POTENTIAL MARKETS FOR RECOVERED PLASTICS

RESEARCH CARRIED OUT BY ENVIROS

AND FUNDED BY THE

JUNE 2002

CONTENTS

NOTE: Information on Engineering Thermoplastics is contained in the companion report on Waste Electrical and Electronic Equipment (WEEE)

SUMMARY

There are many market opportunities for recycled plastics. These markets tend to be aimed at using low value mixed plastic wastes to produce products that are price competitive with products made from virgin materials.

In the UK there is the expertise to recycle plastic and recover value from plastics. However the reprocessing market has not developed the more sophisticated recycling technologies which are available elsewhere in Europe and North America. It appears this is because of the relatively low value of virgin polymers which has prevented development of high cost recycling ventures so far in the UK.

>From this study the current estimate on plastic waste arisings in London is 370,000 tonnes p.a. (240,000 tonnes from households and 130,000 tonnes from commercial and industrial sources). The quantity of waste plastic arisings in London is projected to rise from 370,000 tonnes p.a. to between 400,000 and 420,000 tonnes p.a. during the next 5 years.

The survey showed that the London area appears to be poorly serviced by reprocessors of polyethylene (PE) and polyethylene terapthalate (PET). However the whole of the UK reprocessing industry appears to be under supplied. Reprocessors from outside London and those operating independently are those most likely to take PE and PET collected from the London area. There appear to be several PE reprocessors in the UK with spare capacity to handle clean and contaminated PE.

Several larger reprocessors have shown interest and offered support to work with London Remade to develop collection depots to increase the collection of particularly, PE from the Thames Gateway area.

The research reached the following conclusions on the markets for PET recyclate:

- The market for recycled PET is generally regarded as being limited by supply.
- There is excess reprocessing capacity in the UK and a healthy European and world market.
- Most recovered PET in the UK is used to make fibre for the textile and carpet industry as well as being used in some non-woven applications.
- Plastic bottles are the major source of PET recyclate. In general, sales of plastic bottles are forecast to increase as plastic gains market share from both glass and light metal especially in the alcohol sector. PET bottles can be recovered for use in the re-manufacture of bottles.
- The use of PET woven and tufted carpets is widespread and the market is currently stable, though the carpet use has been declining in favour of other floor coverings. PET sold into the carpet industry comes from virgin and recovered sources, but it appears that the industry judges the spun fibre on price and quality, ignoring the source of the raw material.

In comparison the findings on the markets for high density PE (HDPE)

recyclate in London where the research focused upon opportunities for substituting secondary raw materials for virgin HDPE in plastics manufacture in East London. This objective will be challenging as only a limited number of existing businesses use HDPE (at most 5% of the manufacturers using plastic that were identified used HDPE). Further, most businesses interviewed were not at all receptive to even considering secondary raw material use and most did not require any further support (whether that be financial or in terms of information).

Finally, research into the markets for wood polymer composite (WPC) engineered lumber found that the UK market for timber and joinery and for fencing and decking is forecast to continue to expand over the next four years. The market for new housing is also forecast to increase and this is one of the key indicators of construction growth.

WPC lumber is manufactured to a small extent in the UK, whilst the USA has seen a healthy growth in the markets for this product. In the USA several companies make this product, of which are Strandex and AERT are the most interesting propositions. Strandex is interested in licensing their technology or setting up facilities to produce WPC lumber in the UK. The current markets for these products include decking and landscape products, but other markets such as street furniture, containers and other joinery products could be developed.

The major wood suppliers and distributors are key to establishing an UK market for the WPC timber products, and may consider working in partnership.

SUMMARY OF MARKET OPPORTUNITIES

Polyethylene Terapthalate (PET)

What is PET used for?

Virgin PET is a very common plastic in today's society. It is typically used to package consumer items such as soft drinks, water, beer, mouthwash, peanut butter and salad dressing, and for oven-proof film and food trays. Other uses include chemical drums, carpeting, and pipes and tubing for gas, water, etc.

The variety of applications for the use of PET is wide-ranging because of the properties it possesses, in particular its strength, toughness and transparency. It is a barrier to gas and moisture and resistant to heat.

Packaging uses are likely to remain the main use for virgin PET. Indeed, the volume of PET used continues to increase as more products are being packaged in this polymer.

Recycling PET

PET recovered from the waste stream is sorted from other polymers and by colour either manually or through optical sorting technology.

The recycled PET is either:

- flaked, washed and extruded into a pellet; or
- cracked back to a monomer and rebuilt into a polymer.

Currently, if recycled PET resins are to be used in "food contact" containers, they must either be added into the packaging as a sandwich layer, between two layers of virgin polymer - this is known as "multi layer" technology or be processed back to a monomer and rebuilt into a polymer.

UK consumption of PET far outstrips collection and recycling rates.

Area	Estimated Plastic Bottle Market Size, tonnes in 2000	Estimated Tonnes of PET and in the household waste stream, 2001	Estimated tonnes of PET Collected, 1999
London	52,000#	40,000#	400#
UK	430,000*	300,000#	3,000# (11,300 tonnes* plastic bottles collected - PVC,PET & HDPE)

#Enviros; see section on estimated current and projected plastic waste arisings in London.
*Source; Affordable Plastic Bottle Recycling, Recoup, 2000

Current markets for recycled PET in the UK

Recycled PET is used in the manufacture of polyester fibres and fibre fill in home furnishings, duvets, clothing, carpets and other textiles. Fibres are ideal use for recycled PET because they require less expensive grades and processing than other end uses.

The market for recycled PET in plastic packaging

In general, sales of plastic bottles are forecast to increase by 15% in real terms between 2000 and 2004 as plastic gains market share from both glass and light metal. This represents a significant opportunity for use of recovered PET.

The market for recycled PET in carpet manufacturing

The UK carpet manufacturing industry is a significant user of PET. Although the industry has declined in recent years, it still has considerable market - £1.64 billion in 1999. PET is predominantly used in tufted carpets that are produced by all the major carpet manufacturers using the melt bond process. PET can also be woven with wool or polypropylene to form carpets for special applications. PET is a useful polymer in carpet manufacture as it is less resistant to flattening than some fibres, and it wears well.

Future markets for recycled PET in the UK

There are significant opportunities to used increased volumes of recovered PET. Future market expansion for recycled PET in the UK includes:

- Plastic drinks bottle manufacture;
- Increased use in carpet manufacture;
- Strapping and unwoven fibre.

Plastic drink bottles: Using recycled PET in plastic bottle manufacture is of particular interest because current production of drinks bottles in the UK makes use only of virgin polymers. The use of recycled PET will have to be commercially competitive with the use of virgin PET. However, the industry is dominated by multinational companies whose corporate policy and shareholder pressures are driving them towards the greater use of recyclate in bottle manufacture.

Carpeting: Currently, the PET sold into the carpet and fibre industry is from both virgin and recovered sources. The industry tends to judge the spun fibre on price and quality, rather than the source of the raw material as manufacturers do not use the recycled content of the finished product as a selling point.

Strapping and unwoven fibre: The largest emerging markets for recovered PET are in the manufacture of strapping and unwoven fibres.

All these markets are promising. There is currently a far larger demand for recovered PET than supply currently available in the UK.

Market price for recovered PET

The price of recovered PET is dictated by the current price of virgin PET. Current prices suggest that flaked PET recyclate ranges from £400-500/tonne compared with prime virgin PET of approximately £700-800/tonne.

What London Remade can do to support more recycling of PET

London Remade is interested in establishing viable PET collection systems to

increase the amount of PET recovered from the waste stream in London and to support the development of new and expanded business opportunities for using recycled PET.

High Density Polyethylene (HDPE)

What is HDPE used for?

Virgin HDPE is a plastic with many uses. In particular it is used for packaging products having a short shelf-life and for chemicals with both industrial and household applications. HDPE is used in both unpigmented and pigmented forms. In its unpigmented form, HDPE is typically used for milk, juice, water and laundry product containers. In its pigmented form, it is used for margarine tubs, yoghurt containers and for bottling detergents and bleach. Pigmented HDPE bottles generally have better resistance to stress cracks and chemicals than bottles made from unpigmented HDPE.

The variety of applications is wide-ranging because of the properties of HDPE - stiffness, strength/toughness, resistance to chemicals and moisture, resistance to permeation by gases, and ease of processing and forming.

Recycling HDPE

Recycled HDPE also has many uses. Examples include liquid laundry detergent containers, drainage pipe, oil bottles, recycling bins, benches, pens, kennels, vitamin bottles, floor tiles, picnic tables, timber, fencing and industrial containers.

The main post-consumer source of HDPE in the UK is extracted from household waste via kerbside collections and bring-back banks. This plastic waste is generally in the form of “blow-moulded” packaging.

HDPE recovered from the waste stream is sorted from other polymers and by colour either manually or through optical sortation technology. The recycled HDPE is either:

- flaked, washed and extruded into a pellet; or
- cracked back to a monomer and rebuilt into a polymer.

UK consumption far outstrips collection and recycling rates.

Area	Estimated Plastic Bottle Market Size, tonnes in 2000	Estimated Tonnes of HDPE in the household waste stream, 2001	Estimated tonnes of Post-Consumer Recycled PE includes HDPE & LDPE, 1997
London	52,000#	30,000#	1,200#
UK	430,000*	300,000#	10,000# (11,300 tonnes* plastic bottles collected - PVC,PET &HDPE)

#Enviros; see section on estimated current and projected plastic waste arisings in London.
*Source; Affordable Plastic Bottle Recycling, Recoup, 2000

Markets for products made from virgin HDPE in the UK

More than 0.5 million tonnes of virgin HDPE is consumed annually in the UK.

The main market for virgin HDPE in the UK is in blow moulded products, typically used for consumer packaging. This sector represents about half of the total HDPE consumed in the UK.

The second largest market is for extruded HDPE film and for pipe and conduit manufacture. Combined, these uses represent about a third of the total UK demand for HDPE. While the market for HDPE film has decreased in recent years, it is still a significant consumer of HDPE in the UK. The market for HDPE in pipes and conduit has seen a steady increase of about 4% per year.

Future markets for recycled HDPE in the UK

Potential future markets for recycled HDPE in the UK are to replace the use of virgin HDPE, particularly for non-food contact applications, such as in the manufacture of pipes and conduits.

A survey of small manufacturers of plastic products in the Greater London area showed that the main barriers for using recovered HDPE and other recycled plastics are:

- the quality of the recyclate; and
- the quantity available.

Many manufacturers in Greater London report that the recovered plastics available are of poor quality. This results from improper processing of the recovered materials, or lack of adequate sorting of HDPE to remove contaminants including other polymers. Also, despite the price of recovered plastics being lower than virgin plastics, the supply is irregular. Thus, experience has shown that it is still easier and less time consuming to use virgin supplies.

The opportunity to increase the use of recovered HDPE in the UK

Currently, there is a wide gap between the supply of, and the demand for recycled HDPE in the UK.

London Remade is interested in supporting the significant opportunities that exist to supply the existing HDPE recycling infrastructure in the UK by extracting more HDPE from the waste stream in London. The key issue is to produce significant quantities of recyclate of a more reliable quality than currently exists.

Wood Polymer Composite - using HDPE and LDPE

Multi-national timber corporations have developed an engineered lumber product that:

- uses virgin wood supplies more effectively;
- takes advantage of available wood and polymer waste;
- has less impact on the environment.

WPC is made from wood waste and plastics recovered from the waste stream. WPC compares favourably with wood because of its excellent moisture resistance, wear characteristics and low maintenance requirements. As with wood, the engineered lumber can be primed, painted, stained and covered with laminate or vinyl cladding.

What is Wood Polymer Composite (WPC) Engineered Lumber used for?

In the US, WPC engineered lumber is commonly used as a timber substitute mainly in external and non-structural applications. The most prominent products using WPC include siding and roofing shingles, window sills, door-jams, fence posts, decking and walkways.

In the UK, the main opportunities for WPC engineered lumber are decking, fencing, landscaping products, and some external joinery uses such as window sills and door jams.

How is WPC engineered lumber made?

Depending on the end use, creating a WPC product requires wood material either in the form of a finely ground powder (generally known as wood flour) or in the form of wood particles. The specification of the recovered wood material varies depending upon the final required strength. The production process can vary, but it generally uses equal amounts of polymer and wood which are bound together by melting the polymer to encapsulate the wood material.

Recovered materials specification

The recovered wood material needs to be dry. Suitable wood is available from many sources such as production waste, processed pallets and extractions from the industrial and domestic waste streams.

The recovered polymer material needs to be clean. Low density polyethylene (LDPE), is the resin used most frequently.

The market for timber and joinery in the UK

The UK timber and joinery market is thriving, and manufacturers' selling prices show that it is currently worth more than £10 billion. (source: Keynote Report) The market includes timber processing, semi-finished, and finished wood products. The construction industry is the main consumer of these timber and joinery products. As building in the new housing sector continues to grow over the next few years, this bodes well for the future of the timber and joinery industry. Keynote predicts the timber and joinery market will grow by more than 10% over the next three years.

The market for street furniture in the UK

Street furniture is a diverse sector with a wide customer base including the construction industry, commercial and residential property companies and local authorities. The UK market for street furniture is of the order of £250 million per year. This includes benches and bins to advertising board and signage.

The current situation

While WPC engineered lumber is manufactured and used successfully in the US, the UK market for WPC products is under-developed.

There are several companies that operate in the WPC engineered lumber market in the US. Initial discussions with some of those companies have revealed interest in forming partnerships - such as technology licensing - so enabling them to enter the UK market.

There are several companies in the UK that process plastics recovered from the waste stream. There are also many companies with experience in collecting and processing waste wood. In addition, the timber and joinery market has shown healthy growth in the UK over the past few years.

The opportunity

With the proven technology available and a strong market in the UK, there are clear opportunities to develop and market wood/polymer products and London Remade is interested in supporting them.

RESEARCH FINDINGS - HIGH DENSITY POLYETHYLENE (HDPE), LOW DENSITY POLYETHYLENE (LDPE) AND POLYETHYLENE TERAPTHALATE (PET)

Potential Uses for Recycled Plastic Waste

Street Furniture

Recycled plastic can be used to make chevrons, motorway markers, hazard markers, footpath signs, as well as fencing (posts and panels), snow poles and traffic bollards.

Example - in the USA, the Federal Highway Administration has approved the use of a guard-rail offset block made of 100% recycled plastic and wood. Although the product's initial cost is higher than for conventional block material, it is believed that the post will resist damage and deterioration better than the conventional material, so reducing overall longer-term costs.

Roofs & Floors

Recycled plastics may be used in a variety of ways as components of both roofs and floors, such as in roofing shingles and tiles, and floor tiles. Recycled plastics can also be used as a constituent of cement to form a flooring material. This market has not grown as expected in the USA because of problems experienced when installing these products and the requirement to use specialised equipment.

Plastic Lumber

Plastic lumber is a generic term given to plastic and wood substitutes made from post consumer or industrial scrap plastic. One or more plastic resins may be used, together with various additives for colour, strength and density reduction.

There are two major manufacturing methods.

- The first is continuous extrusion in which the molten plastic is passed through a die and then cooled by a water spray or bath.
- The second is moulding in which the molten plastic is extruded into a mould and then cooled in the mould. Advantages are in weight saving, and thicker, heavier profile production that may be more forgiving of dirty or inconsistent feedstock.

Plastic lumber can be used for domestic and public purposes, for example for signposts, fences, pilings, piers, bulkheads, sea walls, boardwalk decking, and pier impact protectors and railings.

- At least two UK companies, including Environmental Polymer Products based on Merseyside, make a variety of products from plastic lumber, using recycled plastics mainly from industry rather than household origin.

Plastic Piling

Structural plastic piling may be used for bank retention systems for rivers, drainage and reservoirs, and bank restoration and consolidation schemes. Organisations that have recently used plastic piling in a variety of applications include the RSPB, the World Wildlife Fund, Environment Agency and the Forestry Commission.

Aggregate in Asphalt Concrete

There is a wide range of research on the use of recycled plastics in highway construction. This application considerably extends the life of an asphalt pavement, leading to reduced maintenance and reconstruction requirements. As a consequence, life cycle costs of highway and airfield pavements constructed with the binder are suitably lower.

- Two hot processes utilise recycled plastic as a bitumen additive. Novophalt (Baden, Austria) and Polyphalt (Toronto, Canada), are both processes that use recycled low-density polyethylene resin.
- Typically the recyclate for these processes are obtained from the general waste stream. The recycled plastic is made into pellets and added to bitumen at a rate of 4-7% by weight of binder (0.25%-0.50% by weight of total mix).

Geosynthetics

Geosynthetics covers a broad range of plastic products utilised in ground engineering applications, some of which could incorporate recycled plastic.

For example, recycled plastics have been used in Japan for slope protection and shore erosion protection. In the UK, Severn Trent Water has incorporated the use of 'ecoblock' in a number of schemes. Ecoblock provides a soft/hard landscaping system providing grass protection within a durable plastic grid that withstands heavy vehicular traffic. Ecoblock is manufactured from recycled polyolefin-based materials.

Noise Barriers

Recycled plastics are also used in a low cost noise barrier, designed to absorb noise, developed by Acoustic Materials Technology Ltd for use in domestic or commercial situations. In addition a company in Nevada, USA, is marketing a noise wall that works by both reflecting and absorbing noise; it contains recycled plastics together with recycled rubber tyres.

Panels for Cladding & Decoration

Recycled plastic can be used as an alternative to chipboard for panels for interior decoration. The product is aesthetically pleasing and is tough and durable.

Insulation Foam

The use of recycled PET as insulating foam in the construction industry is being developed.

Packaging

British Polythene Industries (BPI) has been recycling over 20,000 tonnes per year of polyethylene, predominantly LDPE, from several sources mainly shop backdoor waste arisings and agriculture films. The recycling process is the same no matter the source, however contamination and other factors impose economic and technical restraints, not least the great variety of plastics used and the problems of storing, handling and transporting very low density, flammable materials.

Figures vary depending the weigh of the packaging, but it takes approximately 20,000 two-litre PET drinks bottles or between 120-300,000 LDPE plastic carrier bags to make up 1 tonne of recyclate. Despite these difficulties, baled quantities of crushed clean containers, separated by plastic types, can be saleable. They are used for new food packaging (using a 'sandwich' of reclaimed material bonded to a barrier film of virgin material); non food packaging products which will tolerate trace contaminants, and products such as carpet fibres and thermal clothing.

A more economic use for low-value soiled packaging films and carrier bags may be as a boiler fuel, as these products tend to be made from PE, which has a very high calorific value (similar to petroleum) and burns reasonably cleanly. However, there is a potential for contamination with plastics containing chlorinated compounds, such as polyvinyl chloride (PVC) which present an environmental hazard; partly because of additives which they contain which can leach out, and because, if burnt at low temperatures, they can produce toxic chlorine compounds. Plastics potentially contaminated by PVC and other chlorinated products should only be incinerated at a plant with full emission control at a temperature exceeding 850C with 6 per cent oxygen for a minimum of 2 seconds retention time. Energy recovery from plastics, particularly in Japan, has encountered difficulties resulting in pollution incidents causing harm to human health and the environment.

Bins & Boxes

Linpac Environmental are producing a series of home compost bins, kerbside collection boxes and street furniture made with recycled hard plastics, generally HDPE. Local authorities can purchase these products with certification stating minimum percentage of post-consumer recycled material used in their manufacture.

Automotive Plastics

Plastics used in the car industry have risen from 70kg per car in 1977 to 100kg in 1997. Today almost 10% of the weight of an average car is accounted for by plastic components. According to the British Plastics Federation (BPF), "105kg of plastics, used as a replacement for metals, in a car weighing 1,000kg could make possible a fuel saving of up to 7.5%".

The most common automotive plastics are Polypropylene (PP), PE, Polyurethane (PU) and PVC.

- PP is most abundantly used, accounting for up to 40% of all car thermoplastics. Applications include bumpers, wheel arch liners and dashboards.

- PVC makes up about 12% of the thermoplastic content of an average 1990's European car. (*Source: Waste watch Information sheet: car recycling*).

Other Applications

Other uses of recycled plastics include cable ducting and pipes, carrier bags, insulation foam, landfill drainage and panels for cladding and decoration. Products made from recycled plastic may have substantial advantages over traditional materials such as woods and metals. Recycled plastics do not absorb moisture, bulge, splinter or de-laminate, require painting or require release agents. Further, they are lightweight, maintenance-free, resistant to rot and corrosion under normal conditions, available in a variety of colours, and economical. Examples include (*Source: Recoup*):

- Industrial Pipe, using durable and rigid plastics like HDPE and PVC.
- Garden Products, using HDPE, LDPE and PP.
- Miscellaneous - refillable notebooks and photo albums, lampshades and children's furniture from recycled bottles. The polymers used tend to be commonly available recovered plastics such as HDPE, LDPE, PP and PET

Potential Uses for Polyethylene Terapthalate (PET)

Staple Fibre

75% of the recovered European PET is used to produce polyester fibres. Reprocessed flakes are melted and spun into strands - the length and thickness of the fibre determines the products made. Fibre lengths from 5mm to 150mm are termed "staple grades" and are the largest single market.

Larger diameter fibres fill anoraks, sleeping bags and soft toys. Recycled PET is also used to spin smaller diameter fibres. These can be woven into fleece fabrics for products such as jackets and scarves. Such fabrics can contain over 95% and up to 100% recycled content, typically "recycled" fleece jacket uses 25 PET bottles.

Polyester fibres are being engineered to provide the same qualities as upholstery foams - 35% recycled content has been introduced to these advanced hollow "conjugated" polyester fibres.

Packaging Applications

Egg cartons and other "formed containers" account for some 8% of recycled PET usage. PET containers for toiletries and household products are able to "close the recycling loop" because bottles using a percentage of post consumer PET are being introduced in growing quantities. Typically for food contact containers the recovered PET is added into the packaging as a sandwich layer, between two layers of virgin polymer - this is known as "multi layer" technology. Manufacturers predict multi-layer bottles can contain at least 50% recovered PET. Single layer containers can use even higher quantities of recycled material than this. All these containers remain recyclable.

Multi-layer soft drink bottles using recycled PET are on sale in a number of countries, including Switzerland and Sweden.

Industrial strapping can make use of high quality recycled PET flake. This is more common in the USA than in Europe.

New Applications

Emerging markets for recovered PET include (*App2. Ref 1*):

- Polyurethane foams made by producing polyester polyps from PET flake;
- Engineering resins developed from recovered PET injection moulded to manufacture some computer and automotive parts;
- "spunbonded" PET in the manufacture of shoe liners, webbing, geotextiles and rucksacks;
- foamed PET.

Table 1 shows the data provided by PETCORE the European PET recycling trade association. The data shows the 2000 and predicted (2002) market size for products containing PET and amount of PET recyclate used by that market.

Table 1 Current and Predicted Size of the European Market for PET

End Use Market	**Total market size in '000 tonnes (includes virgin)**		**% Penetration with Recycled PET**		**Tonnage in '000 tons of recycled PET used**
Year	**2000**	**2002**	**2000**	**2002**	**2000**
Fibre - staple	474	540	15.0	35	71.0
Food contact containers	1111	1311	4.5	25	50.0
Non food contact containers	217	232	3.2	10	7.0
A - Sheet	125	180	14.4	20	18.0
Strapping	37	57	21.6	50	8.0
Injection Moulding	94	100	5.3	10	5.0
Polyols	21	30	9.6	25	2.0
Foams	ND	ND	ND	ND	ND
Chemical recycling	ND	ND	ND	ND	15.0
Totals	**2079**	**2450**	**8.5**	**25**	**176**

ND = NO DATA *Source: PETCORE*

Other Forms of PET

There are several newer forms of PET that have been designed to meet the specific needs of certain industries. New and coloured plastic resins can contaminate existing recycling processes unless segregated for separate recycling. Currently, there is no data on the volumes of these new resins on the market, however it is expected the market for these materials will expand. Some of the forms currently available are discussed below.

Coloured PET

Some colours of recovered PET have a market if segregated and mixed colours may find some application where colour is not important criteria. In

the UK the preferred coloured forms of PET are clear and light blue, used mainly by the drinking water market.

Napthalates

Napthalate based resins extend the performance of polyesters in certain engineering applications. The use of naphlates improves the thermal, mechanical and barrier properties of polyesters enabling them to compete more effectively with other high performance polymers.

- **Polyethylene napthalate - PEN**

  This plastic resin is used to produces bottles that are lightweight, clear, break resistant and have a high degree of barrier protection against oxygen, ultra-violet and moisture. Typically PEN is used for hot-fill foods. This is currently only a small market in the UK, but the market size is expected to increase as plastic replaces glass in the hot-fill (jams etc) and other industries

- **Polytriethylene Napthalate - PTN**

  PTN has potential applications in barrier films and packaging, but this use is not common at present.

- **Polyethylene Terephalate, Glycol modified - PETG**

  PET has two main properties; strength and resistance to permeation by certain gases - carbon dioxide can't get out, but oxygen can get in. This is not ideal for drinks containers so a lining of another polymer is made inside the PET container. This is where the "G" for glycolate comes in as this is used as a lining, being more transparent and making the overall bottle stronger

  PETG is commonly used in medical packaging because of it's resistance to gamma radiation which required for the sterilisation process for pharmaceuticals. It has also found application in retail packaging where extreme impact resistance is required and for use by the drinks industry to bottle fizzy drinks.

  PETG can cause reprocessing problems because it has a different melt temperature when compared to PET.

Plastic Processing Techniques & Technologies

There are 3 main routes for plastics recycling and recovery:

Mechanical Recycling:

Mechanical recycling takes advantage of the fact that plastics soften on heating and can be reprocessed into new plastic products.

For mechanical recycling to be successful the source material must be pre-sorted, because there are so many different varieties of plastics with different properties.

Feedstock recycling (or chemical recycling)

Feedstock recycling involves breaking polymers down into their constituent monomers. This process can be used in refineries or petrochemical and chemical production. Unlike mechanical recycling this technology does not require pre-sorting of the plastics. A range of feedstock recycling technologies are currently being explored and including;

- pyrolysis
- hydrogenation
- gasification
- thermal cracking

Feedstock recycling of PET can use different processing methods to HDPE and LDPE. There are five potential methods of purifying PET from the waste stream. The first two, glycolysis and methanolysis are unable to remove colours added to PET feedstream during original formulation, and therefore require additional purification steps (*App2*. Ref 2).

- **Glycolysis**

  Reaction of recovered PET with excess ethylene glycol under pressure at around 200℃ reverses the polymerisation reaction. The end products can be purified under pressure to remove physical impurities and treatment with carbon to remove chemical impurities.

- **Methanolysis**

  Treatment of PET with methanol, under pressure at around 200℃ results in depolymerisation. One end product can be purified by distillation and crystallisation to give a high quality intermediate, which may be used to make new PET. The other end product is ethylene glycol which may be used for a variety of applications including antifreeze and PET production.

- **Hydrolysis**

  PET may be hydrolysed by treatment with water, acids or caustic soda to give products that require purification before re-use. Commercial hydrolysis is less well established than either glycolysis or methanolysis.

- **Saponification**

  PET may also be hydrolysed by treatment with alkali. Two processes have been suggested for commercialisation: "Recopet" (France) and "Unpet" (USA):

  - "Recopet" is a multistage process in which PET flakes are saponified, filtered and dyes extracted before the end product is extracted and precipitated.
  - The "Unpet" process produces intermediates that are heated to product purified end products.

- **Pyrolysis**

  This process involves heating the polymer to a high temperature in the absence of oxygen to yield a mixture of hydrocarbons. It is intended that the product will be used as fuel or as a general feedstock for the petrochemical industry. However, pyrolysis is not a commercial proposition at the present time.

Incineration with energy recovery

Incineration with energy recovery involves the burning of plastics to generate electricity or heat. The calorific value of most plastics is high and this energy can be recovered from plastics in the waste stream when it is impractical to recover value via recycling.

The options include direct incineration with energy recovery, or the production of refuse-derived fuel (RDF) and packaging-derived fuel (PDF) for incineration. The production of RDF or PDF allows the plastic to be transported in a more economical manner, and leads to a more consistent feedstock for incineration (*App2*. Ref 3 & 4).

Current UK Position

1. In the UK the focus is on mechanical recycling. Examples of the use of mechanical recycled plastic are presented in Task 1 above.

2. Feedstock recycling in the UK is still being developed:

   - The potential for a full-blown, 25,000 tonnes per year project is being investigated by a consortium led by BP Amoco at their Grangemouth site in Scotland to demonstrate feedstock recycling. Using thermal cracking to break down the plastics into their constituent chemicals, for use as a feedstock in refineries for the production of chemicals or even new plastics, means the plant can tolerate mixed plastics and contaminants. This type of can reprocessing compete with mechanical recycling processes.

3. The UK has not pursued the route of incineration with energy recovery to the same degree as some other European countries.

Estimated Current and Projected Plastic Waste Arisings in London

Estimates for the London area have been generated using national waste arising figures and a variety of conversion factors to calculate the percentage attributable to the London area, see Appendix 6. These include population/number of households (both 12%), number of licensed vehicles (10%) and GDP (16%) according to the type and source of material. We have followed the convention of using population or number of households to derive quantities of domestic waste and GDP for waste generated by commercial and industrial sources. In each case, the baseline figure is derived using population (or number of households).

UK Waste Arisings

The DETR Waste Strategy 2000 estimates there are now 2.8 million tonnes of plastic waste generated in the UK annually, with packaging waste amounting to 1.7 million tonnes (domestic 1.2 million tonnes and commercial/industrial 500,000 tonnes) and non-packaging waste 1.1 million tonnes (no breakdown).

Plastics account for 11% of collected household waste by weight (6% dense and 5% film) according to Waste Strategy 2000. Table 2 shows the composition of collected household waste in the UK i.e. broken down by type of material.

Table 2 Composition of Collected Household Waste by Weight

Material	**%**
Paper/Card	32
Putrescibles	21
Glass	9
Plastic (dense)	6
Plastic (film)	5
Ferrous Metal	6
Non-ferrous metal	2
Textiles	2
Other	17
Total	**100**

Source: DETR Waste Strategy 2000

In 1998/99, the amount of collected household waste was 17.2 million tonnes in England and Wales, see Table 3 below.

Table 3 Waste Arisings, England and Wales, 1998/99

Waste Arisings	**Weight, million tonnes**
Regular household collection	17.2
Other (h/h sources, CA sites, household recycling)	7.9
Total household waste	**25.1**

Source: DETR Municipal Waste Management statistics

Based on this analysis, the amount of domestic plastic waste arisings for England and Wales would be 1.89 million tonnes (i.e. 11% of 17.2 million tonnes). This suggests a figure of around 2 million tonnes of domestic plastic waste for the UK as a whole (and by implication 800,000 tonnes of commercial and industrial (C&I) plastic waste arisings). Table 4 provides our best estimates of total UK plastic waste arisings based on available data.

Table 4 UK Plastic Waste Arisings, Thousands Tonnes

Type of Waste	Commercial and Industrial	Domestic	Total
Packaging:	500	1,200	1,700
Non-packaging waste	300	800	1,100
Total plastic waste	**800**	**2,000**	**2,800**

Source: Waste Strategy 2000, Enviros estimates

According to Waste Strategy 2000, the 55% of collected household plastic waste is dense plastic and 45% is plastic film. The previous London Waste Action report (MEL) gave the composition as of household plastic waste as 85% dense plastic and just 15% plastic film. The MEL figures are clearly at odds with the DETR estimates. Other studies suggest plastic film accounts for 40% of household plastic waste and dense plastics for 60% which is more in line with DETR figures. The following figures - Table 5 - are the best estimates of the composition of plastic waste in UK households i.e. broken down by type of plastic material.

Table 5 Breakdown of Plastic Waste Arisings from UK Households

Plastic Type	%	Estimated UK Arisings '000 Tonnes
Refuse sacks and other film	40	800
Transparent PET and PVC bottles	15	300
Milk bottles HDPE/Opaque HDPE	15	300
Other dense plastics	30	600
Total domestic plastic waste	**100**	**2,000**

Source: Enviros estimates

According to DETR Waste Strategy 2000, just 2% of collected household waste is potentially recyclable plastic, see Table 3, all of which would be dense plastic (i.e. 33% of 6% - dense plastic and none of the plastic film). This is equivalent approximately 350-400,000 tonnes.

Currently most plastic recycling in the UK is of "process scrap" from industry; this is easier to recycle than post-consumer plastic waste. Process scrap is recycled (by plastic reprocessors) before entering the waste stream unlike post-consumer waste. There is a regular and reliable supply and it is uncontaminated by previous uses unlike post-consumer waste.

British Plastics Federation figures indicate that the current recycling rate of post-consumer plastics waste generated in the UK from all sectors (domestic, commercial and industrial) is around 5%; this would equate to around 140,000 tonnes assuming a figure of total plastics waste of 2.8 million tonnes. The majority of post-consumer recycled plastic in the UK is polyethylene (PE). BPF estimates are that between 70,000 and 90,000 tonnes of post-consumer PE film are recycled in the UK each year.

In 1997 as shown in Table 6, total post-consumer recycled plastics was 120,000 tonnes, including 76,000 tonnes of PE (66,000 tonnes of which was

PE film i.e. from packaging) and 3,000 tonnes of PET.

Table 6 UK Estimates of Post-Consumer Recycled Plastics, 1997

Polymer Type	Tonnes	%
Polyethylene film	66,000	55.5
Polyethylene others	10,000	8
Polypropylene	20,000	17
Polystyrene	5,000	4
Expanded Polystyrene	2,500	2
ABS	2,000	2
Acrylics	1,200	1
Polyvinyl Chloride (PVC)	10,000	8
Polyester (PET)	3,000	2.5
Total	**119,700**	**100**

Using this breakdown as a guide would suggest that if the figure of 140,000 tonnes of post-consumer recycled plastic is correct then 90,000 tonnes would be PE and 3,500 tonnes would be PET; this may be a conservative estimate. According to the 2001 Materials Recycling Handbook, UK plastic packaging recycling alone was nearly 200,000 tonnes at the beginning of 2000 (but must increase because of the Packaging Waste Producer Responsibility Obligations Regulations 1997 to 285,000 tonnes by the end of this year).

Waste Arisings in London

According to ONS data, there are 2,925,000 households in London and 24,554,000 households in the UK as a whole; this means London accounts for nearly 12% of UK households. If annual waste plastic arisings from domestic sources are 2 million tonnes for the UK as a whole then the figure for London, based on the number of households, should be 240,000 tonnes p.a. London accounts for 16% of UK GDP (see Appendix 6); this suggests that, London will generate an additional 130,000 tonnes of plastic waste from commercial and industrial sources (16% of 800,000 tonnes). Based on UK arisings and London's share of households and GDP, total plastic waste arisings in the London area would equate to 370,000 tonnes p.a.

In 1998/99, 4.1 million tonnes of municipal waste (MSW) were produced in London. The majority of this waste was collected from domestic households but 20% was non-household waste (largely commercial waste collected by local authority rounds from offices and shops); this is a significantly higher proportion than in other regions (Strategic Waste Management Assessment 2000). Domestic waste arisings should therefore account for 80% of total MSW which equates to 3.28 million tonnes.

Estimates on the percentage of the average household waste stream made up by plastics vary (BPF 5-7%, MEL 7.2% and DETR 11% of collected waste equivalent to 7.5% of total waste). Assuming a figure of 7% then if total domestic waste arisings are 3.28 million tonnes p.a. then this suggests that annual plastic waste in the London area should be about 230,000 tonnes from domestic sources.

According to the previous London Remade report, around 400,000 tonnes of plastic were available in London's solid waste stream in 1998/9 (1.5% of the total). Of this, 60% was attributable to waste from the municipal stream (240,000 tonnes), see Table 7, and the remainder from commercial and

industrial activities (for the purposes of that study, arisings of plastic in the commercial and industrial waste stream, beyond packaging, were assumed to be negligible). [*Over 80% of the available household material (83%) was classed as dense plastic (the MEL composition states 1.1% plastics film and 6.1% dense plastic, as a proportion of total household waste)].* Previous estimates of composition of plastic waste arisings nationally suggest that PE arisings in the London area are probably around 130,000 tonnes (split 100,000 tonnes LDPE/film and 30,000 tonnes HDPE) and 30,000 tonnes of PET/PVC.

Table 7 Composition of Plastic Waste in London Households

Plastic Type	**%**	**Estimated London Arisings '000 Tonnes**
Film	43	100
HDPE	13	30
Transparent PET and PVC bottles	15	40
Other dense plastics	29	70
Total	**100**	**240**

>From this study the current estimate on plastic waste arisings in London is 370,000 tonnes p.a. (240,000 tonnes from households and 130,000 tonnes from commercial and industrial sources).

Projected Volumes

The number of households in the London area is projected to rise from around 3 million in 1998/99 to 3.6 million by 2021, an increase of 19% (DETR). Household numbers for England are projected to grow at a rate slightly below this, from 20,540 million to 24,000 million over the same period, an increase of nearly 17%. Assuming the average household generates 0.08 tonnes p.a. (240,000/3,000,000) then plastic waste arisings in the London area should rise by around a thousand tonnes a year over the next 5 years and thereafter double to two thousand a year for the period 2011 to 2021, see Table 8 below.

Table 8 London Projected Growth in No. of Households and Plastic Waste

Year	**No. of Households '000**	**Plastic Arisings Tonnes**
2001	3,128	250,000
2006	3,245	260,000
2011	3,377	270,000
2016	3,520	280,000
2021	3,645	290,000

According to Strategic Waste Management Assessment, MSW production in London is projected to rise by almost 85% over the next 20 years if the current national growth rate (of 3%) is maintained. MSW being produced in 2000 is given as 4.25 million tonnes rising to 7.82 million tonnes by 2020. Assuming that 80% of MSW is collected from domestic premises and 7% is plastic waste then annual plastic waste arisings in the London area could rise from 240,000 tonnes to 440,000 tonnes over the next 20 years (Table 9).

Table 9 London Projected Growth in MSW and Plastic Waste

Year	**MSW '000 tonnes**	**H/H '000 tonnes**	**Plastic Arisings Tonnes**

2000	4,256	3,405	240,000
2010	5,769	4,615	325,000
2013	6,321	5,057	355,000
2020	7,821	6,257	440,000

Forecasts on growth in GDP for the UK are low at around 1.5 to 2% p.a.; this suggests that the plastic waste arising from commercial and industrial sources could rise from 130,000 tonnes p.a. to 185,000 tonnes p.a. over a 20 year period.

Total plastic waste arisings in the London area are projected to rise from 380,000 tonnes to over 500,000 (475,000 - 625,000) tonnes by 2020/21.

Waste projections in the previous London Remade report indicated that the total amount of plastic available in the waste stream would reach 590,000 tonnes by 2020. These projections are based on the increase in the number of households (and thus natural increase for MSW) and increase in GDP for commercial and industrial material.

From this study the current estimate on projected plastic arisings in London is for volumes of to rise from 370,000 tonnes p.a. to between 400,000 and 420,000 tonnes p.a. over the next 5 years and to continue rising thereafter.

Plastics Reprocessors in London

A database has been produced listing companies, contact details and the findings of the telephone research undertaken to understand the current market position. As the database is large it has not been provided here, but is available from London Remade.

COLLECTION AND SORTING

There are several companies processing plastic waste in the London area. These operations cover collection, sorting, baling or granulating and selling on to reprocessors at various locations in the UK.

PET

RECOUP Services Division handle the majority of post-consumer plastic waste bottles from the Greater London area. This material is then exported to the European market or sold on to UK processors. RECOUP claim to have secured long-term markets, and consider themselves to be well placed to advise or co-operate in any London based initiatives.

E Klein and Co, based in the Docklands area, collect and process (granulate etc) PET for the home and export markets. Currently, the material handled is only from commercial and industrial sources.

PE including HDPE and LDPE

Polyethylene film (generally LDPE) is the most available post-use polymer and there are numerous companies of varying size which collect, bale and sell this material to reprocessors.

HDPE from commercial and industrial sources is bought by companies in the wider UK market, such as Linpac Recycling Ltd and Centriforce Ltd in Liverpool.

Examples of HDPE and LDPE collection include:

- Bestway Recycling in London SE19 which collects, sorts and sells 2,500 tonnes/year of post-use commercial and industrial plastic waste to UK (90%) and Asian markets.
- Severnside Waste Paper which collects 1-2,000 tonnes per year of plastics (mostly LDPE film).
- RECOUP and its services division which collects and markets most of the post-consumer plastic bottle HDPE waste from the London area. About 50% is exported to the European fibre industry and the rest is passed on to reprocessors such as Linpac and Delleve for manufacture into pellets.

REPROCESSING OF HDPE AND LDPE

There are three main types of plastics reprocessor:

- In-house processors using process scrap.

- External processors making a product partly or entirely from plastics, acting either to feed their own sales or as part of a group making for others within the group.
- Trade processors, which normally own plastics processing equipment and produce products for one or more customers, having no product range of their own.

- **In House and Trade Reprocessors**

  Manufacturers using process waste rarely accept polymers from external sources. Difficulties in processing a range of materials (grinding, removal of contaminants, inconsistent supply etc.) mean that this primarily local market is very difficult to stimulate.

  Trade processors may use material from recycled or virgin sources in line with the wishes of their customer.

- **External Reprocessors**

  Plastics reprocessors are spread across the UK - this reprocessing activity is not prohibitive in terms of distance, as long as the materials are treated to increase density prior to transport. For example PET bottles recovered in locations such as Portsmouth are transported to Reprise Ltd in Merseyside for further processing, Reprise estimate the transport cost for this journey at £10-15 per tonne - this is based on a full load of 60-70 bales totalling approximately 15 tonnes.

PET Reprocessors

The Greater London area does not contain any significant reprocessors of post-use PET. Reprocessors outside the region are still the destination for much of the recovered PET from the capital. These companies include:

- Reprise Ltd in St Helens, Merseyside, not operating at full capacity. The feedstock is predominantly post-consumer waste bottles. The processed PET is then exported to the European market or sold on to UK manufacturers of fibre products such as Pennine Fibres in Bradford.
- Companies such as Environmental Polymer Products (EPP) and Roydon Granulation on Merseyside, also receive PET material from locations all over the UK.

PE (including HDPE and LDPE) Reprocessors

The UK market for recovered post-use HDPE and LDPE is much larger than PET, with many reprocessors also manufacturing finished products on site. Companies such as Plysu Recycling, EPP, Centriforce, Retex and Linpac all use rigid PE as feedstock for the production of various plastic products.

The Greater London Area does not contain any significant reprocessors of post-use PE. However, there are numerous UK reprocessors of these materials in film or rigid form, such as:

- British Polythene Industries (BPI) which is the largest reprocessor of LDPE film in the UK produces pellets for remanufacture. BPI operates

several sites, and handles over 30,000 tonnes per year. The reclaimed film is supplied by BPI collections and by a network of private collectors (see collection and sorting).

>From the research it was apparent that the UK market for contaminated LDPE packaging film is very small, with most of the material being exported to the Far East. UK plastic decontamination plants exist but appear to have been mothballed as market prices currently make this operation uneconomic.

Linpac Recycling is the leading recycler of rigid plastics (generally HDPE, PE, PP and PS) and in the UK. The material is reprocessed at their Knottingley site (8.5 acres) and then the compounded pellets are passed on to other Linpac sites, other UK users (85%), and export markets. They source HDPE and other hard plastics from commercial and industrial waste in the London area, but significantly do not process PET, due to the management view that the profitable volumes required are not available in the UK.

Plysu Recycling are also a significant plastic reprocessor who purchase recovered plastic for further processing, such as injection moulding of material collection boxes for some Local Authorities.

End Users of Recovered Plastics

Another database has been produced listing companies, contact details and the findings of the telephone research undertaken to understand the current markets for recovered plastics. As the database is large it has not been provided here, but is available from London Remade.

This research has been focused on some of the markets for recovered plastics. In particular the use of:

- PET in drink containers and carpets;
- LDPE in wood polymer composite products;
- HDPE by small manufacturing facilities in London.

PET END USERS

This section identifies the size of the market for PET bottles, and where recycled PET is currently used and by whom. The aim was to contact companies to find out how much virgin & recycled PET is used and to identify barriers to using PET.

Introduction

PET is used for packaging for many consumer items such as, soft drinks and beer, personal care products, car products and agro-chemicals. These applications are wide-ranging because PET is a barrier material with recycled resins frequently being used in combination with virgin materials. A survey carried out by APME (Association of Plastics Manufacturers in Europe) entitled, 'An Analysis of Plastics Consumption and Recovery 1999', shows that in 1999 the demand for plastics continued to grow, with plastics consumption in Western Europe increasing by 5.4% per year to 33.6 million tonnes. On average, each individual in Western Europe consumed 83.9kg of plastics in 1999.

Consumer uses are likely to remain the dominant use of PET. There are future opportunities anticipated for polyester fibres and fibre fill in home furnishings, duvets, clothing, carpets and other textiles. Fibres are ideal for recycled PET because they require less expensive grades and processing than resins (US Freedonia Group, Inc., 1997). Another use is in carpets, with 50 bottles required to make 1 square yard of carpet. [NRF Website]

PET Bottle Market Volume Forecasts

The Sucralose 2001Softdrinks report indicates that future market growth in the soft drinks sector will be as strong if not rather stronger than in 2000, averaging out above 3% growth a year. Carbonates (bottled mainly in PET) should match this growth.

The growth in the PET bottled market will be mainly from bottled water (bottled mainly in PET) which is estimated to grow at more than 10% a year. Also by 2005 the market share of energy drinks should have grown

substantially, as health and functionality increasingly affects consumer buying.

MDB report (MDB-Plastic Packaging Market Development) that although the use of plastics in the production of small and larger bottles is forecast to increase, this growth will be limited by the trend towards lighter weight and the already high penetration of plastic in the market, which will limits the opportunities for further growth. The growth of the PET bottle market will be encouraged by a continuing move away from glass and light metal. However, competition is expected from pouches, generally made from metal plastic composites.

PETCORE estimates for the total European market for PET products are shown in Table 1.

UK PET Container Recycling

The development of market demand will be strongly related to the growth in the amount collected. This growth will mainly be influenced by the impact of UK packaging legislation. Current growth predictions suggest that UK market demand will not be the limiting factor to PET recycling within the UK. As competition for PET is strong both in Europe and from the Far East.

The major barriers to the increased recycling of plastics in the UK are the relatively high cost of material recovery and the lack of sustained, commercially attractive prices paid for baled materials. The cost of collection and marketing of post-consumer plastic bottles are greater than the sales value of the baled bottles. Additional income streams are required for plastic bottle collections to be financially viable - RECOUP: Affordable Plastic Bottle Recycling 2000.

RECOUP is of the opinion that the market is currently supply limited. Therefore the market should concentrate on increasing the collection and availability of post-consumer PET bottles.

- **Market Value of Recyclate**

  Historically users of recycled materials expect to see a cost benefit when replacing their normal materials. Estimates by RECOUP suggest the recycled product should achieve 70-85% of virgin prices. There is a strong relationship between the price of recyclate and the prevailing price of the equivalent virgin grade. Recyclate is very responsive to the price change mechanism that can cause dramatic and cyclical price changes in response to processing capacity or world market events.

- **Current Market Value of PE and PET**

  Prices quoted are intended as a guide only as the price paid for virgin and recovered plastic is dependant on several factors including:

  - Quantity purchased;
  - Quality required; and
  - Length of supply contract.

  Typical Virgin Polymer Prices, £ per tonne

Polymer Type	Oct (2000)	Sep (2001)	April (2001)
LDPE Virgin - (film)	£530	£601	£478
HDPE Virgin- (inj mould)	£580	£539	£527

It should be noted that the end market use dictates the quality of the RPET required as lower grades command a lower price. The price for recycled PET (RPET) tends to be 85% of the virgin price, typical prices for bottle grade RPET in 2001 were £700-900. For most other polymers and lower grade PET (fibre industry etc.) the recycled price was generally about £390/tonne for RPET (wide spec material - not bottle grade). According to RECOUP the price for baled colourless PET bottles in October 2001 was approximately £160 per tonne.

- **Current End Markets**

  In the UK reprocessor capacity and end user demand currently outstrips the supply of material. However, on a European basis, the collection of PET has grown very rapidly and the need to develop new markets is becoming more important.

  Most of the PET is recycled into fibre and used as filling for Duvets, Anoraks etc. Pennine Fibres are the main company producing fibre fill, recovered PET is supplied mostly from Reprise in St Helens. Wellman are the biggest European Recycler of PET with washing plants in Holland and France and a major fibre plant in Ireland. The company produces Polyester Staple Fibre (5mm to 150mm), from post-industrial PET and post consumer PET bottles.

The UK Carpet Industry

The UK carpet manufacturing industry is predominantly based in Yorkshire, Lancashire and the Midlands. According to Carpets International (UK) Ltd, the UK is the second largest consumer of carpets in the world. The carpet market in the UK has declined since the beginning of the 1990's, but it is still of considerable value, with retail sales worth an estimated £1.64bn in 1999.

Generally, the sector has suffered falling demand as consumers have moved to alternative floor coverings. This is reflected in the retail market as carpet sales have declined in value by 20.7% between 1995 and 1999. A forecasts from Key Note suggests that market value will rise by a marginal 0.9% in the year 2000 and thereafter, modest growth is expected of 3.4% between 2000 and 2004 which will bring the market's value to £1.71bn.

- **PET use in Carpet Manufacture**

  The market for man-made fibre in carpets is considered to be stable. Large proportions of PET (30-50%) can be woven in with wool or polypropylene (PP) to form carpets for particular applications, however these applications are limited. Also PET is used in luxury styles as it is less resistant to flattening than some fibres and wears well.

  The most common use of PET is to produce tufted carpets. These carpets use the melt bond process (10% PET, 10% Nylon, 80% Wool) to allow the use of cheaper single ply yarns. Many of the leading manufacturers produce tufted options within their range.

- **Virgin versus Recycled in the Carpet Industry**

  Recycled PET fibre is sold to the Carpet Industry as a direct alternative to fibre made from virgin materials . The recycled PET fibre currently competes equally with virgin PET fibre in terms of price and technical specification.

  Carpet manufacturers do not tend to use the fact their carpets have a recycled content as a selling point. The Carpet Foundation believes that the industry will not be forthcoming in these figures.

- **Opportunity for London Remade to increase the use of recovered PET in the carpet industry**

  The carpet industry provides a well established market for recovered PET, with a steady demand, a known quality criteria and price structure.

  This market provides a clear opportunity for London Remade to supply into, however due to its location in the Northwest/ Yorkshire, the limited capacity and the lack of opportunity to promote the use recycled products via this route suggest it should provide a supporting market into which London Remade could supply PET recovered from the London waste stream in the long-term rather than a prime market.

PET Bottles Recycling

The amount of PET recyclate in Coca-Cola bottles ranges from 10% (USA) to 25%(some parts of Europe), but all bottles in the UK are currently made entirely from virgin material as is also the case for Pepsi in the UK.

Coca-Cola and Pepsi pioneered the use of recovered PET in drinks bottles in the early 1990's, but stopped using recyclate in the UK when virgin PET prices dropped, and they had problems obtaining quality material. Coca-Cola GB has the medium to long-term objective of using recyclate in bottle production, and recently Coca-Cola have restated their plans to have 10% recovered PET in their bottles by 2005. This presents a potential market (through manufacture at Coca-Cola Enterprises) for any PET recovered in London.

It should be noted however that the current amount of post-use PET collected in the UK is only about 3,000 tonnes per year. If we assume London has 40,000 tonnes per annum PET/PVC waste arising, then the key task is to increase the supply of PET bottles to meet the potential requirements of the major bottle manufacturers. This reinforces the view that action should focus on overcoming problems of collecting PET from the domestic waste stream to supply the potential demand.

Using recycled PET in drinks packaging applications is a technically viable option and is financially appealing when virgin PET prices are high. Established markets for fibre and sheet PET applications mean that the development of food grade PET applications is less critical to bottle recycling in the UK.

- **Opportunity for London Remade to increase the use of recovered PET in the bottle industry**

  Supporting the development of PET recycling into bottle production in the UK, with a supply from Greater London would provide excellent promotional opportunities for London Remade and for PET recycling. In addition, as discussed above the market for PET bottles is forecast to increase.

  As there are currently no bottle to bottle operations in the UK, but several bottle to bottle processing operations in Europe, such as Schmalbach Lubeca (S-L) in Beaune (6000tpa), PKR of Germany, and the Dutch companies Wellman and Texpalst, there is a clear opportunity to develop a plant in the UK. A plant of a similar size in the UK would require more recovered PET than is currently available in the UK so there would be the challenge of increasing supply across the country, not just from Greater London.

  The main barriers to supplying this market are that recycled PET (RPET) for use by the bottle industry needs to be to a much higher specification than for other industries and therefore virgin can be cost competitive and provide more consistent quality. The potential incentive from PRN (Producer Responsibility Note) value and recycling credits have not been sufficient in the past to outweigh the risks of using RPET.

  Also if RPET is used in drinks/food containers it must be from an approved process. The quality of the RPET also affects the retail market as there needs to be customer acceptance of recycled plastic in relation to food health issues.

  London Remade have the opportunity to work with partners to develop the collection and supply of PET to end users. As collection rates in the Greater London area are low there is the opportunity to increase the collection of PET bottle from the domestic waste stream significantly by working with the Local Authorities and existing waste collection systems.

  It will be important for London Remade to develop more than one end user for a supply of recovered PET from London. This will ensure that that highest market value can be realised for the recovered material and that there are markets PET with a range of specification. Further work may be necessary to identify other end users that could provided a range of products that could be promoted to the Local Authorities and industry by London Remade, for example the clothing and strapping markets.

HDPE END USERS

The study identified plastics manufacturers in East London (Thames Gateway) and Greater London. A selection of these companies were contacted to determine the quantity of HDPE used already and the potential to use recycled HDPE.

Plastic using SMEs in Greater London

Our research focussing on the Thames Gateway area identified 19 plastic - using small manufacturing facilities; further research identified a total of 83 smaller plastic using manufacturing companies in Greater London. It is worth noting that larger clusters of plastics operations can be found in North London (around Palmers Green), SouthEast (Deptford/Bermondsey) and South West London (Wandsworth/Merton).

A sample of 18 companies (22%) were contacted by telephone. Companies that were most likely to use HDPE were targeted. Only four of these companies use HDPE as a feedstock (5% of total database) and generally in very small quantities. The main products produced were manufactured sheets, plumbing products, artists' folders and moulded products.

The main barriers to using recycled plastics include the quality of the recyclate and the quantity available, as poor quality results in technical difficulties. Although the price is lower, as supply is not predictable, it is easier and less time consuming to use virgin.

LDPE END USERS

The study identified companies using LDPE outside the UK who manufacture wood polymer composite products (i.e. engineered lumber) and street furniture. In addition, the study aimed to identify the size of the market for using engineered lumber in London/ UK (e.g. for cabinet making) and the trend in that market.

Market Size and Structure

It is estimated that the 2000 timber and joinery market was worth £10.94bn at manufacturers selling prices (source Key Note). This market estimate includes total timber processing, semi-finished goods and finished wood products. An estimate of the UK market for timber and joinery by value at current market prices as calculated by Key Note is shown in Table 10.

Table 10 Estimate of Current Market for Timber and Joinery

Finished Wood Products	**1996**	**1999**	**e2000**
Wooden Furniture	4,704	5,100	5,663
Builders Carpentry and Joinery	2,099	2,022	1,955
Other Wooden Products	545	492	496
Wooden Containers	593	468	414
Total	**7,941**	**8,082**	**8,528**

Source Key Note Report

The estimated value of the finished wood products market for 2000 was £8.53bn. The two largest sectors are wooden furniture (kitchens, bedrooms, chairs, seats, office furniture etc.) and Builders Carpentry and Joinery (including products with windows doors etc.)

In comparison, the semifinished products sector had an estimated market share in 2000 of £1.14bn, this includes veneer sheets, plywood, laminboard, particleboard and fibreboard and oriented strand board. The sawmilling and

planning sector estimated UK market share in 2000 was £1.2bn, this sector is also diverse and covers sawn lengths, blocks, poles railway sleepers, wood chips and waste.

As the UK forestry industry is relatively small in size, in relation to UK consumption, the UK industry is weak compared to major overseas suppliers. One of the consequences of this weakness has been extensive rationalisation in the industry, a process that is still continuing.

The construction industry is the major sub-sector for the consumption of timber and joinery products. An important indicator to market growth is the amount of house building that is planned. Forecasts for housing starts and completions indicate a rise between 2001 and 2004, but the future is uncertain. The Southeast has greater demand than elsewhere in the country.

It is forecast that the total market for timber and joinery (finished and semi-finished goods) is expected to grow from £11.16 billion in 2001 to £12.33 billion in 2004 (10.4% growth) - based on the current economic climate.

Another important market is for fencing which has shown a steady increase - approximately 4.5% - over the last few years, despite the decline in agriculture and the impact of foot and mouth disease. This growth is mainly due to the increase in interest in gardening and DIY. In addition the decking market has grown dramatically over that last few years to 20 times it previous size. The combined market for decking and fencing is estimated to be in excess of £100 million in the UK. Growth in this sector is forecast to continue by the Timber Decking Association.

Wood Polymer Composite Engineered Lumber

There are several companies producing small quantities of WPC products in the UK. However, the experience and the markets for WPC engineering lumber in the USA are more advanced as there are several American companies or divisions of large timber companies who manufacture wood polymer composites (WPC).

Table 11 shows the current findings by the Clean Merseyside Centre (CMC) concerning the major US companies.

Table 11 Major US companies producing WPC Engineered lumber.

Company	Location	Product	Polymer Type	Wood Type
Boise Cascade WPC	Idaho	exterior siding	Post use LDPE, LLDPE,HDPE,PP	recycled, kiln-dried, mixed species chunks.
Trex	Virginia	decking; landscape products	Post use LDPE, HDPE	recycled, kiln-dried, mixed species flour
Aert	Texas	decking; landscape products; OEM products	Post use LDPE, HDPE	As above
Strandex	Wisconsin	technology licences	Virgin LDPE,HDPE,PVC	Virgin specific species
Louisiana Pacific WPC	Various	decking, exterior siding, thin-moulded auto	Virgin PP, VINYL	As above

		components.		

As indicated in Table 11 there are several companies using post use polymer and wood from commercial and industrial sources. The finished product is produced by continuous extrusion and uses approximately (in most cases) equal amounts of polymer and wood flour.

According to Preston Horne-Brine, a US Forest Industries specialist and advisor to CMC, there are three fundamental barriers to consider if these technologies are to be transferred & developed in the UK:

1. There must be specific market applications in which WPC products can effectively penetrate & compete, with potential for rapid sales growth in the UK.

2. There must be interest and capability by the company in question to transfer the technology to the UK by licence or expansion.

3. The scale of the technology must be appropriate to consider transfer to the UK into a business context such as London (i.e. moderate sized urban site and existing distribution channels).

These factors considered there is a crucial need to find specific product applications for WPC products that have high growth potential in the UK.

Opportunities to Attract Technology to UK

Boise is currently too preoccupied with start-up of their first commercial plant for the WPC exterior siding product to be interested in expanding their operations to the UK. They may become interested in the UK in 3 to 5 years.

Louisiana Pacific is a licensee to Strandex on WPC technology, although they are an established wood product manufacturer and marketer. Therefore they cannot really be a licensor to anyone in the UK.

TREX and **AERT**, both are heavily into continued development of their technology, manufacturing of product (in a major growth mode), product marketing/sales, and making a go at sustainable business operation with profitability. TREX has been the most aggressive in seeking out global expansion opportunities and was subject to a management buy-out just five years ago, but have recently experienced some problems.

AERT however has a much more independent nature and has developed their technology and business from the ground up. AERT appears to have a very flexible and smart marketing approach that includes a sophisticated penetration of niche markets (for OEM products) and of key industrial waste markets, as opposed to massive growth in one sector.

Both companies are into the decking market and pursuing that rate of growth in it (approximately 25%). However they differ in that TREX's primary approach is blunt marketing whilst AERT has several marketing approaches. This would make AERT the more appropriate to the UK. AERT have not commented yet on their potential interest in the UK.

Strandex is very interested in licensing their technology to a moderate to

small business venture in the UK that can identify and market to appropriate target markets in the UK that have good growth potential. They have experience and a track record in technology transfer. Their equipment is likely to be the most viable for an existing UK business that sees WPC substitution possibilities for product categories that it already makes, distributes, or sells. Strandex technology is focused primarily on utilization of virgin polyethylene resins and wood manufacturing residuals. They can incorporate post-consumer waste plastics and wood, but only in limited percentages and only if the material strictly meets their specification. Their licensees use specific resin types (not mixed together) and including HDPE, PVC, and PP. Hence their different licensees are either using HDPE (post-use plastic milk jugs, containers and some bags, plus postindustrial material called "off-spec") or PVC (vinyl) or PP (largely from postindustrial sources). Their licensees are NOT using LDPE or LLDPE (plastic film and some bags).

Street Furniture and plastic lumber

There are several UK companies which make street furniture and plastic lumber from recovered polymers. Generally, the use of wood flour in the resin by these companies has only been small scale. There is potential for existing manufacturers such as Environmental Polymer Products, Centriforce and others to manufacture a WPC product on a significant scale. It is also plausible that existing plastic timber manufacturers, with their market knowledge etc, could obtain licence from or work with existing US manufacturers.

Identification of End Users for Plastics Recovered from WEEE

A database has been produced which lists companies, contact details and the findings of the telephone research undertaken to understand the current market position. As the database is large it has not been included here, but is available from London Remade.

The focus of the research was looking at the markets for recovered engineering thermoplastics plastics (ETP).

Recycling of engineering thermoplastics (ETP) recycling in the UK

Waste electronic and electrical equipment generally uses many different types of plastic in manufacture. In the case of electronic goods, particularly computer equipment they have often been treated with brominated flame retardants. Typically 50% of the plastic found in WEEE has been treated with flame retardant.

Flame-retardants generally affect the flow properties of recovered plastics making them difficult to reprocess. The variety of plastics generated from WEEE recovery and the difficulty in getting reprocessors to use plastics containing fire retardant usually results in the land filling of plastics that could be recovered. WEEE normally consists of a mixture of the following types of plastics, generally termed engineering thermoplastics (ETPs) (Source: SPE Annual Recycling Conference 1999 www.plasticresource.com):

- High impact polystyrene (HIPS)
- Acrylonnitrile Butadiene Styrene (ABS)
- Polycarbonate (PC)
- PC/ ABS blends
- Polyphenylene Oxide blends (PPO)

The current level of recycling post consumer thermoplastics in the UK is very low. Manufacturers are keen to recycled high levels of their production plastic waste on site by re-granulating, up to 25% of the finished product is re-granulated material sourced from within the company.

Using re-granulated material i.e. process waste from within a company is excepted practice as the properties of the material are known and the heat history is known. When a manufacturer purchases virgin plastics they are supplied with a certificate of analysis. This certification of analysis will detail the physical characteristics of the plastic such as flow specification, colour, and other performance characteristics enabling the customer to determine whether the properties of the plastic will provide the performance characteristics required by the customer.

Current market for ETP

A competitiveness analysis study undertaken for the DTI in 1995 predicted that the use of ETP in the UK would grow at the rate of 8% per year until 1999. In 1994 UK consumption of ETP was around 100,000 tonnes

approximately 11% of European consumption. According to estimates from APME in 2000 the UK consumes 16% of the plastics for electronic and electrical equipment in Europe equivalent to 240,000 tonnes showing a 140% increase on the 1994 figure.

Large multi-national corporations dominate the market for products manufactured from ETP and this forces the drive towards continuous improvement in terms of performance, quality and cost. Indeed the control of the original equipment manufacturers (OEMs) over this use of ETP also drives the manufacture and assembly up the supply chain away from the OEM. A general trend in manufacturing and particularly in the use of injection moulded plastics is for OEMs to have limited or no moulding facilities on-site.

Although OEMs are aware of the pressure of environmental legislation and the interest of stakeholders many feel that although they need to prepare for the forthcoming legislation they also need to keep prices down and therefore customers satisfied.

Often OEMs will provide a supplier with a detailed specification for the product they need to produce. This specification tends to detail the materials that should be used and their percentage composition in the final product. Some more pro-active OEMs are trying to move away from providing detailed specifications that dictate to the supplier the precise material they should use and to move toward using performance specifications that allow the supplier to select the material that will conform to the performance specification. This would give the supplier much more leeway when trying to use recycled plastics in the manufacturing process.

In general, the supplier must conform to the design specification provided by the OEM design team. Often the OEM will be working toward an environmental management system, however reviewing the design specification to require suppliers to increase the recycled content of parts is not common practice as there is much resistance to this move because of the perceived cost and quality implications.

Existing market for recycled ETP

The industry view is that recycled plastic is low grade and low value. There are very few companies that produce high quality recycled plastics in the UK. The ones that do operate in this area claim to produce high quality recycled plastic with clear specifications so the customer knows what the material is and can optimise its use. Recycled plastic is often sold in small batches contaminated by other plastics. This may be caused by poor control of the marking of plastics.

Manufacturers that supply OEMs are interested in using recycled plastics as long as the quality can be guaranteed and could provide certificates of analysis. The incentive for this move would be cost savings. This suggests that recycled plastic must be price and performance competitive with virgin polymers. Competition on cost can sometime prove difficult to achieve especially where small batch sizes and testing to provide a certificate of analysis is required.

Generally finding a market for recycled plastics is dependant on:

- the type of polymer

- the cost of virgin compared to the cost of recycled
- The ease of segregating the materials and removing contaminants such as labels and paint which can significantly add to the cost of recycled materials

The main barriers to using more recycled ETP are the performance characteristics of the plastic; the main message from OEMs was that cosmetic and performance characteristics were the key issues when selecting materials. Even using re-granulated materials in parts that needed to have good cosmetic characteristics was generally avoided.

Technology for recycling ETP

Within the UK the companies contacted were unwilling to discuss technology in any detail. According to Plastics Technology, there are in the USA existing and emerging technologies for separation of co-mingled plastic wastes, such as centrifuges, hydrocyclones and froth /skin flotation:

- Centrifuges are a sophisticated density separation tool. They can accurately separate particles at reasonably high throughputs. The primary drawback to centrifuges is their relatively high purchase and maintenance costs. Generally only small particles can be fed to most centrifuges, so size-reduction expenses can be high. However, high centrifugal forces can overcome particle shape effects.
- Hydrocyclones use a water-based density sorting system. Studies in the USA claim that hydrocyclones are an economical and effective tool for separating mixed durable plastics, and for removing many contaminants from a target plastic. The motive force for effecting hydrocyclone separations is density differential. The greater the difference in density, the higher probability of separating two dissimilar components. In addition the shape of the particles to be separated in a hydrocyclone is also an important consideration. Since one hydrocyclone cannot guarantee close-tolerance separations, it is good practice to install hydrocyclones in series.
- Froth/ skin separation requires the suspension of plastics in a water-based solution of plasticisers and surfactants; this process makes certain plastics hydrophobic. When the solution is aerated the hydrophobic plastics are floated off.

In America and Europe dry and wet technologies to separate the plastic from painted bumpers and plastics in instrument panels have been developed by a partnership between Wipag (Germany) and American Commodities (USA).

MBA Polymers suggest the following guideline costs

	Centrifuge	**Hydrocyclone**	**Froth/ Sink - Sink/ Float**
Cost ($K)	450-650	30-60	15-50
Throughput capacity (lb/hr)	1,000-3,000	5,000-10,000	1,000-2,000

Also the polycarbonate contained in metalised CDs is recovered using hot sodium hydroxide solution by Nisim Corp in the USA. As part of the process they also recover precious metals such as gold from the CD.

The MBA Polymer plant in the USA use many sorting technologies to product

single resin flake, these include proprietary processes to separate contaminants like rubber & metal. In addition, they have at least eight different types of resin identification equipment including, mid-infrared spectrophotometer, near-infrared spectrophotometer and a triboelectric hand held equipment.

Carpo Corp (USA) have developed electrostatic sortation technologies for plastics, the process is dry and can allegedly compete with flotation separation. However the technology can be more complex to apply to plastic mixture containing more than 2 resin types. In Germany, Hamos supplies electrostatic plastic/plastic separators.

APPENDIX 1. STRUCTURE OF PROJECT

This project was instigated in response to discussions between London Remade and Enviros to meet London Remade's desire to research and documents that outline the 'Recycling Market Opportunities' in London.

The purpose of this work was to provide critical information for potential inward investment or local business interests seeking to explore the potential opportunities for developing a recycling related business in the Thames Gateway project area. The primary market information on each material is intended to describe the existing and potential market(s) in the Greater London area i.e. the market size, value and possible segmentation. This will provide business with the intelligence to estimate the opportunities that exist in there area of interest or for their specific operation.

In addition, to the potential market(s) information, this work was also attempts to estimate the current and projected (to 2010) tonnage's of specific materials recovered from the London waste stream.

This work was intended to achieve the following:

1. To support London Remade's efforts to market the opportunities that exist for processors and end users. This report summarises the information that has been collected to allow potential investors and other interested parties access to information concerning:

    - existing and developing sources of material;

    - existing, emerging and potential end-use applications for specific materials derived from the London waste stream.

2. To present to existing and potential waste material re-processors and collectors information concerning existing, developing and future markets for recyclables.

In addition the information could be potentially be used to support London Remade's strategic planning initiative - by highlighting market opportunities.

Separately, pamphlets have been produced summarising the position on some of the materials studied. These were intended to describe the potential markets for selected waste derived materials and the opportunities that may be economically and commercially attractive to interested parties.

Scope

The work has primarily focused on the Greater London area, within the M25. For some of the data, it has been necessary to widen that boundary to determine the situation in the south of England or even to look at the national picture.

>From discussions between London Remade and Enviros it was agree that the focus for this project would cover:

- Plastics

- Tyres
- Waste Electrical & Electronic Equipment (WEEE)

The definition of end-user markets used within this report includes any operation that will take waste derived materials as a substitute for raw materials in their services or products - with or without the intervention of a reprocessor. An example of an end-user would be a plastic goods manufacturer, but not the purchasers of those plastic goods manufactured with a recycled content.

In addition, this report attempts to identify any new/emerging end-use markets which would potentially be relevant in Greater London.

Project Methodology

The following tasks were carried out for each material and the findings are presented within this report. However, because of the nature of the targeted materials, certain variations will be made on a material specific basis.

Task One

For each material, the various alternative markets which have proven economically and environmentally viable were investigated. This information sets out to describe the various commercial applications that have been developed in the UK and other countries.

Task Two

For each material the processing techniques and technologies have been investigated and defined.

Task Three

The priority to be given to potential markets identified under Task One was determined through discussion with London Remade with the aim of identifying opportunities with the greatest potential for Greater London. Later work was focussed on these priorities.

Task Four

The current and projected volumes of recovered materials were estimated using existing data, such as the London Remade Prioritisation Study, the Environment Agency's Strategic Waste Management Assessment: 2000 and Government's Waste Strategy 2000.

Task Five

An analysis of current activities in the potential market areas highlighted in Task Three was undertaken. In particular this included:

Part One - Identification of companies in the Greater London area which are or could reprocess one or more of the materials being examined and those which service the end-user markets identified.

A selection of these companies where contacted to ascertain:

- the quantity (in tonnes) of material processed;
- the end-use markets serviced;
- current and planned processing capacity;
- interest in diversifying their markets;
- if support was required to assist them in maximising their potential to exploit their existing and new markets for recycled materials.

Part Two - Identification of companies in the Greater London area who are or could be end-users of waste derived materials being examined.

A selection of these companies were contacted to ascertain:

- the current consumption of recycled materials in their products and services
- the perceived potential to include recycled materials in their products and services;
- the barriers to uptake of recycled materials in their products and services;
- if support was required to assist them in developing their products and services to take advantage of recycled materials.

All information received was recorded on a simple spreadsheet.

Task Six

Writing pamphlets which could be used by London Remade for promotional purposes. The intention was that :

- the content of the pamphlets would depend on the material concerned.
- the pamphlets should attract the attention of businesses and encourage a more serious exploration of the commercial opportunities offered through London Remade.

Any issues identified during the previous tasks were highlighted, such as gaps in the supply chain and market opportunities for both re-processors and end-users. Also, problems with the supply chain were identified and reported as appropriate, e.g. where material (i.e. waste) supply is restricting market growth.

Task Seven

This report constitutes the final report summarising the findings of the market research undertaken and presenting the market data in detail for future use.

APPENDIX 2: REFERENCES

Ref. 1: APME web page plastics and the environment.htm (or try www.apme.org/environment - making the most of plastics after use - the facts)

Ref. 2: Various PETCORE web pages (e.g. petcoreapps.htm, petcoreappsnext.htm etc)

Ref. 3: Waste Watch Information Sheet: Plastics - plasticsWW.htm

Ref. 4: www.recycle.mcmail.com/film.html

APPENDIX 3: CONVERSION FACTORS

Details of conversion factors used in making estimates for current and projected London volumes based on national waste arisings.

Car Ownership

Nationally there has been an increase in car ownership over recent years but in the London area there has been virtually no change, see Table A. The net effect is that the number of vehicles registered in London has fallen as proportion of the total number of vehicles registered nationally. This may be due to increasing congestion and parking difficulties having a deterrent effect.

Table A Licensed Vehicles, millions

Year	London	GB	London as % of GB
1994	2.72	25.2	10.8
1995	2.68	25.4	10.6
1996	2.72	26.3	10.3
1997	2.72	27.0	10.1
1998	2.73	27.5	9.9

Source: Driver Vehicle Licensing Agency

The number of households without a car is much higher in London than elsewhere in Great Britain (39% compared to 30% for GB and just 20% for the rest of the South East), see Table B. In London, multiple car ownership is lower than the national average (16% compared to 25%) and considerably lower than the rest of the South East (with 33%).

Table B Percentage of Households with Cars (1996-98)

Region	No Car	One Car	Two Cars	Three or More
London	39	44	14	2
Rest of South East	20	47	27	6
GB	30	45	21	4

Source: DETR

Population

The UK's population is projected to increase gradually from an estimated 59.2 million in 1998 to reach 63.6 million by 2021 (Table C). This is equivalent to an annual average growth rate of 0.3%. The combined population of England and Wales was 52.4 million in 1998 accounting for 88.5% of the total UK population and their share of the UK's population is expected to rise slightly to 89.2% by 2021.

The population in London was 7.2 million in 1998 representing 12.2% of the UK, 12.5% of Great Britain and 13.7% of England and Wales.

Table C UK Population Trends (Thousands)

Country	1998	2001	2011	2021
England	49495	50187	51922	53715
Wales	2933	2950	2993	3047
Scotland	5120	5109	5087	5058
N. Ireland	1689	1708	1771	1821
UK	**59,237**	**59,954**	**61,773**	**63,641**

Source: Government Actuary's Department

In 1999, the population of London was 7,285,000 and the UK's population was 59,954,000 (and therefore London's share remained at 12.2%), see Table D. London's population is set to rise to 7.7 million by 2021 (still 12.2% of UK).

Table D London's Population Trends (Thousands)

Year	1999	2001	2006	2011	2016	2021
London	7,285	7,215	7,337	7,470	7,609	7,736
UK	59,501	59,954	60,860	61,773	62,729	63,641
London as % of UK	12.2	12.0	12.1	12.1	12.1	12.2

Number of Households

According to ONS data, there are 2,925,000 households in London and 24,554,000 households in the UK as a whole (Spring 2000).

According to DETR data, there were 3,061,000 households in London in 1998 and this figure was set to increase to 3,128,000 by 2001, a rise of 2% over the three years (or 0.07% pa), see Table E. Household numbers in the London area are projected to grow from just over 3 million in 1998 to 3.6 million by 2021, an increase of 19%. Household numbers for England are projected to grow at slightly below this figure from 20.5 million to 24 million over the same period, a rise of nearly 17%.

Table E Household Numbers and Projections, Thousands

Year	London	England
1998	3,061	20,540
2001	3,128	20,992
2006	3,245	21,733
2011	3,377	22.519
2016	3,520	23,313
2021	3,645	24,000

Source: DETR

Gross Domestic Product

Table F GDP by Industry Group, 1997

Industry Group	UK		London		London as % of UK
	£ million	%	£ million	%	
Agriculture	10,595	1.5	44	-	0.4
Mining & quarrying	4,003	0.5	203	0.2	5.1
Manufacturing	148,619	21.3	12,490	11.5	8.4
Electricity, gas & water	16,230	2.3	1,603	1.5	9.9
Construction	36,927	5.3	4,556	4.2	11.4
Distribution, hotels & catering, repairs	108,450	15.5	18,347	16.9	16.9
Transport & communications	57,916	8.3	10,995	10.1	19.0
Financial/business services*	158,485	22.7	35,978	33.1	22.7
Public admin & defence	38,101	5.4	5,070	4.7	13.3
Education & health	85,162	12.3	11,491	10.6	13.5
Other services	34,567	4.9	7,868	7.2	22.8
Total	**699,055**	**100**	**108,645**	**100**	**15.5**

** includes adjustment for financial services*
Source: Office for National Statistics, Region in Figures - London

Table I GDP by Selected Regions, 1999

Region	GDP
UK (=100%)	£771.9 billion
London	15.9%
South East	15.8%
East	10.6%
North West	10.0%
England	85.5%
Wales	4.0%
Scotland	8.3%
Northern Ireland	2.2%

Source: ONS