



Recycling and Municipal Waste

Price
50p

Household and Municipal Waste

Most people think of waste as the material collected by dustmen on a weekly basis. In fact, as Table 1 shows, household waste makes up a small percentage (9.3%) of total waste. Industrial and commercial waste is over twice as great by weight and even this is dwarfed by the estimated amounts from construction, mining and other sources.

Formerly municipal, industrial and commercial wastes were mostly dumped in landfill sites, often usefully. Many level playing fields lie over 'tips'. Now landfill, though still the cheapest mode of disposal, is seen as unsustainable and the EU, through directive 1999/31/EC, requires countries to reduce it.

The directive has 3 aims. First to make landfill an environmentally safer process, for example by preventing toxic liquids leaking into aquifers or nearby streams. Tips must now be separated into three categories: hazardous, non-hazardous, and inert and be well engineered and managed. Second to divert as much *biodegradable* waste as possible away from landfill. 35%, 50% and 75% of the 1995 weight must be diverted by 2010, 2013 and 2020 respectively. (These percentages are more onerous than they

sound because the weight of waste has increased since 1995.) Landfilled biodegradable waste generates methane that, if not captured, is 20+ times worse than carbon dioxide for global warming. Third to reduce the *quantity* of waste and/or view it as a resource. The UK Government has added extra sticks in the form of landfill taxes. These are £2.50/tonne for inert material, and £48/tonne for non-hazardous waste for the 2010/11 year rising by £8/tonne/year until at least 2013.

Generally it is easier to reuse commercial and industrial than household waste because the waste streams are larger and simpler. A cardboard box factory for example produces mainly cardboard off-cuts for which simple uses such as chicken litter can be found. Sainsbury generates 80,000 tonnes of mostly food waste which can go straight to a digester. Compare this to household waste which can include broken toys, old shoes, junk CDs, and broken china as well as more obvious items like paper and plastic bags.

This note concentrates mainly on municipal waste, all of which is deemed non-hazardous. About 90% of this arises from households with the remainder from small commercial properties collected by the same trucks. The specific goals for councils are (a) to divert the biodegradable waste, which

Type	Weight Mt	%
Household	30.5	9.3
Commercial	35.4	10.8
Industrial	42.0	12.8
Mining	96.9	29.4
Construction + Demolition	106.1	32.3
Sewage sludge	1.1	0.3
Dredged materials	16.6	5.0
Agriculture	0.4	0.1
Total	329.0	100

Table 1 Waste/year Sept 2005

makes up about 50% of the total (see Table 2), from landfill according the percentages above (b) to re-cycle or otherwise use as much non-biodegradable waste as possible to avoid the £48/tonne landfill tax and (c) to contribute to government targets to increase the weight recycled or composted to 30 and 33% by 2010 and 2015 respectively. In fact municipal waste reached 38.6% in the 09/10 year with a further 13.6% going to energy from waste (EfW) plants.

Being clear about definitions

Municipal waste was formerly the rubbish collected from households by dust carts and weighed at weighbridges at tips or incinerators. Later it included the weighed contents of bottle and can banks, waste paper containers and some of the increasingly diverse collections of cardboard, organic waste, oil, batteries, scrap metal, clothing, plastic bottles and so on. When calculating the percentage recycled or producing energy it is important to note the imprecision of the boundaries. Some high figures on the continent arise because municipalities collect more business waste than in the UK. here the collection of garden waste has helped the statistics greatly. Garden waste is biodegradable. *None* was collected before so the 100% skews the old figures. In 2007 one council's recycling rate jumped from 5 to 27% even though 'dry' waste (cans etc) recycling only doubled to 10%.

A further issue is that some recycled materials never pass a weighbridge. Milk bottles, for example, are collected, washed and recycled by dairies and this high rate of recycling is missed. Clothes can be recycled at jumble sales. Nearly new and car boot sales are missed. Householders who use empty jam jars to preserve garden fruit or empty containers in their



This machine takes plastic bottles and cans, sorts by bar code, and credits customers. See also P4

Type of household waste	% by Weight	Bio?
Garden waste	24.0	Y
Food waste	9.4	Y
Newspapers etc	6.5	Y
Other paper/board	11.9	Y
Plastics	7.1	N
Textiles	2.9	50%
Glass	6.8	N
Wood	4.1	N
Metals	7.1	N
Other	20.2	Some
Total	100.0	

Table 2 Composition of household waste

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workshops are 'recycling'. None is in the statistics.

A third problem is that recycling is a vague term. Many assume it means repeated use of the same material for the same purpose time and again like milk bottles. Much glass does go back into new glass, aluminium cans into more cans and paper into new paper and so on but in many cases all that happens is that a *second* use is found, often in a much lower value product. Much green glass for example is just ground up and used to replace sand in road surfacing, on golf course greens or for grit blasting. It is true that, when used as a flux in brick making, glass reduces the temperature needed to fire the bricks and so saves energy and, it is claimed, a better filter media in water treatment plants than ordinary sand, but a report published by Grant Thornton in June 2006 and a study by Arup both showed that grinding up glass for roads and filters generated *more* CO₂ than if dumped in landfill*. Paper is better. Recycling plants recover c. 80% of the incoming material, so paper is being recycled 5 times.

Fourth, recycling is universally done on the basis of weight because this is easy to measure. Weight is one reason why so much attention was given to glass which is heavy by volume. It would be just as logical to calculate percentages by volume and more logical to calculate on the basis of toxicity. For example the UK uses over 600 million batteries a year with a total weight of around 25,000 tonnes. This is a small percentage of the total weight of waste, yet batteries can contain cadmium, mercury and lead, all highly damaging to the environment. Happily battery recycling was boosted in February 2010 when stores selling batteries were required to take used ones back. 25% of household batteries should be collected by the EU directive date of 2012.

Lastly we should be aware that much waste is exported to developing countries like India or China where some will be dumped and some recycled without environmental control, for example where the PVC cover on electrical wire is burnt from the copper without regard to the toxic gases released.

Why was waste increasing?

Up to 50 years ago over half household waste came from ash from coal burning fires. Open fires are now rare but we are incomparably richer and inevitably buy extra goods. 50 years ago people darned socks, took shoes to be repaired, washed nappies and found handymen to repair equipment, sharpen knives and so on. Now labour costs have risen relative to manufacturing making it cheaper to buy new and throw repairable items away. Nappies, razor blades etc. are now sold as 'disposable'. 50 years ago people had few washing machines, TVs and so on. Now all kinds of labour saving devices and electronic gadgets arrive in cardboard boxes with polystyrene (more recently paper mache) protection. People own more clothes and women, particularly, consider them 'worn out' or 'out of fashion' sooner than before. Large quantities of food are left uneaten because this waste can be 'afforded'. Newspapers are larger because advertising has increased with wealth and the products on offer.

The change most complained about is the increase of packaging. 50 years ago grocers would have open bags of sugar, sultanas, rice and so on and shoppers helped themselves. Rising hygiene standards on the one hand and convenience on the other means much more food is pre weighed and pre packed. Second, much of our increased

wealth has come from 'economies of scale'. There are now fewer production centres but larger distribution networks so the average item travels a greater distance and needs more protection. One target has been plastic bags (though the 10 billion bags given away in 2008 only added 2 kg/year to a household's waste, less than 1% of the 360 kg of food which also goes). However, a charge of €22c a bag in Ireland has cut demand to a fifth of ours so UK stores, which are beginning to charge, could do much more. The sale of milk and cereals in simple bags also helps. The good news is that the weight of municipal waste has fallen 11% since the peak in 2006/7 and the amount recycled rises steadily.

Strategies: design

To go further and faster however we need a waste minimization strategy which starts at the product design stage, not when it is collected. Designers need to ask "how is this or that new product going to be re-used or disposed of when it reaches the end of its life?". Suppliers need incentives to offer 'easy to recycle' items. This means the *cost* of disposal should be included in the price the consumer pays as far as possible. The notion of 'paying up front' for disposal is not a new idea. The old deposit schemes for bottles provided an incentive for return in good condition. For larger items like domestic appliances or cars, purchase prices need to include vouchers to cover disposal, redeemed by the contractor managing the collection and recycling service.

Strategies: matching supply and demand

A second strategy is to reduce unnecessary variety. For example the UK is a net importer of green glass, much containing wine. Formerly the surplus was shipped to Brazil. Now much ends up as high quality but low value sand. The problem could be reduced, for example, if more UK bottled beer was sold in green bottles or if more short life wine was sold in clear glass bottles (dark glass reduces deterioration of wine in sunlight) or if brewers adopted a *standard* range of bottle sizes. Standardisation would allow whole bottles to be returned to any brewery, as in Germany and Canada, avoid the energy cost making new bottles from crushed glass and simplify deposit and return schemes. A 90% return of glass bottles was achieved in the Czech Republic with a deposit system. Standard sizes could be extended to all glass containers and all the EU.

Strategies: minimizing contamination

One often sees instructions at paper bins saying NO cardboard or NO yellow pages or, at can banks, NO foil. The problem is compounded for good citizens when, for example, some bins allow cardboard and others don't. When, after all, does thick 'paper' become 'cardboard'? Should jam jars be washed first (using energy) or not? Is a juice carton plastic or cardboard? (Plastic apparently). Contamination and confusion are real obstacles to successful recycling. Glass recyclers for example will reject whole loads because crockery is found. The problem with 'yellow pages' is the quantity of yellow dye used but a moment's thought makes it clear the yellow is unnecessary. Directories could retain the yellow cover or a yellow trim at the edge.

Plastics present a greater problem. Bakelite, cling film, detergent bottles, polystyrene and so on are all plastics, all made from oil, but cover a large range of chemical formulae. The humble milk container uses one kind of plastic for the

* Arup found making glass used 843 kg CO₂/tonne. Reusing, recycling, turning into glass fibre, used in bricks, and ground up for filter material saved 620, 314, 275, 66 and - 43 kg/t respectively. They pointed out Government should be concentrating on reduction and reuse rather than merely trying to push the % recycled up.

bottle and, until recently, a harder one for the top, and another for the label. The label needs glue and the empty bottle may contain some milk, so this one item contains 4-5 different materials. Lumping all plastics together and melting them down will produce a 'goo' suitable for garden gnomes and fence posts but not, for example, new milk bottles.

The American Society of Plastics Industries has a scheme, set up in 1988, in widespread use worldwide. This sub-divides plastics into 7 main groups with items marked with a rounded triangle symbol, a number (1 to 7) inside and letters beneath. 1- PET is typically used for clear drink bottles; 2- HDPE, for opaque food and other food containers; 3- PVC, for a range of building materials, such as gutters, and cling film; 4- LDPE, for plastic bags; 5- PP, for rigid containers such as yoghurt pots; 6- PS, for foam packaging and lightweight rigid trays; 7- for other plastics**. All have a market value. All can be recycled, though contamination, for example through colour, may mean the second use is of lower value than the first. The UK is pressing to make this system (or something similar) adopted across the EU. Plastics recycling faces 2 problems however. First markets are still limited. Second, because plastic generally and plastic containers especially are light, the energy used transporting large volumes is high.

Re-using paper is easier. Though better quality paper contains large quantities of potential contaminants such as china clay as well as ink, most newsprint ink comes from vegetable dyes and, when the paper is processed, both ink and clay can be disposed of as 'soil conditioner' with the fibres reconstructed for newsprint. Most newspapers are now printed on recycled paper. Had the inks been toxic (as some are) this would have been impossible - a good example of considering the 'second use' at the 'first use' stage. Japan claims to recycle all paper.

Strategies: expanding markets

Having sought first to make products re-usable and second to minimise contamination, the third key strategy is to develop markets which can use the recycled material. The creation of WRAP, the Waste and Resources Action Programme, was one of the Labour government's better initiatives. Established in April 2000 as a Government funded non-profit making agency its job is just this: to find new markets for the different waste streams. WRAP searches for uses, funds research, brings partners together and looks at supply chains. One initiative was to separate out food and garden waste and compost or digest them. (Composting is an aerobic (in air) process, digestion an anaerobic (no air) process. Digestion reduces the volume by 20% and produces methane for electricity). Both produce fertiliser. For some time growers were reluctant to use this fertiliser (which needs minimum concentrations of the nutrients nitrogen, potassium and/or phosphate) because they had no guarantee of what it contained. WRAP, working with the main players, agreed technically exacting modes of processing and set up a certification scheme. Two thirds of all recycled waste fertiliser was certified in 2005 and has been accepted by prestige growers such as RHS Wisley.

The twin issues of seeing new markets and helping to develop them, with technical and financial support and tight

standards, is important. It is now possible to crumb tyres for use as carpet underlay as well as use them whole for coast protection. The market for recycled aggregates has grown rapidly because standards have been agreed. Aggregates were the major reason for a rise in recycled materials from 1.8 to 2.5 M tonnes between 2003 and 2004 and 69% of all construction and demolition waste is now recycled. Even so recycling is not cheap. Until early 2008 the value of recycled materials was sustained by China who imported large tonnages. Councils could offset the cost of collection and sorting through sales. The global recession cut demand and prices. (Mixed plastic fell from £200/t to nothing in autumn 2008) so much waste had to be stored - a double whammy for the council taxpayers. Happily the market is improving.

Why recycle?

Hitherto recycling has been pushed in the belief that the UK is running out of landfill sites though this is a subjective view. We also fear we are drawing down the planet's resources but this is only true in limited fields. Paper can be produced, wool grown on sheep and cotton in fields for ever. There is no shortage of iron ore or bauxite (for aluminium) or sand for glass. The real threat to the planet comes from over reliance on fossil fuels and the *dominant* reason for recycling should be to reduce the *net* energy needed to make the goods we use.

Recycling itself uses energy in collection, sorting and treatment. There comes a point where the energy used to recycle is *greater* than producing the product in the first place. The notion that *all* waste should be recycled is not sensible. Although FoE has campaigned for 'at least' 75% recycling a more realistic target is probably 60%. In Europe the Dutch do best at 64% but eco-conscious Denmark and Sweden recycle only 41% of municipal waste and incinerate over 50% and over 40% respectively. Furthermore one cannot logically support wood burning power stations and *oppose* burning waste paper in an EfW plant. It is true incineration of any kind produces dioxins, a fraction of which are carcinogenic, but it is rarely noted these amount to 0.5% of those produced in the UK with *60 times as much* arising from fireworks and accidental fires.

The option of incineration does not mean regressing on recycling. It does mean that the decision to recycle or not should be based on *energy* saved.

Separating the waste streams:

Although Table 3 divides household waste into 10 categories, much is mixed. For example items are often sold in boxes with a cardboard back and perspex front. Even so there are some obvious rules. First glass should be returned as whole containers where possible so they only require washing. They should not be incinerated as they have no energy value. This is true of metal, including items like washing machines, and especially aluminium whose production emits 9 tonnes of CO₂/tonne of metal. It is true too of anything inert, such as rubble. Food and garden waste should be composted or digested to produce methane and fertilizer.

This leaves paper and wood products, plastics and textiles, and all kinds of mixed up waste that is not easily separated. Paper can be either recycled or incinerated. For a long time most household waste paper was used to light coal fires but this is no longer so. In 2005, of the 12.7 M tonnes of paper and card used by households, commerce and industry, only

** 1. PET polyethylene terephthalate 2. HDPE high density polyethylene
3. PVC polyvinyl chloride 4. LDPE low density "
5. PP polypropylene 6. PS polystyrene
7. Other, mostly polycarbonates

4.6 Mt were recovered and of this 1.7 Mt had to be exported. Where the energy 'break even' point occurs is not clear. Paper requires logging, transport to pulp mills, and processing including bleaching. If the energy used for this is A and the energy *reclaimed* through incineration is B the net energy consumed using raw materials is A-B. Recycling needs to use less than A-B to be environmentally superior.

Of the other items, wood is difficult to recycle and the markets for plastics, textiles and much of the 'other' still need to be developed but will always be limited.

Collection systems:

A point implied above is the importance of minimising the energy used in *collection*. If a household has to make a long detour to drop off, say, cans or cardboard the fuel used by their car may *exceed* the energy saved by recycling. Similarly doorstep collection systems which send different vehicles for glass, metal, paper and general rubbish may improve collection but use more energy in the fuel.

There is a further dilemma. If households are required to sort their waste they will make mistakes. The more complicated the rules, the more mistakes made. Pepsi cans look like other aluminium drinks cans but are in fact made of steel and many 'cans' are now made of plastic. How brown does a greenie-brown wine bottle have to be before it goes in the brown glass bank? Some households will cope better than others. Slowly the better collection schemes are becoming clearer. First 'drop off points' need to be sited where people go often, such as major supermarkets, so journeys to distant recycling centres are avoided. (A brilliant scheme has been seen in a Montreal supermarket (picture on front page). Containers and cans are fed into a machine which reads the *bar code*. This tells the machine what the item is and allows it to divert it down one of several chutes for compaction to reduce its volume. At the end a receipt is printed out for the customer to redeem at the checkout). Second, door step collections will increase the volume sent for recycling, the best option being one box for paper and a separate box for 'all other recyclables'. This is because sorting machinery is improving all the time and 'all in' boxes reduce the risk of householder mistakes and transport costs. Alternatively, where MBT (Mechanical and Biological Treatment) is available all waste can be taken in bulk where the organic matter will go for digestion; recyclables for reuse; inert matter for landfill; and the rest, called Refuse Derived Fuel (RDF) or Solid Recovered Fuel, for incineration. Ideally the recyclables would be used by on site factories, with the incinerated fraction and methane from digestion used for local heat and power.

We should be wary of 'pay-as-you-throw' schemes. Bar coded, lockable, wheelie bins sound fine in theory but the cost will impact on large families and householders will reduce costs by burning waste on open fires, driving to a tip, flushing stuff down the toilet and taking rubbish to work. Fly tipping will increase. None will be an environmental gain.

Energy from waste:

Historically incineration was a dirty but easy way to reduce the volume of waste. A great technical success of the last 50 years has been improvements in air quality using the Clean Air Acts with the adoption of smokeless zones and ever tightening controls on factory emissions. Incinerators now meet exacting standards and many act as CHP plants.

Several cities worldwide have tried a more complicated (and thus more expensive) but cleaner process known as pyrolysis (or pyrolysis with gasification). The waste is heated in the absence of oxygen. This injection of energy breaks down the hydrocarbons in the waste to simple gases on the one hand and a carbon 'char' on the other (plus any inert materials or metals not extracted previously from the waste stream). In the second stage, the char is combined with air and steam to produce hydrogen and carbon monoxide (the old 'town gas' mixture) leaving ash. The gases released from the first and second stages are burnt in a third 'oxidation' stage, at temperatures above 1200 °C (high enough to destroy virtually all organic pollutants and particles) to produce steam for electricity generation and/or heat. Unhappily pyrolysis has not proved to be commercial, though research continues. It has not been possible to maintain the minimum calorific value necessary in the incoming waste. On the other hand a company called Sterecycle was asked to double a working 100,000 tonne/year plant at Templeborough, Rotherham in January 2009 and received planning permission for another at Wentloog near Cardiff in July 2009. Sterecycle put 'black bag' rubbish (household waste after most recyclables have been taken out) into autoclaves with pressurized steam. The 50% or so of organic matter gets concentrated into a biomass fibre (sterefibre) leaving c. 20% clean glass, plastic, textile and metal recyclables and 30% for landfill. Sterefibre can be burnt, act as soil conditioner, or made into cardboard boxes. Costs are not known but sound expensive. Tragically a fatal accident occurred at Templeborough in January 2011 which will put back development.

Conclusions:

Helped by the accession of 12 new entrants the UK is halfway up the EU recycling table for municipal waste, up from 6% recycled in 1999 to 38.6% in 09/10.

Neither recycling nor incineration is as cheap as landfill and it is probable the landfill tax needs to be even higher than now to allow recycling to compete freely in the market.

The key conclusions are that we must think much more about reuse or disposal at the *design* stage and provide *incentives* for good design. Also that waste strategies should be based not on maximising recycling (because this is somehow 'good') but on *minimising energy use*.

There are 3 other important conclusions. First there are a multiplicity of collection strategies*** and even the most conscientious consumer can be confused. It is time to produce simpler guidelines.

Second, we must not underestimate the amount which needs to be done to find markets for recyclables. The market will not do this by itself. WRAP and others need resources to increase recycling opportunities.

Third, though recycling will not itself alleviate our main environmental challenge, global warming, an intelligent (not hectoring) campaign of education has the potential to change the public's mindset from a 'who cares' to a more thoughtful concern for the planet. This must be a good thing.

*** At end 2007 Marks + Spencer paid for 5 solar powered rubbish bins in Bournemouth. These crush the rubbish, compacting it by 8 times, and when full 'ring' the depot so that they can be emptied.