Climate Change and Waste Management: The Link

Sustainable waste management is moving up the political agenda and includes issues of sustainability, escalating waste growth and public concern over proximity to proposed waste treatment facilities as well as implications for greenhouse gas emissions and mitigating climate change.

Increased greenhouse gases in the atmosphere have caused the temperature of the earth to rise by 0.6°C over the last 100 years. The 10 warmest years of the 20th century all occurred in the last 15 years of the century and 1998 was the warmest year on record. Thermal expansion and glacier melting are causing sea levels to rise, exposing populations to increased risk of flooding. Patterns of precipitation are changing, with greater likelihood of extreme events and more areas subject to water stress, with consequences for agricultural production. Developing countries are particularly at risk. Global temperature will continue to increase causing further disruption to climate patterns. Ultimately all this can only be brought under control by stabilising greenhouse gas concentrations in the atmosphere.

Significance of waste management

Waste management generates carbon dioxide and methane which are both greenhouse gases[1]. Everyday waste contains readily biodegradable carbon based organic matter such as kitchen waste, garden waste, and paper, and slowly biodegradable organic materials such as lignin (wood-like material). Some products such as plastics, contain carbon derived from the fossil fuels which are used as a feedstock (oil). The treatment and disposal of these wastes has a direct influence on the emissions of these greenhouse gases.

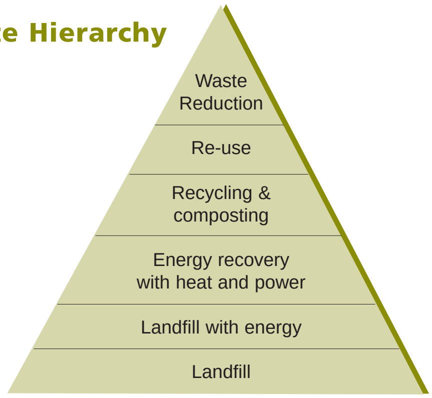
When we manage the treatment and disposal of our wastes we are also managing the method by which the carbon will be released back into the environment: similarly the changing climate impacts on the way waste will need to be stored, treated and disposed of, and will also alter the risks associated with waste (e.g. pests, diseases).

When materials are broken down by organisms in the presence of air, the gas released is carbon dioxide. Methane is also produced when the material decomposes in the absence of air. Weight for weight methane is 21 times more powerful than carbon dioxide as a greenhouse gas[2].

1 Under international guidelines carbon dioxide from biomass is not included in national total greenhouse gas emissions because an equivalent amount of carbon will be removed again from the atmosphere as the crops or timber regrows. Carbon dioxide from fossil carbon contained in waste is included in national totals.

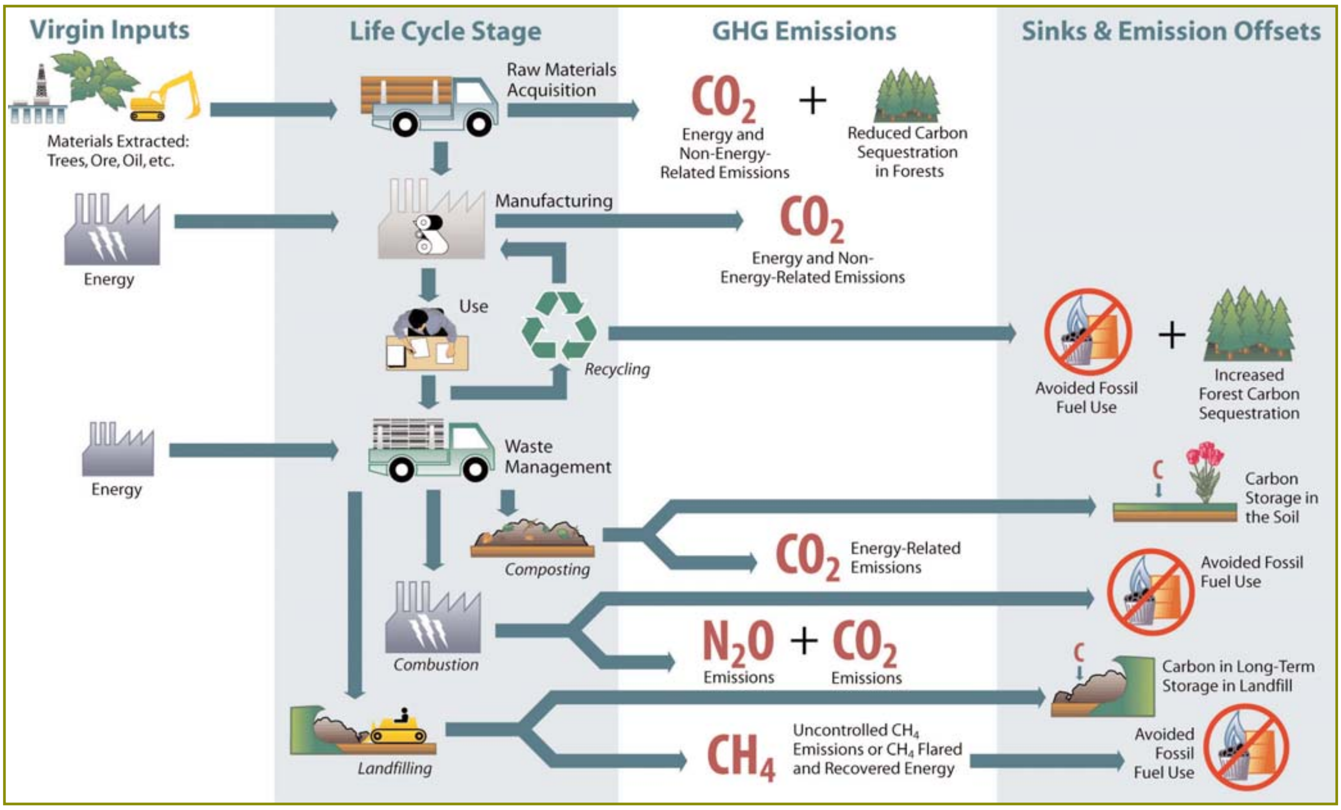
2 Twenty one is the global warming potential (GWP) of methane using a 100 year time horizon as estimated by IPCC in 1995. This is the value used in international reporting of emissions. IPCC has more recently estimated the 100 year GWP to be twenty-three.

The Waste Hierarchy



It is the absence of air in landfill sites which gives rise to the formation of methane through the decomposition of the waste. Currently over 70% of waste in the UK is landfilled, presenting a significant problem with the management and control of the methane emissions. One tonne of biodegradable waste produces between 200 and 400m3 of landfill gas. Landfill gas methane emissions contributed around 25% of total UK methane emissions in 2001, and about 2% of UK total greenhouse gas emissions[3].

A landfill dominated strategy is no longer acceptable for biodegradable wastes, leading to a change in culture with greater emphasis being placed on treatment options further up the waste hierarchy. This should also help achieve the UK's commitment under the Kyoto Protocol to reduce greenhouse gas emissions by 12.5% below 1990 levels[4] in 2008-2012.



http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteBasicInfoGeneral.html

This diagram of the life cycle of materials from raw materials through to final disposal shows various waste management options and illustrates the link between waste management and greenhouse gas emissions. Greenhouse gases can be produced at each stage from raw material extraction, transport, manufacturing, use and final treatment or disposal of materials. By relating this life cycle to the waste hierarchy, we can see how each level of the hierarchy impacts on climate change.

Waste reduction and particularly waste avoidance or prevention is at the top of the hierarchy. Waste prevention has a direct impact at the first life cycle stage. Avoiding unnecessary waste, for example excessive packaging, reduces the demand for raw materials which would otherwise have been extracted. This reduces emissions of carbon dioxide from fossil fuels and preserves carbon stocks in trees; it reduces transportation needs and associated fuel consumption and vehicle pollution. The knock-on effect of this saving is cumulative throughout the whole cycle, saving significant emissions of greenhouse gases which would otherwise have been emitted right through to disposal of the material. Waste prevention is therefore the most important aspect of waste management in terms of greenhouse gas reduction, and is where efforts should be focused.

Re-use of products and materials is almost as effective, preventing the return of the carbon within the materials to the environment for as long as possible. Re-use also reduces demand for new raw materials and therefore reduces climatic impacts from this and associated materials transportation.

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3 http://www.environment-agency.gov.uk/yourenv/eff/resources_waste/213982/207743/?lang=_e

4 the base year for fluorinated compounds is 1995

Recycling reduces the need for raw materials, and keeps valuable resources from being disposed of and further contributing to greenhouse gas emissions. Recycling does require an energy input to reform the materials into different products, and this energy usually comes from burning of fossil fuels and the release of carbon dioxide to the atmosphere. The composting of garden and sometimes kitchen waste produces carbon dioxide as part of the aerobic decomposition process. Anaerobic digestion of organic waste produces methane and carbon dioxide which is collected through the process and can be used as a fuel. The recycling of biodegradable organic wastes is central to meeting the requirements of the Landfill Directive.

Further down the hierarchy, incineration, or energy recovery, converts energy stored within the materials to useful energy, reducing fossil fuel requirements and so saving on carbon dioxide emissions and other harmful pollutants. The original material is converted to ash and gases, implying the need for more extraction, manufacturing and transportation of materials. Incineration without energy recovery is mainly a volume and toxicity reduction process, and has the benefit of preventing materials decomposing in a landfill with the possible uncontrolled release of gases.

Generally, the least favourable environmental option in terms of potential climate change emissions is landfill. However there is a wide variation in terms of the level of control over emissions from landfills. Landfills produce methane due to the decomposition of wastes in the absence of air. There are many basic unengineered landfills around the world today which have no system for collecting this harmful greenhouse gas, and emissions remain uncontrolled to the atmosphere.

Modern landfills in the UK which accept biodegradable wastes are engineered to capture the gases produced. In 2001 in the UK about a third of the 500 landfill sites taking significant amounts of biodegradable waste also had gas controls, and many sites extract the gas for energy recovery[5]. At the end of December 2003, 209 projects contracted under the Non Fossil Fuel Obligation, the Renewables Obligation, the Scottish Renewables Obligation and the Northern Ireland-Non Fossil Fuel Obligation had been commissioned and were generating electricity, with a capacity totalling 441 MW[6]. About 42% of renewable gas and electricity now comes from landfill gas in Great Britain[7]. Burning the methane produces carbon dioxide, which has a much lower global warming potential per mass of gas emitted[8], and does not count towards national total emissions where it is derived from biomass - which is the case for landfill gas. Extending gas recovery systems for landfills will further reduce methane emissions.

However, by consigning materials to landfill we are limiting the potential for reuse, recycling or recovery of valuable resources, increasing the demand for new resources and generating more greenhouse gas emissions. This is not sustainable waste management.

New Technologies and Climate Change

The EC Landfill Directive imposes targets to limit the amount of biodegradable waste sent to landfill, requiring changes to waste management practices. These will also help meet the UK's legally binding commitments under the Kyoto Protocol which has now entered into force.

So, consistent with the responsibility of individuals and businesses to reduce their impact on climate change through waste prevention, reuse and recycling, it is also the responsibility of the waste management sector to play its part in helping put in place the technology, infrastructure and knowledge to achieve a significant reduction in greenhouse gas emissions for residual waste.

5 http://www.environment-agency.gov.uk/yourenv/eff/resources_waste/213982/207743/?lang=_e

6 http://www.restats.org.uk/renewables_obligations.html

7 http://www.restats.org.uk/renewables_obligations.html

8 Carbon dioxide is the dominant anthropogenic greenhouse gas because the absolute amounts emitted are much greater than for other greenhouse gases, and this outweighs the lower global warming potential.

New waste management technologies have a key part to play in diverting the amount of biodegradable waste sent to landfill. Each technology contributes in different ways; composting, for example, is an aerobic activity, allowing the biodegradable waste to decompose in the presence of air and therefore producing carbon dioxide, as opposed to the much more damaging methane generated under anaerobic conditions. Anaerobic digestion plants make use of the methane production in a sealed vessel and collect it for use as a high energy fuel, consequently displacing the need for fossil fuels, and again releasing the less potent greenhouse gas carbon dioxide after combustion of the gas.

Mechanical Biological Treatment (MBT) plants frequently incorporate in-vessel composting or anaerobic digestion as the 'biological' treatment element of the process. The 'mechanical' sorting element of an MBT process removes some recyclable materials from the mixed waste stream, saving on the need for raw material extraction, whilst the biological process may treat the organic fraction (in some systems) so it may be landfilled or used as a soil conditioner with reduced greenhouse gas emissions. Additionally in some MBT plant, the combustible materials (e.g. paper and plastics) can be separated for use as a fuel to generate electricity and / or displace fossil fuels.

Autoclaving is a new technology to be applied to municipal waste which relies on the action of steam and pressure to produce a fibrous material from the organics in the mixed waste. This can potentially be recycled into useful products if outlets are available. Alternatively there is the potential to use the fibre or 'flock' as a fuel to generate electricity and/or displace fossil fuels. Materials such as metals and glass are partially cleaned due to the steam, and may be recycled, saving on raw material extractions and associated greenhouse gas emissions.

Advanced Thermal Treatment technologies such as pyrolysis and gasification also divert biodegradable waste from landfill. Pyrolysis is a medium temperature (300°C to 800°C) thermal process where organic based materials are broken down under the action of heat in the absence of oxygen. A pyrolysis oil or combustible gas may be produced which can be used as a fuel to generate electricity, saving on fossil fuel requirements. A solid char is also produced which can be additionally processed via gasification (see below) or disposed of to landfill. However it will no longer decompose releasing greenhouse gases.

Gasification is a higher temperature (800-1200°C) thermal process. Air or oxygen is introduced into the system in small quantities to generate higher temperatures. Outputs include a combustible gas containing carbon monoxide and hydrogen which can be used as a fuel to produce electricity, again reducing the need for fossil fuels. Carbon dioxide will be released from both pyrolysis and gasification processes upon combustion of the fuel gas. A solid char is produced which may be recycled into other applications in the construction industry, reducing the need for extraction of raw materials or which may require disposal if no markets for recycling are available. This char will have negligible gas generation potential if landfilled.

Summary

Better management of our waste can significantly reduce emissions of greenhouse gases to the atmosphere. By encompassing the principles in the waste hierarchy we can turn waste materials into resources to be valued, reducing the need for increasing extraction of raw materials and fossil fuels. Technologies already available in the market place offer opportunities to recover materials and energy from waste which would otherwise be landfilled, with the potential for methane release to atmosphere. It is increasingly important that we act to reduce the impact of climate change, and one way we can all help is to reduce the amount of waste we produce and the amount of energy we use. Emphasising this important link between waste management, greenhouse gas emissions and climate to the general public is central to raising environmental awareness.

For more information on the role of new waste technologies in diverting biodegradable waste from landfill, contact the New Technologies Supporter Programme. Helpline: 0870 240 9894 Email: Wastetech@enviros.com
Website: www.defra.gov.uk/environment/waste/wip/newtech/supporter.htm

Further Reading:

United Nations Climate Change Convention http://www.un.org/ecosocdev/geninfo/sustdev/climate.htm

International Panel on Climate Change http://www.ipcc.ch/pub/reports.htm

Defra http://www.defra.gov.uk/environment/climatechange/index.htm