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WASTE

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1. What is Sustainable Waste Management?

Sustainable development, according to the **Brundtland Report**, can be defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.



The economic development of a country can cause an increase in pressures on its environment and increases the need for a reduction in environmentally damaging activities. Some of these damaging activities involve the production and disposal of waste.

Building upon the policy document ‘Making Waste Work’ published in 1995, the Waste Strategy 2000 for England and Wales describes the policies concerning the recovery and disposal of waste. These policies are a requirement of all countries in the **European Union** (EU). The key objectives of the strategy are to reduce the amount of waste produced, to increase the amount of waste recycled and to limit the risk of pollution from waste.

The idea of ‘sustainable development’ has been incorporated into the themes of the Waste Strategy 2000 and specific targets have been set, to be achieved by 2005. The UK has implemented the EU strategy by developing the idea of a ‘waste management hierarchy’. This encompasses the processes of reduction, re-use, recycling and recovery, in that order of priority.

2. Waste Arisings in the UK

Domestic / Municipal Waste

Domestic / municipal waste refers to household and commercial solid wastes. These are disposed of by, or on behalf of the local authority. Waste generation is much lower in developing countries, whereas the USA has more than double the waste generation per person than many European countries, including the UK.

In the late 19th and early 20th centuries, dust and cinder from domestic coal fires constituted the major component of waste in the UK. With the introduction of the 1956 Clean Air Act, and the consequential move away from coal fires by the 1960s, there was a corresponding fall in dust and cinder waste. The largest increases in domestic waste contribution have been paper and board, metals, glass and plastics, reflecting the increasing importance of consumables in society. The UK now produces nearly 30 million tonnes of domestic waste each year, about 7% of total waste arisings (428 million tonnes, 1999).

There are significant differences between the composition of municipal and domestic wastes generated in various European countries. Waste content is affected by the following factors:

- socio-economic factors;
- type and level of industrialisation;
- geographic location;
- climate;
- level of consumption;
- collection system;
- population density;
- the extent of recycling;
- legislative controls and;
- public attitudes.



Industrial / Commercial / Minerals Waste



Each year, approximately 50 million tonnes of industrial waste are generated in the UK. The waste is produced by a wide variety of industrial processes such as the food, drink and tobacco industries, producing approximately nearly 9 million tonnes of waste per year alone. Commercial waste accounts for 6% (or 25 million tonnes) of total waste arisings in the UK, whilst the mineral extraction industry produces 119 million tonnes of waste per year.

In Europe, 330 million tonnes of industrial waste are produced per year. Germany produces the largest quantity, with 70 million tonnes, and Norway the least, with approximately 2.5 million tonnes per year. Outside of Europe, the USA produces 400 million tonnes of industrial waste per year, more than all of the European countries put together.

Industrial and commercial waste includes food wastes, animal wastes, chemical wastes, fuels, oils and greases. The composition of industrial waste can be very mixed, and depends greatly on the type of industrialisation most prevalent in a given country.

Building Waste

The building industry generates large amounts of waste through demolition and construction. Approximately 72 million tonnes of waste are generated each year, making the building industry responsible for producing approximately 17% of the total UK waste.



Within Europe, there is a large variance in the amount of building waste generated. Austria, for example, produces approximately 18 million tonnes of waste per year and Germany produces 120 million tonnes.

Building waste is usually very bulky and consists of:

bricks



concrete



wood



glass



soil



tiles



The largest percentage of demolition waste in the UK is made up of soil, stones and clay.

Sewage Waste

Raw sewage from domestic households and some industrial and commercial **effluent** is treated, with **sewage sludge** formed as a by-product. Rainwater also enters the sewage systems along with these wastes.

Sewage sludge is typically composed of a combustible fraction and an organic content. The combustible fraction consists of carbon, hydrogen, nitrogen, oxygen and sulphur. Crude protein, fat and fibre, and non-fibrous carbohydrate constitute the organic content.

In 1999, the total UK dry sewage sludge production was estimated to be about 1 million tonnes per year. This can be compared to Greece, which was estimated to be producing the lowest



amount of sewage waste in Europe, at 15 thousand tonnes. The second highest producer of sewage waste in Europe, after the UK, was Italy, producing 800 thousand tonnes a year. Currently, there are only ten water and sewerage treatment companies in the UK which treat our wastes.

Agricultural Waste

Agricultural waste contains organic material, which may be livestock manure, **slurry**, crop residues and **silage effluent**. In 1999, it was estimated that approximately 87 million tonnes of waste was produced per year by housed livestock alone.



Agricultural waste control was not very well developed in the past. Some agricultural wastes were subject to regulation under the Environmental Protection Act, 1990. However, the recently implemented **European Commission** (EC) Framework Directive on Waste will cause more farm wastes to be controlled.

Household, non-organic and some other agricultural wastes now fall within the controlled waste regulations.

European countries produce approximately 700 million tonnes of agricultural waste per year. However, there is wide variation in the amount of wastes produced by individual countries in Europe. For example, France produces 400 million tonnes per year, but Austria produces less than 1 million tonnes per year.

Special Waste

The term “special wastes” refers to hazardous wastes, i.e. those that are dangerous to treat, keep or dispose of. They are generally harmful to human, plant or animal life. These wastes must be handled or disposed of with special precautions. In the UK, special waste is subject to certain regulations under the 1996 Special Waste Regulations Control Act. This legislation was devised to conform to European legislation. In addition, wastes that are explosive, highly flammable, toxic, **carcinogenic**, **mutagenic** or have other hazardous properties, are also termed special wastes.



Contaminated soils that contain hazardous materials such as heavy metals, pesticides, tars, oils or other organic materials from old

industrial sites may also be defined as hazardous waste. An example of such a site may be an old gasworks.

In 1998, it was estimated that there were 4.8 million tonnes of special waste produced. This excludes hazardous wastes treated or disposed of at the point of production. In comparison to the total waste arising in the UK, these figures appear to be low, but due to their hazardous nature, treatment is difficult and expensive.

The majority of the wastes produced are from the chemical and primary metal industries. Sludge or liquids represent 80% of the wastes generated. The last ten years have seen an increase in the quantity of hazardous waste arisings by approximately 50%. The increase not only shows a rise in the production of such wastes, but also in the reporting of special wastes.

3. Waste Disposal in the UK

In the UK, the most common disposal method is landfill. Incineration, ***anaerobic digestion*** and other disposal methods are also used.

Landfill

Each year approximately 111 million tonnes, or 57%, of all UK of controlled waste (household, commercial and industrial waste) are disposed of in landfill sites. Some waste from sewage sludge is also placed in landfill sites, along with waste from mining and quarrying.



The UK has valuable minerals that are mined extensively for industry. The extraction of these minerals produces large holes in the ground, which need to be filled in and landscaped. The use of these sites for the burial of waste seems a convenient solution. The UK has ideal underlying geology in many places, making landfill a cheap waste disposal option. In 1994 there were approximately 4000 landfill sites in the UK.

A large number of landfill sites can be found in many parts of Europe and the USA. However, some countries do not have significant amounts of suitable land and so landfilling is scarce. For example, Japan disposes of most of its country's waste by incineration as the geology is unsuitable for landfill.

Traditionally, waste would be dumped into a site and forgotten, but nowadays this is an unsustainable practice with increasing amounts of waste being produced. Today's generation must dispose of waste in a way that will do the least damage possible, and keep the environment fit for the future.

There are two main types of landfill sites that can be used:

Attenuate and Disperse Landfills: this method relies on the uncontrolled release of *leachate* into the environment. This is a very gradual permeation through the surrounding groundwater and geological strata. This process is called attenuation, and is supposedly sufficiently slow to enable the dilution of any contaminants to such an extent that they are rendered safe.

Containment Landfills: in North America, Japan and Europe, this is the predominant form of landfill site. Any escaping liquids or gases from the degradation of waste in this type of site are managed or treated. In some countries, such as the USA and France, a specific form of containment called entombment is used where the waste is kept dry and leachate generation is minimised.



Once a landfill site is full up, it must be capped, covered over and landscaped to blend in with the natural environment.

Incineration

Incineration is the second largest waste disposal method in most countries. In the UK, approximately 5% of household waste, 7.5% of commercial waste, and 2% of industrial waste is disposed of by incineration. When burning waste, a large amount of energy is given off. Modern incinerators use this energy to generate electricity and hence prevent energy from being wasted.



The UK houses numerous types of incineration plants, ranging from large scale, mass-burn, and municipal waste incinerators to clinical waste incinerators.

In the UK, in the 1990s, many hospitals had clinical waste incinerators. However, emissions from the burning of hazardous hospital waste were said to be too high under the Environmental Protection Act of 1990. Many hospitals could not meet the new regulations and were forced to shut the incinerators down. Today, hospitals tend to share one large incinerator to dispose of the wastes for a number of hospitals.

Large-scale municipal solid waste incinerators experienced similar problems in that they did not comply with EC legislation. Many of them were shut down, with the exception of four that were fitted with gas clean-up systems. The clean-up systems cost a great deal of money.

Incinerators are classified as either Mass Burn Incinerators or other types of incinerators. Mass Burn Incinerators are used throughout the world for the disposal of municipal solid waste. Other types of incinerators are responsible for the disposal of other waste, for example clinical waste.

Anaerobic Digestion

Anaerobic digestion

decomposes waste in a similar way to a landfill site, but in an enclosed chamber. Digestion takes place in an oxygen-free environment. Bacteria thrive in this environment by using the oxygen that is



chemically combined within the waste. They decompose waste by breaking down the molecules to form gaseous by-products (methane) and small quantities of solid residue.

Anaerobic sewage plants produce significant quantities of methane, which can be used to generate electricity. Liquid and solid organic fertilisers are also formed, and can be sold to cover operating costs.

For several years, sewage sludge and agricultural waste has been treated by anaerobic digestion, and the process is now being used for municipal solid waste. It requires the ***biodegradable*** section of the waste to be separated from other material and put into digestion chambers.

In the UK, anaerobic digestion is not a major waste disposal method. The UK has only a small number of plants, and each can handle approximately 260-300 tonnes of waste per year. However, a number of plants are currently being developed to increase the usage of anaerobic digestion. Many other countries already utilise anaerobic digestion to dispose of large amounts of waste, e.g. Denmark treats 1.1 million tonnes of waste per year.

Other Disposal Methods

Pyrolysis

This relatively recent method of waste treatment heats organic waste without oxygen to produce carbonaceous char, oils and combustible gases. Relatively low temperatures of about 400-800°C are used to degrade the waste materials.

The oils may potentially be used as fuels, as they have a higher energy density than the raw waste, or used to derive chemical feedstock. Solid fuel or char-oil may be produced from the char, or it may be used as carbon. The pyrolysis plant itself may be powered by the energy from gases generated during the ***thermal degradation*** of the waste materials.

Investigations have been made into further developments of pyrolysis systems for municipal solid waste, plastics, tyres, biomass and sewage sludge. Commercial exploitation of energy from some of these waste materials has also been under development.



The ***Non-Fossil Fuel Obligation*** has encouraged the use of pyrolysis systems as a means to produce energy in the UK, by subsidising the cost of fuels produced by the process.

Gasification

This process is similar to pyrolysis, with the exception that oxygen is used. A gas product, ash and a tar product are the by-products of a reaction in air, steam or pure oxygen, at high temperature, with the available carbon in the waste. Higher operating temperatures are used than for pyrolysis, with 800-1100°C for air gasification, and 1000-1400°C with oxygen.

The gases produced during the process can be utilised by direct combustion in a boiler or furnace, and the heat energy is used to produce steam for electricity generation or for process heat. Both pyrolysis and gasification have been used in modern developments of ***thermochemical*** waste processing, and several combined systems are now at the commercial stage.

Composting



Organic waste, such as garden or food waste, may be biodegraded by composting. This process may take place over as little as 4-6 weeks, by which time a stabilised product is reached.

Individual households have practised small-scale composting for many years, and the UK Government is now encouraging this. By the year 2010, the Government hopes to have 30% of domestic waste either recycled or composted. Large-scale composting schemes are also being developed, with the collection of organic waste from parks and civic amenity sites. Garden and food wastes are collected directly from households in separate kerbside collections. Large central facilities can then compost the collected organic waste.

The stabilised product can be added to soil, especially clays, to improve soil structure, and also act as a fertiliser and ***mulch***. It is also used to improve moisture retention in the soil.

The amount of biodegradable material in landfills will be greatly reduced, with the effect that less landfill gas and leachate will be produced. This is a benefit for the operation and management of landfill, but it is a disadvantage for those landfills designed as bioreactors to generate landfill gas for energy recovery.

There are other major sources of organic waste as well as domestic, park and garden wastes. For example, agricultural waste, sewage sludge, forestry waste and food waste all constitute organic waste.

Other countries have a much larger waste composting industry than the relatively small scale one practised in the UK. France, the USA, Portugal and Spain, have relatively high rates of waste composting, whilst Japan has a low composting rate.

4. Energy From Waste

Introduction

There are numerous ways to recover energy from waste, including the burning of landfill methane and waste incineration. By 1998, 3 million tonnes of waste per year in the UK were being recovered for energy production.

Landfill Gas Extraction

In recent years many countries have begun to develop larger landfill sites, making landfill gas extraction a viable energy recovery project. In 1995 there were 75 schemes set up in the UK to utilise energy from landfill gas (***methane***). The USA and Germany have also developed a large number of similar schemes.

It has been estimated that 6-8 tonnes per cubic metre per year of methane gas is produced from landfill gas extraction. This method was first utilised to power boilers and furnaces in close proximity to the landfill sites. However, present schemes use the gas to power engines and generate electricity. In 2000, landfill gas provided approximately 250 megawatts (MW or million watts) of electricity in the UK, about 21% of all electricity produced by renewable sources. This figure should increase further in the coming years.



Heat Extraction

When waste is incinerated in large amounts, heat energy can be recovered and used for heating schemes in factories, hospitals and other large-scale complexes.

Waste Derived Fuel (WDF)

WDF is a fairly feasible way of recovering energy. It is available in two forms: palletised (solid blocks) and shredded. The palletised form can be burnt in many conventional boilers and larger combustion units can use the shredded form. This fuel has half the ***calorific value*** of coal and is therefore not always economically viable for companies. Incentives are often required to encourage firms to use this type of fuel.

5. Waste Recycling

Introduction



The definition of recycling is to pass a substance through a system that enables that substance to be reused. Waste recycling involves the collection of waste materials, and the separation and clean up of those materials.

In the UK, the household and commercial sectors have relatively low recycling rates. This is in comparison to some other wastes, such as construction and demolition waste and sewage sludge.

Paper

The paper industry generates vast quantities of waste in the form of paper off-cuttings and damaged paper rolls. This paper can be put back into the **pulping** process and recycled.



Paper constitutes approximately 200kg, or one third, of UK household waste per year. Of this amount, a maximum of 60%, or 120kg, is recyclable.

In 1990 Great Britain recycled 32% of paper and board packaging, and by 1998 this figure had reached 38%. It is projected that this figure will increase in the future.

To encourage the public to recycle wastepaper, many council have arranged house to house collection schemes. Separate bins and containers are provided specifically for paper. They are collected at regular intervals and taken to be recycled.

Glass



Approximately 6-8% of UK household waste comprises of glass jars and bottles. However, the largest producers of waste glass bottles are hotels and pubs, as the vast majority of drinks are bottled.

A large proportion of glass is collected in bottle banks and taken to be recycled. There are over 20,000 bottle banks in the UK, and they are mainly found in car parks. There are usually three bottle banks, one for each colour of glass; clear, green and brown. Waste sheet glass is also produced, for example windows, and approximately 15% of this glass is recycled.

Within Europe some countries have recycling rates as high as 80% (Switzerland and the Netherlands). Britain's current rate of 22% is relatively low compared to this.

Plastic

Plastics make up a large amount of waste, since they are available in numerous forms. There are two main types of plastic; **thermoplastics**, which are the most common (approximately 80%), and **thermosetts**. Thermoplastics melt when heated and can therefore be remoulded. This enables thermoplastics to be recycled relatively easily.



In Western Europe the largest amounts of plastic occur in the form of packaging. Plastic waste tends to be sorted by hand, either at a materials recycling facility or the householder can separate it. This may then be taken to a plastic recycling point or collected by the council.

The UK produces approximately 4.5 million tonnes of plastic waste per year. Most of this waste arises from packaging. The UK has a plastics recycling rate of only 3%. In Germany the recycling rate for plastic is 70%.

Metal

The UK has a recycling rate of approximately 60% for iron and steel. Most of this waste comes from scrap vehicles, cooker, fridges and other kitchen appliances. It is estimated that the metal content of household waste is between 5 and 10%. It is mainly made up of aluminium drinks cans and tin-plated steel food cans.

Aluminium recycling is widely established in the UK. It is an expensive metal and can therefore produce high incomes for recycling schemes. Copper, zinc and lead are also recycled in the UK. In 1998, approximately 36% of aluminium drinks cans were recycled, 10 times the recycling rate from 10 years earlier. Some other countries have very high recycling figures for aluminium drinks cans. The USA, for example, recycles 64% and Australia 62%.

Tyres

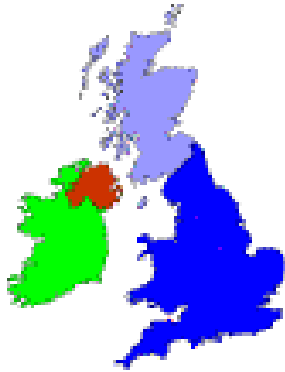
Every year in the UK between 25 and 30 million scrap tyres are generated. Approximately 21% of these tyres are retreaded and reused. The old tread is ground off the tyre and replaced with a new tread. However extremely large amounts (50%) are placed in landfill sites throughout the country. Other tyres may be incinerated.



Conclusion

Throughout the 1990s there has been a steady increase in waste recycling in general. This is a consequence of a heightening awareness of the environment, and environmental issues, by both the media and the public. The Waste Strategy for England and Wales, however, has set targets to increase the rate of waste recycling by 2010.

6. Waste Legislation in the UK



In the UK, there is no single piece of legislation that controls waste management. The treatment and disposal of waste is controlled by numerous pieces of legislation that are modified to keep the UK in line with European Community Directives.

In 1989, the **European Commission** published a strategy to cover waste prevention, re-use, recycling, recovery and disposal. Following this the 'Waste Management Strategy' for the UK was set out in the Environmental Protection Act of 1990. The Act looks at the environmental impacts of waste on the air, land and water as a whole. Prior to this Act, the different parts of the environment were looked at under separate controls.



In 1995 the UK Government adopted a further approach to sustainable waste management with a strategy entitled 'Making Waste Work'. The strategy covered England and Wales and aimed to reduce the amount of waste ending up as landfill, and to make the best possible use of any waste that is produced. In 1997 the Scottish Environmental Protection Agency produced a similar strategy. This was followed in 2000 by the Waste Strategy 2000 for England and Wales, a strategy for managing waste and resources better in order to deliver more sustainable development.

In implementing the waste strategies, the final decision about any type of waste will be made according to the Best Practicable Environmental Option, i.e. the solution that does the least damage to the environment as a whole, at an acceptable cost.

7. Waste Efficiency

Reduce

The reduction of waste is thought to be the most important aspect of waste management. It involves avoiding, eliminating and reducing waste at its source, and is beneficial to the community as a whole. Technological developments and design improvements within the manufacturing industry can improve product lifetimes and reduce waste from raw materials. The use of packaging materials and energy may also be reduced. Improvements in office procedure in the commercial sector can decrease the use of paper and other consumables.

Re-use

Many products can be designed so that they can be used more than once, for example refillable bottles, retreaded tyres and wooden pallets. It is also possible for products to have secondary usages; old tyres can be used as boat fenders.



Recover

There are numerous ways in which the value of waste can be recovered:

Recycle

Recycling involves taking waste material and turning it into a usable material. Numerous material can be recycled, with the most common being paper, glass, metals and plastics.



Composting



This produces a valuable fertiliser, and hence reduces the need for artificial fertilisers. It also reduces pollutant emissions that would occur if the waste was disposed of in a landfill site. Although it is an environmentally friendly waste disposal method, only 0.5% of household waste is composted. The government plans to promote composting schemes within the community.

Energy from Waste

The recovery of energy from waste has a great deal of potential as it can provide heating schemes and electricity generation. This also gives waste disposal companies some income to pay for disposal as they can sell the electricity.



Glossary

Anaerobic digestion: the breaking down of food material by living organisms, in the absence of oxygen.

Biodegradable: capable of being decomposed by bacteria, or other biological means.

Brundtland Report: a report by Gro Harlem Brundtland of the United Nations, outlining the actions that need to be taken for sustainable development to be achieved globally.

Calorific value: energy content.

Carcinogenic: cancer-causing.

Effluent: liquid discharged as waste, for example from an industrial plant or sewage works.

European Commission: the governing body of the European Union (EU), which develops legislation affecting countries within the EU.

European Union: an organisation made up of a number of countries within Europe, called Member States. The EU aims to work together to improve living standards for the populations of those countries.

Leachate: water that carries salts dissolved out of materials through which it has percolated, especially polluted water from a refuse tip.

Methane: a colourless odourless flammable gas, used as a fuel, and the main constituent of natural gas.

Mulch: half-rotten vegetable matter, peat, etc. Used to prevent soil erosion or enrich the soil.

Mutagenic: causing genetic mutation.

Non-Fossil Fuel Obligation: action taken by the Government to decrease the use of fossil fuels and promote the use of renewable energy. Renewable energy projects are subsidised by the Government to encourage this.

Pulping: the process of adding water to paper to enable recycling to take place.

Putrescible: liable to decomposition, giving off a foul smell.

Sewage sludge: the solid components of sewage.

Silage: any crop that is harvested whilst green and kept succulent.

Silage effluent: the liquid produced by the decomposition of silage.

Slurry: a suspension of solid particles in a liquid.

Thermal degradation: the decomposition of a substance when heated.

Thermochemical: chemical reaction requiring heat to allow it to take place.

Thermoplastics: plastics that become soft when heated.

Thermosetts: plastics that cannot be remoulded once they are set.

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