positions of composting green waste and energy recovery options (other than anaerobic digestion) against the environmental criteria selected are not clear; more evidence is needed. Recent research has found that composting green waste offers greenhouse gas savings which are on a par with energy recovery[65]. Energy recovery can avoid more air pollution, since burning food waste avoids using fossil fuels. However, composting avoids more water pollution where use of artificial fertilisers are avoided. [66] There are also some benefits of applying composts to soils which are more difficult to quantify, such as improving soil structure. No data sources have been identified which consider resource depletion.

Research into home composting shows that free garden waste collections lead to an increase in waste collected (including Household Waste Recycling Centres) [67]. Promotion of home composting can divert 150kg of waste (mainly garden waste) from local authority collection per household per year[68]. Local authorities should therefore consider promotion of home composting alongside any collection schemes. Composting complements other options in the waste hierarchy.

Other Energy Recovery Options

As a renewable material, garden waste replaces the combustion of fossil fuels when used to generate energy, and so even in incineration facilities which only recover electricity it offers some environmental benefit.[69]

Segregated and non segregated green waste may also be a suitable feedstock for the production of renewable transport biofuels, renewable heat power and/or renewable chemicals through advanced biofuels and biorefinery technologies. These can often provide greenhouse gas savings and reduce demand for resources through production of a range of fuels, power and materials from bio-based waste. There is currently limited evidence of their benefits relative to other technologies.

Landspreading of shredded garden waste is another recovery option. We do not at present have evidence of its environmental benefits relative to other waste management methods.

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[64] DEFRA (2008): *Monitoring of peat and alternative products for growing media and soil improvers in the UK 2007*

[65] Kranert, M., Gottschall, R., Bruns, C. & Hafner, G. (2010). Energy or compost from green waste? A CO2-based assessment. *Waste Management*. 30: 697-701
WRAP (2010) *Environmental Benefits of Recycling – 2010 update*

[66] WRAP (2010): *Environmental Benefits of Recycling – 2010 update*

[67] WRAP (2007) *Biowaste Cost Benefit Analysis Report* and Appendices
WRAP (2009) *Update to Biowaste Cost Benefit Analysis Report*

[68] WRAP (2009): *Home Composting Diversion: District Level Analysis*

[69] WRAP (2010): *Environmental Benefits of Recycling – 2010 update*

Landfill

Garden waste should be diverted from landfill wherever possible. It degrades over a short space of time in landfill, giving rise to methane emissions. Even where some of these are captured for flaring or energy recovery, the overall impact is still negative. [70]

[70] ibid.

3.4 Textiles

The Defra Sustainable Clothing Roadmap estimates that the UK generates 2 million tonnes of textile waste (including clothing, carpets and footwear) every year, of which about half is clothing. Of the total, 1 million tonnes goes to landfill from the household waste stream, and 0.5m tonnes are collected for re-use or recycling in the UK and overseas.[71]

Prevention

Prevention includes direct reuse of clothing without the need for repair.

Businesses, local authorities and individuals can reduce textile waste by increasing the lifetimes of textiles. 50% of clothes, uniforms, textiles and rugs disposed of by businesses are usable without repair. A third of clothing disposed of by households is usable without repair.[72]

A study of Salvation Army textile reuse and recycling operations established that the reuse (collection, sorting, baling and distribution) of 1 tonne of polyester or cotton garments uses between 1.8 and 2.6% of the energy required for the manufacture of these goods from virgin materials[73].

Preparing for re-use

For textiles, the logistics and environmental impact of re-use (i.e. selling, exchange or donation of textiles that have not become waste), and activities preparing for re-use (collection, sorting, cleaning and re-sale) are very similar.

Taking into account the whole system, including the manufacture of new synthetic and natural fibres, the benefits of reuse and preparing for re-use are significant. They include significant savings in water use, energy use, raw materials and greenhouse gas emissions. For example, it takes 7,000-29,000 litres of water to produce 1kg of cotton fibres. This is the same as the average UK resident uses in 46-192 days[74]. Diversion of water for growing cotton can have dramatic consequences, as seen in the Aral Sea disaster.

Where an item requires repair, the limited evidence suggests that this is preferable to recycling.[75]

In 2010 WRAP will report the findings of research into carpet tile reuse.

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[71] Oakdene Hollins (2009): *Maximising Reuse and Recycling of UK Clothing and Textiles*, report prepared for Defra

[72] Cooper, T. (2004) Inadequate life? Evidence of consumer attitudes to product obsolescence, *Journal of Consumer Policy*, 27, 421-449

[73] ERM. (2002): *Streamlined Life Cycle Assessment of Textile Recycling*. Report completed for the Salvation Army Trading Company Ltd

[74] http://www.defra.gov.uk/sustainable/government/progress/regional/summaries/16.htm

[75] EDIPTEX. (2007). Environmental assessment of textiles. Danish Ministry of the Environment, Environmental Protection Agency

Allwood, J., Laursen, S.E., Malvido de Rodriguez, C. & Bocken, N. (2006). *Well Dressed? The present and future sustainability of clothing and textiles in the United Kingdom*. University of Cambridge Institute for Manufacturing

Recycling

Many textile items can be recycled by businesses or in the home, for example cut up and used as cloths, dusters, or packaging material.

Most of the collected textiles which are not reused are recycled into lower value products (e.g. mattresses, wipes, carpet underlay, automotive components or niche clothing). Closed loop recycling of clothing has been tried[76], but is not widespread at present.

The environmental benefit of recycling is not as great as for reuse, which avoids all elements of production, but it is still appreciable. The assessment of whether an item is suitable for reuse or recycling is normally made by a company or charity sorting textiles, rather than the local authority. On average savings for 1 tonne of material sent for sorting for reuse or recycling are anticipated to be over 3 tonnes CO_2 equivalent.

Carpets are made from natural and synthetic fibres, which still have a value once the carpet is no longer wanted; they can be used in a wide range of applications from sports surfaces to insulation.

The industry-government Material Action Plan being developed aims to lay out measures to reduce landfilling of carpet waste. It is considering the technical and financial aspects of recycling. It is due to be published in 2010.

Energy Recovery

The environmental impacts of sending textiles to energy recovery vary with the type of fibre they are made of (natural fibres or synthetic (mostly oil-based) fibres).

Both types of fibre will combust and can be used to generate energy. Natural fibres used to generate energy replace fossil fuels. Even in incineration facilities which only recover electricity, this offers some environmental benefits. Synthetic fibres used in place of a fossil fuel do not give the same benefit. All the studies identified assume that there is a mix of both types in the waste stream.[77]

The energy generated by combusting textiles is not as high as the energy saved through reuse or recycling. Projections to 2031 consider that this will continue to be the case. [78]

Landfill

Textiles made of natural fibres biodegrade in landfill, which releases methane emissions. Even where some of these are captured for flaring or energy recovery, the overall impact is still negative. [79] Landfilling textiles should be avoided.

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[76] For an example, see http://www.teijin.co.jp/english/news/2009/ebd091118.html

[77] WRAP (2010) *Environmental Benefits of Recycling*; and Allwood, J., et al (2006) *Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom*, University of Cambridge.

[78] ERM (2006) *Carbon Balances and Energy Impacts of the Management of UK Wastes* WR0602, Defra.

[79] WRAP (2010): *Environmental Benefits of Recycling – 2010 update*

3.5 Wood

WRAP estimate that 4.7 million tonnes of wood waste were generated in the UK in 2008-9. [80] However, this is likely to be an underestimate due to a lack of data from the construction sector, and is likely to be lower than previous years because of the economic downturn. The vast majority of arisings came from construction and demolition activities. Packaging was also a significant source. 619,000 tonnes of wood waste came from the municipal waste stream, and slightly less from industrial sources.

The ***sustainability of timber*** is important when considering environmental impacts. The benefits of preventing wood waste, preparing wood waste for re-use, recycling it or recovering energy from it are all the greater if unsustainably sourced wood is being replaced or avoided.

This is because where forests are managed sustainably, the amount of CO_2 absorbed over the life of a tree should be in balance with the amount of CO_2 emitted at the end of the life of the tree and its products. In contrast, where wood is sourced from forests which are being clear-felled, additional CO_2 is emitted to the atmosphere due to land use change.

Prevention

Businesses and individuals can prevent wood waste by reusing wooden items (e.g. furniture, pallets, structural timber). They may also identify ways to reduce demand for timber (e.g. lightweighting). Prevention avoids the impacts of producing and distributing these timber products.

Preparing for reuse

Extending the life of wooden products offers environmental benefits. The nature and size of these depends on the source of the virgin wood which is not being used, and on the amount of refurbishment required. The potential benefits include reduced biotic resource depletion and savings in raw materials and greenhouse gas emissions. [81]

Recycling and energy recovery

Scientific research on the relative environmental merits of waste management options for wood is currently sparse[82]. Only 3 Life Cycle Assessments, and 5 LCA-like reports have been identified. Two of these were published in the UK.

Most of the evidence suggests recycling is preferable to energy recovery in terms of climate change, whereas energy recovery is preferable regarding resource depletion, since fossil fuels are avoided. The evidence on other air pollution impacts is mixed. For recycling, the results are influenced by the type of recycling. For energy recovery, the results are influenced by the efficiency of energy recovery and the type of energy recovered. [83]

[80] WRAP (2009) Wood Waste Market In The UK
[81] WRAP (2010) Environmental Benefits of Recycling – 2010 update
[82] Defra has commissioned research on this; it is due to report in March 2011.
[83] WRAP (2010) Environmental Benefits of Recycling – 2010 update. The wood chapter contains references to the separate studies mentioned, as does the Bibliography below.

Recycling and recovery options for wood waste depend very much on the type of waste wood, and how well sorted it is. Wood waste encompasses saw dust, doors, beams and planks, furniture, etc. It may be clean (untreated), or contaminated with additives such as paint, glue and preservatives, or nails.

- Clean wood waste can be recycled into a variety of end products, including panelboard, mulch or animal bedding.
- Contamination with paint, preservatives or other chemicals and materials (eg nails etc) reduces the range of feasible recycling applications. In some cases treated wood is classified as hazardous waste, and has to be managed accordingly.

To maximise both the quantities of wood recycled and the benefits of doing so, wood should be ***graded according to the end markets it is suitable for*** where possible (see Annex B for guidance on this).

The Waste Strategy for England (2007) estimated that recovering energy from 2 million tonnes of waste wood could save 1.15 million tonnes of CO_2 eq emissions, with greater benefits derived if heat is recovered as well as power. [84] Use of wood in energy recovery has the potential to reduce depletion of non-renewable resources and reduce greenhouse gas emissions from energy production.

Lower grade waste wood in particular is an underutilised renewable fuel resource.[85] As of November 2008, approximately 20% of dedicated biomass electricity generation capacity was fuelled by waste wood. The UK currently imports virgin wood for fuel and sends waste wood to landfill. There is clearly an opportunity to address this situation.

Landfill

In landfill, wood breaks down and release methane emissions over a long time. The rate at which it degrades depends on the type of wood, landfill conditions (e.g. how wet the landfill is), preservatives etc. Over 100 years, emissions from 1 tonne of wood can vary from near zero to 5 tonnes CO_2 equivalent. [86] Therefore waste wood should be diverted from landfill.

[84] Waste Strategy for England 2007
[85] Waste Infrastructure Delivery Programme (2008): *Waste Wood as a Biomass Fuel, Market Information Report*, Defra,
[86] F.A. Ximenes, W.D. Gardner and A.L. Cowie (2008) The decomposition of wood products in landfills in Sydney, Australia, *Waste Management* Vol 28 (2008) pp 2344–2354
Morton A. Barlaz (2006) Forest products decomposition in municipal solid waste landfills *Waste Management, Vol 26, 2006, pp 321-333*
Micales J.A.; Skog K.E. (1997) The Decomposition of Forest Products in Landfills, *International Biodeterioration and Biodegradation*, Vol 39 (1997) , pp. 145-158

3.6 Glass

In 2008 over 2.6 million tonnes of glass packaging was used in the UK, 61% of which was recycled[87]. The vast majority of that made in the UK is clear, and the rest is split roughly evenly between amber and green glass. In the hospitality sector (hotels, pubs etc.) waste may comprise 10-30% glass[88].

Other types of waste glass include architectural glass (e.g. from windows), automotive glass (e.g. windscreens) and glass in electrical equipment. Glass in electrical equipment (e.g. Cathode Ray Tubes) is covered in section 4.9 below.

British Glass figures suggest that in 2006, 1.1 million tonnes of flat glass were produced in the UK. It is estimated that up to 500,000 tonnes of flat glass waste is produced from buildings each year within the UK. Of this, just under half is currently recycled, from the manufacturing industries as well as from the construction and demolition industry.[89]

Preventing glass waste

Minimisation of the amount of glass used for a given function, and reuse both have significant benefits due to the avoidance of raw materials and energy for manufacturing new glass. [90] Prevention the use of 1 tonne of virgin glass could avoid over 800kg CO2 eq greenhouse gas emissions.[91]

This is true for re-use even when impacts across the whole system (eg collection and washing of containers) are taken into account.

Recycling

Glass can be recycled an infinite number of times. There are two main options for recycling glass.

The first is closed loop recycling through remelt, whereby glass ('cullet') collected for recycling is used in new glass products, replacing virgin glass. This avoids the use of significant amounts of raw materials and energy, including in transport. Remelt may take place in the UK or abroad (mostly in Spain, Italy and Portugal). Export does reduce the environmental benefits of recycling, but it does not negate them. [92]

The second option is open loop recycling, for example through use as aggregates, where the glass is blended with other aggregates in various applications (e.g. road surfaces). The environmental benefits of using glass in

[87] National Packaging Waste Database https://npwd.environment-agency.gov.uk/filedownload.ashx?fileid=4aea5fa0-9048-439a-9675-7251935ed544
[88] http://www.instituteofhospitality.org/info_services/recycling, Fact File No. 4, *Reducing Waste*
[89] For an introduction to the to the main types of glass and how they can be recycled, please see www.wrap.org.uk/manufacturing/info_by_material/glass/types_of_glass.html
[90] WRAP (2010) LCA Of Example Milk Packaging Systems: Retail
[91] Enviros (2003) *Life Cycle Carbon Dioxide Emissions. A Life Cycle Analysis Report*. Prepared for British Glass by Enviros Consulting Ltd. British Glass, Sheffield
[92] WRAP (2007) *Assessment of the International Trading Markets for Recycled Container Glass and their Environmental Implications*; WRAP, Banbury

this manner are negligible, because of the relatively low impact of the material aggregate being replaced. [93]

In order to maximise the environmental benefits of a recycling scheme, the system should deliver colour sorted glass which meets the quality requirements for use in remelt applications. For materials which do not meet quality requirements, recycling into aggregates may be one of the only options available.

Advice on how to set up a collection system to deliver this can be found in PAS 101 (full reference in Section 5) and WRAP's guidance on collections[94].

For businesses and non-packaging glass (e.g. CRTs, windows) more information is available on the WRAP website[95].

Energy recovery and landfill

For glass, these options sit alongside each other at the bottom of the hierarchy. No energy can be recovered from waste glass. Some value may be recovered if the incinerator bottom ash can be used, for example in construction, but in environmental terms the benefits are negligible.

Where it is present in mixed waste destined for energy recovery, it should be removed, either by encouraging greater recycling by businesses and householders, or by sorting before the energy recovery process.

As an inert material, glass does not degrade in landfill. However, it is lost to the resource economy and takes up landfill space Therefore every effort should be made to separate it for recycling.

[93] Enviros (2003) *Life Cycle Carbon Dioxide Emissions. A Life Cycle Analysis Report*. Prepared for British Glass by Enviros Consulting Ltd. British Glass, Sheffield
[94] WRAP (2009) *Clear steps to a cleaner collection*
[95] www.wrap.org.uk/manufacturing/info_by_material/glass/types_of_glass.html

3.7 Metals

Industry estimates that 15 million tonnes of metal waste arise in the UK per annum, of which over 13 million tonnes are recovered and recycled[96]. In 2008, 34.6% of aluminium packaging and 61.7% of steel packaging were recovered or recycled.[97]

Most waste metal arising from households is in the form of packaging (cans for food, pet food and beverages), white goods (washing machines, refrigerators, cookers, etc) and brown goods (televisions and video players etc). Waste metal from such sources accounted for 4.3% of municipal waste in England in 2006/2007, or 1.2 million tonnes.[98]

The metal fraction of waste electrical and electronic equipment is covered in Section 3.9.

Prevention

Ways of preventing metal waste include lean production and product lightweighting. Metals require significant quantities of energy and raw materials in their extraction and manufacture. This varies enormously for different types of metal. For aluminium, avoiding 1 tonne of virgin metal could avoid over 10 tonnes of CO_2 eq greenhouse gas emissions.[99]

Re-use opportunities depend on the type of product in question. Primary metal packaging offers little or no scope for re-use, whereas secondary and tertiary packaging (cages, drums, stillages) offer many opportunities. The second-hand market for vehicles is well established. Reuse of white and brown goods is addressed in section 3.9 below on WEEE.

Preparation for re-use

Re-using metals avoids the environmental impacts associated with their production (see 'prevention' above).

Opportunities for re-use of *waste* metals depend on what the metal is to be used for or is part of. There are opportunities for refurbishment of metal waste from household WEEE (covered in section 3.9) and to end-of life vehicles. Opportunities are available for in the C&I sector, where reconditioning of drums, containers, machinery etc is widespread.

Recycling

The environmental benefits of recycling metals are unequivocal across a range of environmental indicators, including greenhouse gas emissions and resource depletion.

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[96] http://www.recyclemetals.org/about_metal_recycling

[97] National Packaging Waste Database https://npwd.environment-agency.gov.uk/filedownload.ashx?fileid=4aea5fa0-9048-439a-9675-7251935ed544

[98] Municipal Waste Composition Report March 2009 - http://randd.defra.gov.uk/Document.aspx?Document=WR0119_8662_FRP.pdf

[99] European Aluminium Association (2008): *Environmental Profile Report for the European Aluminium Industry*

Research has found recycling of aluminium to have a lesser environmental impact compared to incineration and landfill, delivering greenhouse gas (GHG) emission savings of 9 tCO_2e per tonne aluminium recycled. [100]

The GHG emissions savings for recycling of steel are somewhat more modest at 0.94 kg CO_2e/kg steel compared with incineration, and 1.33 kg CO_2e/kg steel compared with landfilling, but are nevertheless pronounced.[101]

The British Metals Recycling Association Provides a directory of metal recyclers[102].

Businesses and local authorities can collect more primary packaging metals by increasing on-the-go recycling infrastructure[103] and promoting recycling at work. Alupro, the industry recycling association for aluminium, and Corus, one of Europe's steel producers, both offer advice to about such initiatives (see http://www.defra.gov.uk/environment/waste/localauth/recycleonthego/index.htm www.alupro.org.uk and www.cspr.co.uk).

Energy recovery

No energy can be recovered from waste metals. If they pass through the energy recovery process they can subsequently be extracted from the ash for recycling. However, every effort should be made to remove them from the recovery fraction, either by encouraging greater recycling by businesses and householders, or by sorting before the recovery process.

Landfill

Metals may rust in landfill and break down, or may remain in situ. As there is no opportunity to recover value, landfill remains at the bottom of the waste hierarchy.

[100] European Aluminium Association (2008): *Environmental Profile Report for the European Aluminium Industry*
[101] WRAP (2006): *Environmental benefits of recycling*
[102] http://www.recyclemetals.org/
[103] http://www.defra.gov.uk/environment/waste/localauth/recycleonthego/index.htm

3.8 Plastics

The UK uses over 5 million tonnes of plastic each year. The major markets are for use in packaging, construction and automotive products, but plastic is also used in furniture, electrical items and agricultural films (see Annex C).[104]

Plastics may be derived from fossil-based oil or from plant materials ('biopolymers'). Biopolymers can have the same characteristics as conventional polymers or can be made in such a way that they biodegrade at the end of their life. Bioplastics are estimated to still account for less than 5% of plastics used in packaging.

'Oxo-degradable' plastics are made of fossil fuel, and contain additives which allow them to degrade faster than conventional plastics. They are not suitable for composting and may not be suitable for conventional recycling.[105]

Preventing plastic waste

Taking into account the whole system, including collection, sorting and cleaning of plastics, prevention provides benefits due to the avoidance of raw materials and energy in manufacturing new plastics.

Preparing for re-use

Plastic drums for bulk packaging can be re-conditioned. We are not aware of other reconditioning activities for plastics. Preparing for re-use provides benefits due to the avoidance of raw materials and energy in manufacturing new plastics.

Recycling

Plastics collected for recycling are sent to a variety of markets. There is a growing domestic market for products made using recycled plastic, including closed loop applications such as bottles. Plastics are also sent abroad for recycling; the environmental benefits of this vastly outweigh the transport impacts.

Recycling of plastics avoids a significant amount of raw materials and energy use, reducing greenhouse gas emissions and contribution to acidification, even when transport is taken into account. The exact impacts depend on the material being replaced and the relative life of the alternative product.[106]

Plastic bottles are the most commonly collected type of plastic at present, with savings of 1-2 tonnes CO_2 equivalent per tonne recycled depending on the polymer[107]. In 2008, WRAP trialled a variety of technologies for sorting and

[104] WRAP (2007) Market Situation Report – Autumn 2007 Realising the value of recovered plastics
[105] Defra (2010): Assessing the Environmental Impacts of Oxo-degradable Plastics Across Their Life Cycle, http://randd.defra.gov.uk/Document.aspx?Document=EV0422_8858_FRP.pdf
[106] WRAP (2006) Environmental Benefits of Recycling
WRAP (2010) Environmental Benefits of Recycling
[107] WRAP (2010): *LCA of Example Packaging Systems for Milk*

recycling mixed plastic packaging. These trials showed that these activities can be environmentally beneficial.[108]

Some plastics made from bio-based materials may also be suitable for recycling[109], although the quantity on the market is not understood to be high enough to allow economic recycling at present.

Energy Recovery

Plastics have a high calorific value relative to other wastes; they can generate a large amount of energy when combusted. However, when plastics are made from fossil fuels (i.e. oil), the greenhouse gas emissions from recovering energy are far higher than any other waste management technique for plastics. Both recycling and energy recovery help conserve resources, but energy recovery is likely to conserve less resources than recycling, and so appears less beneficial. [110] It could reduce contributions to eutrophication relative to recycling. This is because recycling involves a washing process, utilising detergents to remove unwanted materials, such as food waste. However, most studies find in favour of recycling. [111]

Some alternative technologies, such as pyrolysis or incineration with combined heat and power, show potential to save more energy in the future, but currently have higher greenhouse gas emissions than other techniques. [112]

Some bio-based plastics may be suitable for anaerobic digestion, but this will depend on the specific characteristics of the polymer. When sent to energy recovery, bio-based plastics substitute for fossil fuels, leading to environmental benefits over landfill.

Landfill

Conventional plastics will degrade very slowly, if at all, in landfill conditions. However, they are lost to the resource economy and take up landfill space. In terms of greenhouse gas emissions, sending plastics to landfill is preferable to conventional energy recovery, but is less preferable in terms of of all other environmental indicators commonly considered in Life Cycle Assessment[113]. Overall, landfill remains the bottom of the waste hierarchy.

Plastics which are designed to degrade may or may not breakdown in landfill depending on their properties and the landfill conditions. There is a lack of research into this at present, but if the materials do decompose they are likely to lead to emissions of methane. A proportion of this is captured for energy recovery but much also escapes into the atmosphere.

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[108] WRAP (2008): *Domestic Mixed Plastics Packaging Waste Management Options* WRAP (2008) LCA of Management Options For Mixed Waste Plastics
[109] WRAP (2010) Environmental Benefits of Recycling – 2010 update
[110] WRAP (2010): *LCA of Example Packaging Systems for Milk*
[110] WRAP (2008): *Domestic Mixed Plastics Packaging Waste Management Options*
[111] WRAP (2010) Environmental Benefits of Recycling – 2010 update
[112] WRAP (2008) LCA of Management Options For Mixed Waste Plastics
[113] WRAP (2010) Environmental Benefits of Recycling – 2010 update

3.9 WEEE

EA figures for 2009 show that 1.54 million tonnes of electronic and electrical equipment (EEE) was purchased by householders and businesses. Of this, about 80% was purchased by households.[114]

By far the largest component of WEEE is metals. Plastics, metals-plastics mixtures, and glass from screens are the next largest groups.

The hazardous components that can arise in some WEEE require specific waste treatment. For example cathode ray tubes in TVs and monitors and flat panel displays require specialist treatment. These hazardous components should be removed from the WEEE and treated separately. The remainder can go then down the normal recycling route.

Prevention

For some items (mobiles, drills,cameras, strimmers, some small kitchen and personal care products), research due to be published by WRAP in late 2010 shows that the impact of production is far greater than their consumption of energy in use.

Defra is working on a series of projects to encourage manufacturers to design products to last for longer, and can be repaired more easily. WRAP is due to publish further research in 2010 which informs the debate on when it is appropriate to repair or reuse certain items rather than replace them.

Preparing for re-use

There is a thriving market for reconditioned large appliances and IT equipment, and again repair and refurbishment avoid the environmental impacts of manufacturing new goods.

Recycling

Even when the environmental impacts of collection and reprocessing are considered, WEEE recycling proves to be clearly advantageous from an environmental perspective compared to incineration or landfill.[115]

This is because the benefits of recycling the metallic and uncontaminated plastic fractions of WEEE outweigh the impacts of the recycling process, in terms of greenhouse gas emissions, and resource depletion. Recent demonstration work has shown a 50-75% reduction in emissions from using recycled WEEE plastics rather than virgin plastics.[116]

In addition, it is estimated that only 1% of 'speciality' metals (or "rare and precious metals" used in electronics are recycled. Research by the United

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[114] http://www.environment-agency.gov.uk/business/topics/waste/111016.aspx

[115] R. Hischier, P. Wäger, J. Gauglhofer (2005): *Does WEEE recycling make sense from an environmental perspective? The environmental impacts of the Swiss take-back and recycling systems for waste electrical and electronic equipment*
Jaco Huisman and Ab L. N. Stevels (2006): *Eco-Efficiency of Take-Back and Recycling, a Comprehensive Approach*
Y. Barba-Gutierrez , B. Adenso-Diaz, M. Hoppa (2008): *An analysis of some environmental consequences of European electrical and electronic waste regulation*

[116] WRAP (2009): *Separation of mixed WEEE plastics final report*

Nations Environment Programme suggests that chip makers use more than 60 of these metals, with demand for Indium for example expected to double to by 2020. Recycling these metals is between 2 and 10 times more energy efficient than smelting the metals form virgin ores (which are also to be found in very few places on Earth).[117]

Other forms of recovery

Once the metal fraction, printed circuit boards, high-quality plastic fractions etc have been taken out for recycling, incineration with energy recovery is preferable for the residual combustible waste.

Any hazard associated with the material will require consideration before sending this material for further recovery. The hazardous components of WEEE call for specific waste treatment, and are not covered in this guidance. They will be covered in the guidance which will follow the Strategy for Hazardous Waste Management in England.

Landfill

Landfill is the waste management method of last resort for WEEE, and should be avoided.

[117] Schluep, M et al (2009): Recycling – from E-Waste To Resources, United Nations Environment Programme, http://www.unep.org/PDF/PressReleases/E-Waste_publication_screen_FINALVERSION-sml.pdf

3.10 Tyres

In the UK, about 0.5 million tonnes of tyres are disposed of every year. Most of these tyres are removed from vehicles at garages or tyre retailers and replaced; around a quarter are removed from end of life vehicles. Since 2006, the Landfill Directive has prohibited the disposal of tyres in landfill.

Industry data suggests that in 2008, about one quarter of UK waste tyres were re-used; half was recycled and most of the rest was used for energy recovery.[118]

Prevention

Manufacturing tyres uses energy and raw materials like oil and natural rubber, and can produce harmful chemicals. Reducing the number of tyres that need to be produced therefore has benefits for the environment.

If the life of tyres can be extended, then less waste tyres will be produced. Reusing tyres for their original purpose means that new tyres do not have to be manufactured. This means that the use of virgin material and the energy in manufacture are avoided, leading to environmental benefits.

Preparing for re-use

Retreading is another way of re-using most of the materials in a tyre: the old tread is removed and a new tread applied to the tyre. It is a remanufacturing process and offers high environmental benefits in terms of reduced greenhouse gas emissions, contribution to acidification, eutrophication and resource depletion.[119]

Recycling and recovery options

Options for the treatment of tyres include, in order of environmental benefit (greatest benefit at the top):

- Closed loop recycling and use in road surfaces
- Energy recovery through cement kilns and pyrolysis
- Open loop recycling
- Energy recovery through gasification, incinerators and microwave treatment

This does not follow the waste hierarchy, but it is informed by current life-cycle assessment research.

Closed loop recycling and use in road surfaces

Tyres can be recycled in several ways. Breaking the tyres down into crumb and using this in place of virgin rubber or bitumen (e.g. in flooring and surfaces) has positive environmental benefits[120]. To promote this,

[118] http://www.etrma.org/pdf/2009_11_09__ETRMA_PR_ELTs_recovery_rate_in_2008.pdf
[119] Centre for Remanufacturing and Reuse (2009): *The carbon footprint of retreaded versus new light commercial vehicle tyres*
[120] EA (2004) *Life Cycle Assessment of the Management Options for Waste Tyres*
Villanueva, A., Hedal, N., Carlsen, R. (2008) *Comparative life cycle assessment of two options for waste tyre treatment: recycling in asphalt and incineration in cement kilns* IFEU Heidelberg

businesses and local authorities can consider procuring recyclate and recycled products in place of virgin materials.

More information about current and potential applications for tyre-derived materials can be found at www.wrap.org.uk/tyres.

Energy recovery via cement kilns and pyrolysis

Several options exist for the recovery of energy from waste tyres.

The most environmentally beneficial method is to burn them in *cement kilns*, where they replace coal[121].

Pyrolysis (breaking down materials at a high temperature in the absence of oxygen) can also have environmental benefits, producing steel, carbon and oil, and in some cases heat and power as well[122]. Pyrolysis produces less energy than cement kilns, but it produces raw materials. At present, the technology is less beneficial than a cement kiln, but more beneficial than other energy recovery, e.g. incineration with energy from waste or gasification (see below).

Open loop recycling

Other, less beneficial methods of recycling include recycling tyres for use in sea defences or drainage fill. This is because these applications avoid materials with low environmental impacts (e.g. gravel).

Energy recovery through gasification, incinerators and microwave treatment

At present, incineration with energy recovery and gasification do not recover as much energy as alternative options, nor avoid raw materials. Microwave treatment can also recover steel, carbon and oil, but the energy required in this process means that it is not an environmentally beneficial option.[123]

Landfill is prohibited for tyres.

[121] EA (2004) *Life Cycle Assessment of the Management Options for Waste Tyres*
[122] ibid
[123] ibid

3.11 Residual 'black bag' waste

In 2008/09, nearly 22 million tonnes of residual municipal waste were sent to landfill or incineration in the UK[124]. The environmental consequences of this depend on the composition of the waste. The more organic matter is removed for example, the less methane is released from landfill sites. Over time, the changing composition of residual waste may mean that practical management options need to change.

Prevention

Residual waste can be prevented through:

- all the prevention measures for the other waste streams in this document
- and ensuring that as much waste as possible is sorted, prepared for re-use, recycled or recovered, instead of being put in the bin.

For general guidance on prevention please see WRAP's Waste Prevention Toolkit (a link is provided at the end of this section).

Straight reuse and cleaning or repair activities are not feasible options for mixed residual waste.

It is possible to extract glass, plastics and metals for **recycling** from residual waste (through so-called 'dirty MRFs'). In theory, it would allow some of the environmental benefits of recycling those materials to be achieved. However, we do not have evidence of the extent to which the energy needed to sort and wash those materials could offset these environmental benefits.

Energy Recovery

'Energy from Waste' (EfW) covers a variety of processes and technologies. Some of them are described in the flowchart at Annex D.

The England Waste Strategy 2007 stated that where waste cannot be reused or recycled, it makes economic and environmental sense to use it as a renewable fuel.[125]

The UK Renewable Energy Strategy ("RES") identifies waste biomass as an under-used resource which could provide a significant contribution to our renewable energy targets and reduce the total amount of waste that is landfilled in the UK.[126] Although Defra and DECC are keen to see a greater uptake of Anaerobic Digestion, source segregated food waste is the optimal feedstock, not mixed residual waste.

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[124] http://www.statswales.wales.gov.uk/ReportFolders/reportFolders.aspx; http://www.defra.gov.uk/evidence/statistics/environment/wastats/bulletin09.htm; http://www.doeni.gov.uk; http://scotland.gov.uk/Publications/2008/08/19084547/0

[125] The Office of Climate Change's analysis suggested that with moderate financial support in place, the potential for heat from waste could be approximately 4 TWh a year, and with more ambitious policies in place the long-term potential to generate energy from waste might be in the order of 45 TWh.

[126] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx (see page 108)

There are three common routes for producing energy for residual waste:

i) Processing of the residual waste using intermediate technologies such as mechanical and biological treatment or autoclave to produce solid recovered fuel (SRF) residues; or
ii) Direct combustion
iii) Gasification or pyrolysis

Generating heat and electricity together through Combined Heat and Power (CHP) is one way of making our energy production more efficient.[127] The best CHP systems can increase the overall efficiency of an EfW plant from 20-25% to around 60-70%. In CHP plants, the residual heat in the exhaust steam from the generation of electricity is captured and used instead of being discarded. This results in a highly efficient use of fuel and a significantly reduced level of CO_2 emissions when compared to the separate generation of electricity and heat in power stations and heat-only boilers. It can be used whenever electricity is generated through combustion of a fuel, including all types of biomass and biogas electricity generation. CHP should be implemented wherever possible.[128]

i) Processing residual waste using intermediate technologies

A number technologies are commercially proven:

- Direct thermal treatment of waste (eg autoclave);
- Mechanical pre-treatment of waste followed by thermal treatment;
- Mechanical pre-treatment of waste followed by biological treatment and landfill of residue (i.e. biostabilisation); and
- Mechanical pre-treatment of waste followed by biological and thermal treatment

Residual waste could be passed through further treatment, such as ***Mechanical Heat Treatment (MHT) or Mechanical Biological Treatment (MBT)***. Some recyclables, such as metals and glass, could be separated out at this stage.

- ***MBT*** is a residual waste treatment process that involves both mechanical and biological treatment processes. The first MBT plants were developed with the aim of reducing the environmental impact of landfilling residual waste. MBT therefore complements, but does not replace, other waste management technologies such as recycling and composting as part of an integrated waste management system.

[127] http://chp.decc.gov.uk/cms/what-is-chp/
[128] For more information, see the CHP Information Note from the Waste Infrastructure Delivery Programme (http://www.defra.gov.uk/environment/waste/residual/widp/documents/chp-information-note090127.pdf)

Recyclables derived from the various MBT processes are typically of a lower quality than those derived from a separate household recyclate collection system and therefore have a lower value.

- The objective of ***MHT*** is to separate a mixed waste stream into several component parts using mechanical and thermal (including steam) based technologies. This provides further options for recycling, recovery and in some instances biological treatment. The processes also sanitise the waste, by destroying bacteria present, and reduce its moisture content. *Autoclaving* is a form of MHT.

  Glass and metals derived from some MHT processes have the potential to be significantly cleaner than those from MBT processes due to the action of steam cleaning, which can remove glues and labels. Other recyclables such as plastics may also be extracted from some systems. However, most plastic materials are deformed by the heat of the MHT process, some to a greater extent than others, potentially making them more difficult to recycle in some instances.

Both MBT and MHT produce outputs often described as Compost Like Outputs (CLO), and they can produce Solid Recovered Fuel (SRF)[129]. For information on their use please see the Environment Agency Position Statement[130].

Depending on its characteristics, SRF can be used in industrial combined heat and power production, cement kilns, purpose-built waste combustion plants, co-firing with other fuels (e.g. coal in power stations), and treatment in advanced thermal technologies, such as pyrolysis and gasification. SRF is classified as a waste and therefore any facility using the fuel will be subject to the requirements of the Waste Incineration Directive[131].

SRF can then be sent to a fuel user. Industrial and commercial users may prefer SRF to untreated residual waste either as a consequence of how untreated waste is perceived or because of practical, technical issues related to a refined fuel's energy efficiency and compatibility with storage and transportation conditions on industrial sites

ii) Direct combustion

Direct combustion (incineration) is a well-established technology used to generate electricity.

[129] Also referred to as Refuse-Derived Fuel (RDF)
[130] http://www.environment-agency.gov.uk/static/documents/Leisure/mbt_2010727.pdf

[131] Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste

iii) gasification or pyrolysis

Gasification is the heating of organic materials, including mixed waste or biomass, at high temperatures (above 700°C) with a reduced amount of oxygen and/or steam.

Pyrolysis is a similar high temperature decomposition process, but is carried out in the absence of oxygen. This process requires an external heat source to maintain the temperature required.

The *outputs* from both gasification and pyrolysis comprise a solid residue and a synthetic gas (syngas). The solid residue is a combination of non-combustible materials and carbon. The combustible part can then be burned to produce electricity. The gas can be burned independently in a boiler, engine or gas turbine to produce electricity. Pyrolysis also yields a char which could be used to replace coal in certain applications. Some pyrolysis processes produce gasses that can be condensed into a liquid fuel.

There are other technologies such as plasma arc gasification, but the majority of these are still in their development stage for dealing with mixed waste.

Where MBT (and by analogy, MHT) outputs are used as fuel (not replacing coal) or landfilled, the evidence contrasting MBT and direct energy recovery suggests that unless the rate of energy recovery is low, MBT comes below combustion in the waste hierarchy[132]. Where MBT outputs are used to generate SRF to replace coal (e.g. in co-combustion or cement kilns) this could be more advantageous[133]. Eunomia (2006), the only UK based comparison identified, suggest that MBT is preferable to combustion[134]. The use of Combined Heat and Power (CHP) technologies can improve the efficiency of each of these treatment routes and may change this ranking, depending on the combinations being compared.

Residual waste may also be a suitable feedstock for the production of renewable transport biofuels, renewable heat, power and/or renewable chemicals through advanced biofuels and biorefinery technologies. These can often provide greenhouse gas savings and reduce demand for resources. There is currently limited evidence of their benefits relative to other technologies; this is being gathered.

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[132] BIWA (2003) *Klimarelevanz der Abfallwirtschaft im Freistaat Sachsen. Gutachten im Auftrag des Sächsischen Landesamtes für Umwelt und Geologie*, BIWA Consult, Freiberg (Sachsen).
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[133] IKr (2006) *Ökologische und ener- getische Bilanzierung des Vorhabens MKK*, IKr, Bremen

[134] Eunomia (2006) A Changing Climate for Energy from Waste? Friends of the Earth, London

Landfill

Landfill is currently the most common means of dealing with residual waste in the UK, and this continues to be the most unsustainable waste management option.

This gives rise to methane emissions, a proportion of which are captured for flaring or energy recovery. The Low Carbon Transition Plan promotes an increase in this proportion. In parallel, the Landfill Directive sets targets to reduce the quantity of biodegradable municipal waste sent to landfill, which in turn should lead to a reduction in methane emissions. However, the overall impact of landfill will continue to be negative as there is a range of additional environmental impacts, and not all methane emissions are captured.

4. Submitting new evidence

This guidance will be reviewed on a yearly basis and updated as necessary.

Scientists from Defra, DECC, WRAP and the Environment Agency will consider academic publications and other scientific studies.

If you have delivered or commissioned research on any of the environmental impacts taken into account in this guidance, or would like to submit evidence that you may be aware of, please contact:

Waste Hierarchy Review
c/o Waste Research and Evidence Programme
Defra
Ergon House
Horseferry Road
London SW1P 2AL

wasteresearch@defra.gsi.gov.uk (with 'Waste Hierarchy Review' in the subject line, please)

PART 3: REFERENCES AND FURTHER SOURCES OF INFORMATION

1. Further sources of help

Guidance on the legal definition of waste and its **application** can be found at [insert link after publication – consultation closed; analysis ongoing]

The ***WRATE*** tool developed by the Environment Agency is at http://www.environment-agency.gov.uk/research/commercial/102922.aspx

Netregs (www.netregs.gov.uk) provides advice and guidance on preventing, reusing and recycling business waste. This includes guidance tailored to individual business sectors.

WRAP's Waste Prevention Toolkit for ***Local Authorities***
http://www.wrap.org.uk/applications/waste_prevention_toolkit/restricted.rm

A simple guide to assist ***community sector reuse/ refurbishment organisations*** in complying with waste regulations: http://www.environment-agency.gov.uk/commondata/103599/ld1__reuse__refurb_631037.doc

WRAP's ***reclaimed building products guide*** provides architects, designers and contractors with opportunities to specify and procure reclaimed building materials and products when responding to a client requirement for reused and recycled content.
http://rcproducts.wrap.org.uk/construction/reclaimed_building.html

www.bre.co.uk has advice and tools for the ***construction sector*** in relation to waste management and prevention.

www.smartwaste.co.uk includes a suite of tools and services designed for the ***construction & demolition industry*** on waste prevention and responsible management.

The Environment Agency has issued a ***technical guidance series for individual industrial sectors***, which set BAT standards and include compliance standards for avoidance, recovery and disposal of waste:-

- General (all sectors):
  http://publications.environment-agency.gov.uk/pdf/GEHO0410BSFX-e-e.pdf
- Combustion activities:
  http://publications.environment-agency.gov.uk/pdf/GEHO0209BPIN-e-e.pdf
- Gasification, liquefaction and refining installations:
  http://publications.environment-agency.gov.uk/pdf/GEHO0209BPIW-e-e.pdf
- Metals (various sectors):
  http://www.environment-agency.gov.uk/business/sectors/117205.aspx
- Intensive farming (pig and poultry):
  http://www.environment-agency.gov.uk/business/sectors/40069.aspx
- Mining waste operations

http://www.environment-agency.gov.uk/static/documents/Business/614_MiningWaste_TGN_v1.0.pdf

- Paper and pulp http://publications.environment-agency.gov.uk/pdf/GEHO0209BPJB-e-e.pdf
- Food and drink (general and specific sectors): http://www.environment-agency.gov.uk/business/sectors/39869.aspx
- Chemical (general and specific sectors): http://www.environment-agency.gov.uk/business/sectors/117135.aspx
- Incineration of waste: http://publications.environment-agency.gov.uk/pdf/GEHO0209BPIO-e-e.pdf
- Textile sector http://publications.environment-agency.gov.uk/pdf/GEHO0209BPJC-e-e.pdf

The Environment Agency has also published ***regulatory position statements*** on:

- Wood waste http://www.environment-agency.gov.uk/static/documents/ps005_2077240.pdf
- The sustainable management of biowastes http://www.environment-agency.gov.uk/static/documents/Research/overarching_2010742.pdf

Environment Agency guidance on environmental permitting for anaerobic digestion can be found at: http://www.environment-agency.gov.uk/static/documents/Business/AD_and_Environmental_Permitting.pdf

The European Commission has published BREFs (BAT reference documents which apply to individual sectors across the EU) which contain advice on waste prevention and management:-

- Paper and pulp, ftp://ftp.jrc.es/pub/eippcb/doc/ppm_bref_1201.pdf
- Incineration of wastem, http://eippcb.jrc.es/reference/wi.html
- Mineral oil and gas refineries, http://eippcb.jrc.es/reference/ref.html
- Textile sector, ftp://ftp.jrc.es/pub/eippcb/doc/txt_bref_0703.pdf
- Cement, lime and magnesium oxide manufacturing, http://eippcb.jrc.ec.europa.eu/reference/cl.html
- Large combustion plants, http://eippcb.jrc.es/reference/lcp.html
- Metals (links to various BREFs for individual sectors), http://www.environment-agency.gov.uk/business/sectors/117205.aspx
- Food and drink (links to various BREFs for individual sectors), http://www.environment-agency.gov.uk/business/sectors/39869.aspx
- Chemicals (links to various BREFs for individual sectors) http://www.environment-agency.gov.uk/business/sectors/117135.aspx

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Annex A: legislation and quality standards on food waste

1. What you must know: the legislation on treatment

All of the composting/anaerobic digestion options outlined above must comply with the Environmental Permitting (England and Wales) Regulations 2010 (SI 675) (see: http://www.defra.gov.uk/environment/policy/permits/guidance.htm). However, there is an exemption from the need for an environmental permit for small scale composting operations handling up to 10 tonnes of food waste at any one time.

All of the composting/anaerobic digestion options outlined above that take food waste from homes or businesses, or where compost created from *any* sort of kitchen/catering waste leaves the site (whether or not this waste was generated on site or brought in from elsewhere) also need to be carried out in accordance with Regulation (EC) 1774/2002 and the Animal By-Products Regulations 2005.

Among other things, the Animal By-Products Regulations 2005 dictate that such composting activities must not take place on a premises where livestock are present, and that composting of cooked food or animal or dairy wastes is not allowed in anything other than an enclosed composting vessel due to the risk of attracting vermin. The landspreading of catering food waste is also subject to the Regulations, where animals could have access to the land on which food waste is being spread.

Defra Animal By-Products and environmental permitting Q&A can be found at:
www.defra.gov.uk/foodfarm/byproducts/wastefood/composting/compost-ganda.htm
www.defra.gov.uk/foodfarm/byproducts/wastefood/composting/index.htm

There is an exemption from the requirements of Regulation (EC) 1774/2002 and the Animal By-Products Regulations 2005 for 'home composting' which allows people to compost their own kitchen waste provided that it does not leave the premises – and businesses and schools can, likewise, benefit from this exemption. In both circumstances the compost created cannot leave the site, nor can food be removed from the premises to compost elsewhere without approval of the composting site under the Animal By-Products Regulations. ‘Home composting’ must not take place on a premises where livestock are present, nor is composting of cooked food or animal or dairy wastes advised due to the risk of attracting vermin.

2. Quality standards for the commercial recovery of food waste.

To provide outputs that are of suitable quality to sell onwards as products (and meet relevant Publicly Available Standards (PAS) and Quality Protocols – see

below), anaerobic digestion require uncontaminated inputs of food waste and composting requires food waste *or* mixed food and garden waste[135].

Publicly Available Standards (PAS100 for compost[136] and and PAS110 digestate[137]) have been developed as a means of applying quality standards to compost and digestate. They help differentiate products that are safe, reliable and high performing.

In addition, Quality Protocols have been developed for both compost and digestate.[138] They clarify the point at which waste management controls cease to apply and provide confidence to users that digestate/compost conforms to an approved standard. Quality Protocols apply in England and Wales only.

These quality benchmarks improve the marketability of AD/composting products and can thus help make them economically feasible.

Local Authorities can consider promoting home composting and include centralised composting as part of their waste management contracts, and specify the use of compost and/or digestate for the maintenance of public open space, verges etc. If they do the latter, ensuring that the products meet the quality standards above is highly advisable.

[135] Note that whilst AD plants do process garden waste, ensuring an appropriate mix of inputs is essential, therefore it is normally inappropriate to collect large amounts of garden waste mixed with food waste for processing via AD.
[136] http://www.wrap.org.uk/composting/production/download_pas_100.html
[137] http://www.organics-recycling.org.uk/index.php?option=com_docman&task=cat_view&gid=64&Itemid=86
[138] See http://www.environment-agency.gov.uk/business/topics/waste/114395.aspx

Annex B: Wood Recyclers' Association Grading Structure

The Wood Recyclers' Association[139] has developed the following grading structure for non-virgin wood for recycling into products, feedstocks and fuels. Please note that it is not a set of specifications, nor a standard, nor is it intended to be included in contract documentation, all of which require more detail.

Grade of wood	Typical markets	Typical sources of raw material for recycling.	Typical materials	Typical non–wood content prior to processing	Notes
Grade A. **"Clean" Recycled Wood**	A feedstock for the manufacture of professional and consumer products such as animal bedding and horticultural mulches. May also be used as fuel for renewable energy generation in non WID* installations, and for the manufacture of pellets and briquettes.	Distribution. Retailing. Packaging. Secondary manufacture e.g. joinery. Pallet reclamation.	Solid softwood and hardwood. Packaging waste, scrap pallets, packing cases, and cable drums. Process off-cuts from manufacture of untreated products.	Nails and metal fixings. Minor amounts of paint, and surface coatings.	Some visible particles of coatings and light plastics will remain. Excludes grades below. Is a waste for W.M.Regs* requirements. Does not require a WID installation**
Grade B. **Industrial Feedstock Grade**	A feedstock for Industrial wood processing operations such as the manufacture of panel products, including chipboard and medium density fibreboard (MDF)	As Grade A, plus construction and demolition operations and Transfer Stations.	May contain up to 60% Grade A material as above, plus building and demolition materials and domestic furniture made from solid wood.	Nails and metal fixings. Some paints, plastics, glass, grit, coatings, binders and glues. Limits on treated or coated	The Grade A content is not only costly and difficult to separate, it is essential to maintain the quality of feedstock for chipboard manufacture, and for PRN revenues. Some feedstock specifications contain a 5 – 10% limit on former panel products such as

[139] www.woodrecyclers.org/

				materials as defined by WID.	chipboard, MDF, and plywood. Excludes Grade D. Is a waste for W.M.Regs* requirements. Does require a WID installation, unless granted an exemption**
Grade C. **Fuel Grade.**	Biomass fuel for use in the generation of electricity and/or heat in WID** compliant installations	All above plus Municipal Collections, Recycling Centres Transfer Stations And Civic Amenity Recycling sites	All of the above plus fencing products, flat pack furniture made from board products and DIY materials High content of panel products such as chipboard, MDF, plywood, OSB and fibreboard.	Nails and metal fixings. Paints coatings and glues, paper, plastics and rubber, glass, grit. Coated and treated timber (non CCA or creosote).	Suitable only For WID installations**. Material coated and treated with preservatives as defined by WID may be included. Excludes Grade D Is a waste for W.M.Regs* requirements.
Grade D **Hazardous Waste**	Requires disposal at special facilities	All of the above plus fencing, trackwork and transmission pole contractors.	Fencing Transmission Poles Railway sleepers Cooling towers	Copper / Chrome / Arsenic preservation Treatments Creosote	Is a waste for W.M.Regs* requirements. Does require a special WID installation.

*Waste Management Regulations – this grade requires a waste management licence (or exemption) until final use, and is subject to waste transfer regulations. The definition as to whether a material is a waste or not is under review (September 2009).

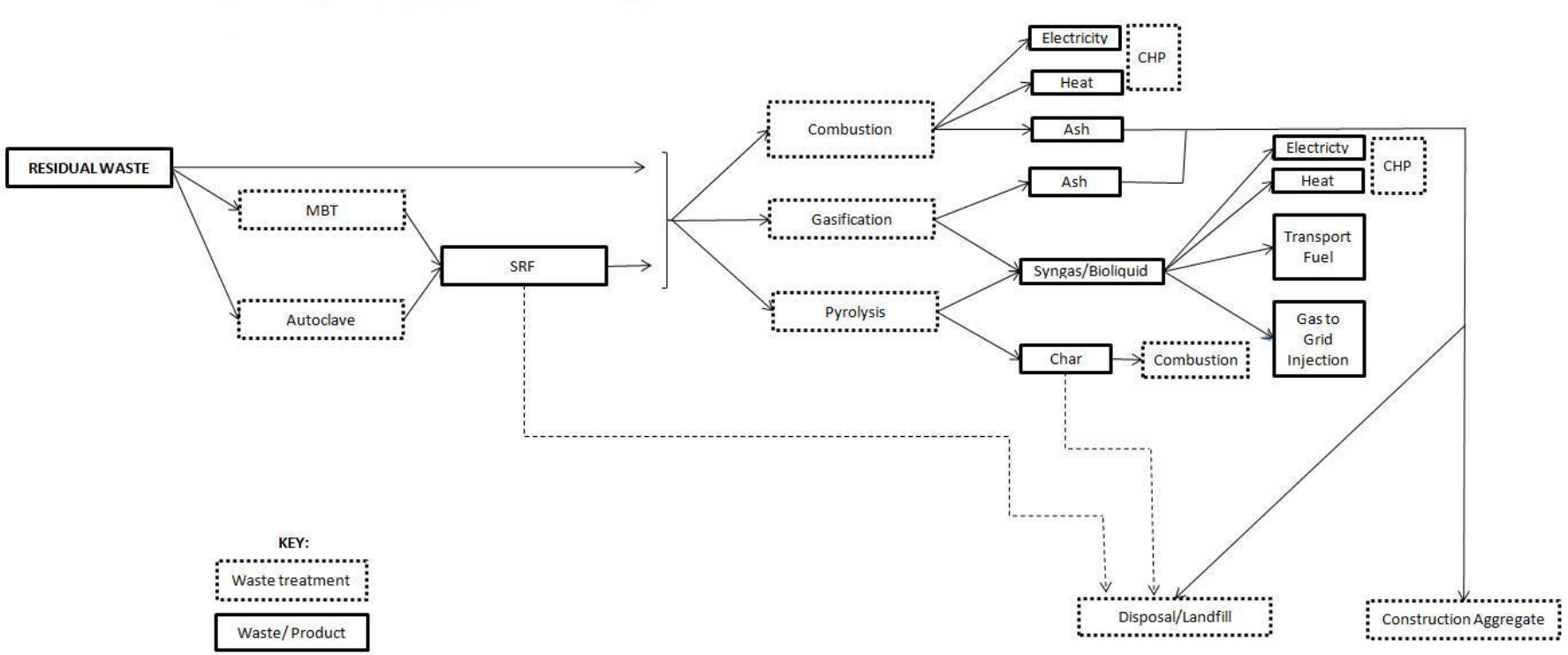
** A Waste Incineration Directive-compliant installation is required to allow this grade to be used as biomass.

There will be some coated or treated wood in all grades, as it is impossible to identify or exclude every particle of such material.

Annex C: Common plastics, their uses and recycling applications

Polymer	Symbol	Common Uses	Common Recycling Applications	Material replaced
Polyethylene Terephthalate (PET)		Fizzy drink and water bottles, salad trays	Fibre for stuffing, carpets etc., packaging	Natural and synthetic fibres, Virgin PET
High Density Polyethylene (HDPE) / Low Density Polyethylene (LDPE)		Milk bottles, bleach, Cleaners, shampoo bottles, Carrier bags, bin liners and packaging films	Bottles (non-food and food), boxes, crates, bins and underground pipes.	Virgin HDPE, LDPE
Poly Vinyl Chloride (PVC)		Pipes, fittings, window and door frames (rigid PVC). Thermal insulation (PVC foam) and automotive parts	Building products	Virgin PVC
Polypropylene (PP)		Margarine tubs, microwaveable meal trays, fibres and filaments for carpets, wall coverings and vehicle upholstery	Crates, boxes, chemical containers	Virgin PP
Polystyrene (HIPS or EPS)		Yoghurt pots, foam burger boxes and egg cartons, plastic cutlery, packaging for electronic goods and toys, insulation	Loose fill packaging, stationery, garden furniture, building products	Virgin EPS, other polymers, wood, concrete

Annex D: Energy from Waste for residual waste: the options



Annex E: Summary of Publicly Available Specifications (PAS) Relevant to Waste

PAS 100 is a standard that **composted materials** must meet in order to achieve Composting Association accreditation and to be able to use the TCA logo. It represents the national compost benchmark, i.e., the minimum requirements for the process of composting, the selection of materials from which compost is made, and how it is labelled. To achieve BSI PAS 100, compost must be made from biodegradable materials that have been kept separate from other waste and must be produced at centralised, on-farm or community composting facilities. PAS 100 does not extend to end products of home composting for self-use.

In England and Wales, compost certified to BSI PAS 100 is of recognised quality but it is still considered a waste. Compost needs to comply with the Quality Protocol for Compost in order for it to be classified as a product. Although quality compost can be sold, it requires regulatory control for its handling, transport and application. BSI PAS 100 is the preferred baseline standard for achieving QP certification.

PAS 101 provides a comprehensive standard for **recovered glass**, and covers all raw container glass collected in the UK for recycling. It is based on a four-tier grading system for raw cullet quality. Grades are assigned according to the degree of colour separation, contamination and particle size.

PAS 102 sets out quality requirements for **recycled / processed glass for some specific secondary end markets**:
– glass in ceramic sanitary ware production;
– glass as a fluxing agent in brick manufacture;
– glass in sports turf and related applications (e.g. as top dressing, root zone material or golf bunker sand);
– glass as water filtration media (e.g., in applications for waste water treatment);
– glass as an abrasive.
Colour, contamination limits and particle size requirements of processed glass are specified for each secondary market and test methods are detailed as appropriate.

PAS 103 is a classification and grading system for the quality of collected **waste plastics packaging** intended for recycling. The classification and grading is carried out by a visual assessment of each batch of waste plastics. The quality of the waste is specified, and the waste graded, according to the following criteria:

- main original application of the waste;
- main polymer type(s) present;
- main colour;
- contaminants.

The intention is to increase the value of waste plastic and to expand the market by enabling suppliers to provide better information to potential buyers about the waste plastics being offered for sale.

PAS 104 provides quality assurance (and guidance for good practice) for the supply of **post-consumer wood for consumption in the manufacture of panel board products.** It was developed to provide post-consumer wood waste processors with a set of nationally recognised quality parameters, thus enabling them to maximise the quality and value of the wood chip they produce and increase its uptake by panel-board manufacturers. BSI PAS 104 includes a set of four quality requirements on particle size, moisture content, colour and contamination together with test methods which can be used to quantify quality aspects of a load in case of a dispute between parties. It also contains a guide to good practice in the segregation, collection and processing of post-consumer wood, focusing on how to achieve a high quality processed wood chip product.

PAS 105 makes recommendations for, and gives guidance on, good practice in the collection, handling and processing of **recovered paper intended for recycling** within UK end markets. It is applicable to paper collected by local authorities, local authority contractors, community groups and charities, households and other commercial establishments. It sets out the key requirements for the municipal waste sector to provide a quality of material that minimises losses from cross-contamination throughout the entire recycling process. By providing a consistently high quality raw material stock to the recycler, the collector and sorter enable maximum recycling process efficiencies to be achieved.

PAS 107 provides a specification for producing different grades of **size-reduced tyre rubber**, each of a consistent and verifiable quality. It sets out a formal material specification system and defines minimum requirements for the initial storage, production and final storage of size-reduced, tyre-derived rubber materials intended for a range of applications in existing and emerging secondary end markets.

PAS 108 gives specifications for the density, porosity and dimensions of **tyre bales**. It enables suppliers of compact tyre bales to demonstrate consistent and verifiable quality and size. It addresses the production, handling, storage, transport and placement of standardised tyre bales, including their dimensions and properties. In addition, guidance is given on engineering properties and typical construction applications. The compression of tyres into bales provides a means of reusing them whilst at the same time reducing the demand for primary aggregate materials in construction.

PAS 109 sets minimum requirements for the production of **recycled gypsum from waste plasterboard**, covering:

- the selection, receipt and handling of input materials;
- the specifications of product grades; and
- the storage, labelling, dispatch and traceability of the products.

It also specifies requirements for a quality management system to ensure the recycled gypsum being produced is consistently fit for its intended uses.

PAS 110 (not yet finalised / published) will enable producers of **digestate** from anaerobic digestion (AD) plants to verify that their product is of consistent quality and fit for purpose. It covers whole digestate, and the separated fibre and separated liquor produced by separating whole digestate, from AD systems that accept only source-segregated biowastes. It specifies:

- controls on input materials and the management system for the process of anaerobic digestion and associated technologies;
- minimum quality of whole digestate, separated fibre and separated liquor; and
- information that is required to be supplied to the digestate recipient.

The digestate producer is also required to carry out Hazard Analysis and Critical Control Point planning and implement a quality management system.

PAS 111 (currently under development by BSI, WRAP and Oakdene Hollins) will give requirements for processing waste wood into a material suitable for use in new applications or end-products. It will be applicable to the receipt, storage, grading, preparation and testing of waste wood intended for secondary end markets. It will not be applicable to the reuse of wood products.

Waste wood sources include post-consumer, industrial packaging, industrial processing and construction and demolition arisings. Secondary end markets include panel-board manufacture, energy recovery applications, animal bedding and agricultural and soil amelioration applications.

It is recommended that the scope for PAS 111 should include pre-consumer wood waste as many wood recyclers in the UK handle significant quantities from such sources. This is wood waste such as sawdust and offcuts from manufacturing or sub-manufacturing processes that has not yet reached the end-user.