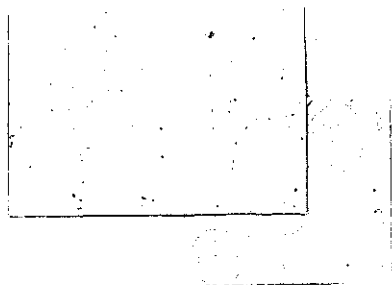
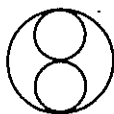


Local Paper



waste paper and non-wood fibres
for a sustainable paper cycle
in the South-east

Bioregional Development Group



Sue Riddlestone and Sarah Welsh

edited by: Pooran Desai

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Preface - Why we carried out this study

The need to recycle resources locally

Local recycling of resources is an important step towards achieving sustainability. Current recycling of paper is organised mainly on a national and international scale. Though recycling per se is to be encouraged, it is desirable that this occurs on a local and regional basis to avoid the environmental and health costs associated with transport.

Our vision - a local paper mill

In this report we have decided to start in our own backyard to see what is possible in our own community. Of course our findings will be relevant to other regions in the UK (and overseas) as well.

The London Borough of Sutton is one of the leading local authorities in developing green initiatives. The waste collection schemes implemented by the council are some of the most innovative. Can the move towards sustainability be taken a step further by turning locally collected waste into paper to supply back to the community and organisations resident in Sutton? Or if this scale is too small to be viable in practice, could a scheme be operated on a regional basis - involving say South London and neighbouring Surrey and Kent?

Benefits of local paper production would include;

- decreased road transport,
- generation of local employment,
- creation of community size enterprises, and
- showing residents direct results of recycling.

Non-wood fibres for paper

If we are to be self sufficient in locally produced paper, recycling is only part of the answer. Virgin fibre will always be necessary as during recycling some paper is lost and there is some deterioration of the fibres. This can be from wood pulp, or perhaps more interestingly, from traditional UK crops such as flax and hemp. These non-wood fibres are long and strong and can be pulped on a smaller scale using less energy and fewer chemicals than wood based paper. Indeed, Bioregional Development Group is currently working on the revival of the growing and processing of these crops in our bioregion, Surrey, Sussex and Kent to produce paper and textiles to supply local markets (Riddlestone & Desai, 1994).

An outline feasibility study

As a first step towards this ideal of local recycling of paper we have aimed in this report to establish:

- the amount and grades of paper and rag waste arising in the London Borough of Sutton and Greater London and what currently happens to this waste;
- how waste paper collection schemes operate with particular reference to Sutton and London;

- what grades/sources of paper are under-utilised and what grade of paper it would be best to produce;
- appropriate scale technology for a local/regional recycled paper mill;
- whether it will be necessary to de-ink collected wastepaper and the most appropriate technology to do so;
- potential sites for a mill including what mills are operating in our region;
- summary of environmental considerations such as energy use, effluent and water consumption;
- possible ways forward, possible partners and ways of involving the local community and businesses;
- recommendations as to next steps.

These points are considered in the report in the following sections.

Section 1 is an appraisal of the current situation with regard to UK paper production, paper production in our region, imports, forests and use of recycled paper. The need to reduce paper consumption is discussed.

Section 2 investigates the complexities of recycling to produce a quality, high grade office/printing paper. We look at the subject from an environmentalists point of view - that energy and water be used as efficiently as possible and waste be minimised and recycled. In order to minimise transportation the smallest viable scale of mill is investigated.

Section 3 describes current waste paper collection schemes, amounts of paper collected and waste generated in Sutton with reference to Greater London. Attitudes of recyclers and consumers and technical specifications required for office and print machinery are detailed.

Section 4 discusses bioregional development and its relevance to the paper cycle, examines the potential for the use of agricultural by-products to upgrade waste paper and then proposes a vision of a sustainable paper cycle in the South-East and draws final conclusions and recommendations for ways forward.

As authors of this report we do not claim to be experts in the collection and processing of waste paper. We have however, conducted our research as thoroughly as we were able, taking advice from industry and building upon the work we have already carried out as part of our Bioregional Fibres Project.

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Abstract - Local Paper

This report aims to set out the potential for sustainable paper production in our region, the South-East of England. In particular we looked at the collection and recycling of office waste paper upgraded with non-wood virgin fibres to produce high grade printings and writings papers. This grade currently contains less than 6% recycled paper.

The report concludes that the smallest technically viable size of paper mill to manufacture these high grades of paper would produce 10,000 tonnes per annum and could be served with high grade waste paper from a 20 mile radius in our region.

Section One Paper and recycling in the UK

There is a need for greater self sufficiency in paper in the UK as part of the drive towards sustainable development. The imperatives and potential for local recycling of paper can be seen if we briefly examine virgin paper sources, the current UK paper market and the situation with regard to recycling paper and rags in the UK.

1.1 Paper and recycling in the UK - the current situation

Paper and the world's forests

In the UK we primarily use imported virgin paper. In the last decade there has been much concern about the impact of modern forestry techniques and ever-increasing rates of extraction on the world's forests. A recent report by the Worldwide Fund for Nature (WWF) cited papermaking as one of the greatest threats to natural forest survival (Dudley & Stolten, 1995).

In Europe, 50% of timber felled now goes to make paper and board* (35% worldwide). Most of this timber comes from softwood plantations, but native forests in Europe, North America, Latin America, Russia, Australia and Asia continue to be felled to produce paper (see figure 1). It has been estimated that 20-30% of pulp and paper produced in Canada and North America come from old growth forests (WWF, 1995). Most of the UK's imported paper pulp (37%) and 11% of our finished paper and board products come from these countries (Pulp and Paper Information Centre, pers comm). Once cleared old growth forests are often re-planted with non-native tree species.

Plantations are often cited as the answer to meeting our paper needs, but many environmental problems are associated with them. Most plantations are monocultures of non-native species, usually conifer or eucalyptus (WWF, 1995). They usually replace an existing natural habitat, leading to reduced biodiversity and detrimental changes to the local ecology. In addition, indigenous people are often displaced.

It is clear that we need to reduce our virgin paper consumption in order to alleviate the pressure on the world's forest resource.

UK paper consumption

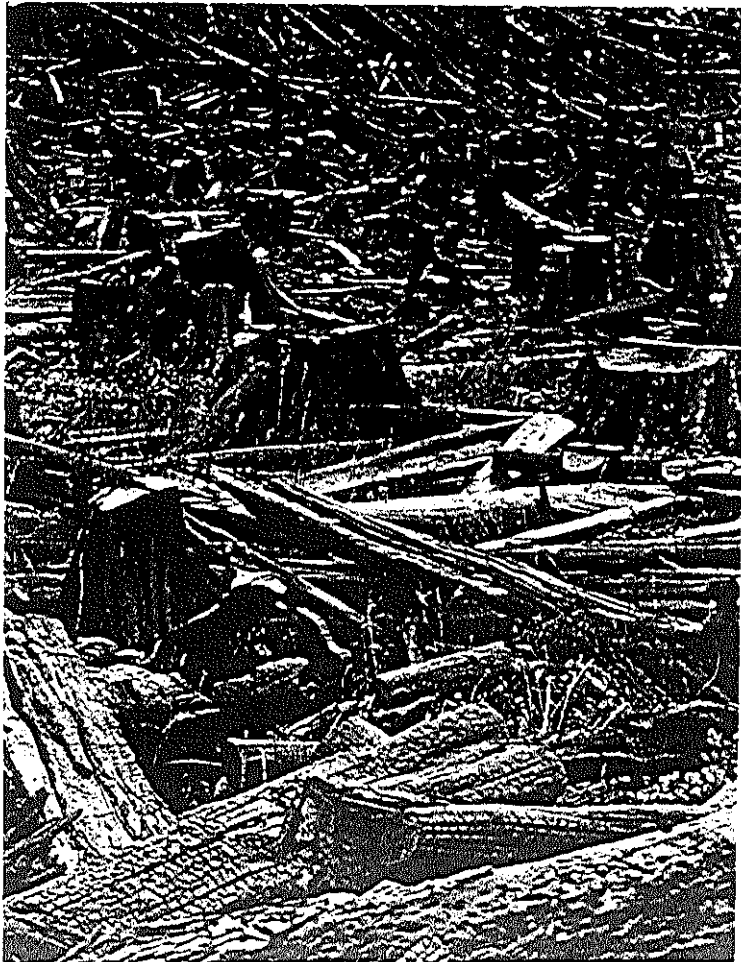
In the UK we import 73% of the paper we consume, either as finished paper and board products or as virgin pulp for papermaking in the UK paper industry.

In 1994 we consumed 11.6 million tonnes of paper and board, or 200kg per person (PFGB, 1995, b). This is a staggering 20% increase in consumption on the 1992 figure of 9.6 million tonnes (BPBIF, 1993). Paper pulp prices were extremely low from 1991 to late 1993 - woodpulp cost approximately £250 per tonne in late 1993, compared to £430 per tonne in July 1995, (Borregaard UK, pers comm) which may account for some increased consumption. UK Paper consumption by sector is detailed in figure 2.

* board is the term used by the paper industry for cardboard - as distinct from particle board such as chipboard

The fact is that paper consumption both in the UK and globally continues to rise. A recent report by Friends of the Earth (FoE, 1995) states that if we are to have sustainable and equitable use of wood globally, then we in the UK must reduce our consumption by 65%. FoE state that this can be achieved through consuming less (see the end of this section), and replacing virgin wood use with recycled paper or the use of non-wood fibre alternatives.

Figure 1 - Clearcutting old growth forest, Clayquot Sound, Canada.



UK paper production and imports

The paper industry is divided into two main parts;

1. pulping
2. papermaking

Some mills, known as "integrated" mills, carry out both pulping and papermaking on one site. In the UK there is little pulping, but some papermaking - the UK paper industry is mainly geared to producing finished paper and board products from imported paper pulp and waste paper. There are a number of different grades of paper and board i.e. newsprint, packaging board and printing and writings papers. We will consider paper grades in more detail in the following sections. In the UK we produce all of these different types of paper and board.

From the figures in Box 1 we can deduce that we are importing 73% of the paper and board products that we consume (PFGB,1995,b). Paper and pulp imports cost the UK £4 billion annually (Pulp and Paper Information Centre - PPIC - pers comm) - an increase of £1 billion on 1993 figures.

Box 1 - Some figures about the UK paper industry.

In the UK we consume 11.6 million tonnes of paper and board, of this:

- we produce 4.6 million tonnes of paper and board (40% of our total consumption);
- we import 7 million tonnes (60%) of finished paper and board products, mainly from Scandinavia;
- we import virgin wood pulp to produce paper in the UK mainly from Canada, North America and Scandinavia, pulp imports account for 31% of fibrous raw materials used in UK papermaking; and
- we produce and export 1.2 million tonnes (10% of our production).

There are 99 paper mills in the UK producing a variety of grades of paper. There are only eight pulp mills in the UK, producing just 5% of the total UK paper consumption and exports (PFGB, 1995b) - four produce packaging and newsprint from UK wood, four make tea-bags, cigarette paper and banknotes from annual plant fibres (Riddlestone & Desai,1994).

Box 2 - Some points on waste paper in the UK:-

- waste paper accounts for 62% of UK paper and board production and is being used mainly to produce card, packaging and newsprint;
- printings and writings grades contained only 6% waste paper in 1994, but much of this is likely to be mill off-cuts known as "pre-consumer" waste, not true waste i.e. "post consumer".
- Recycled content of imported paper is not recorded.

Scope to increase the use of recycled paper in the UK

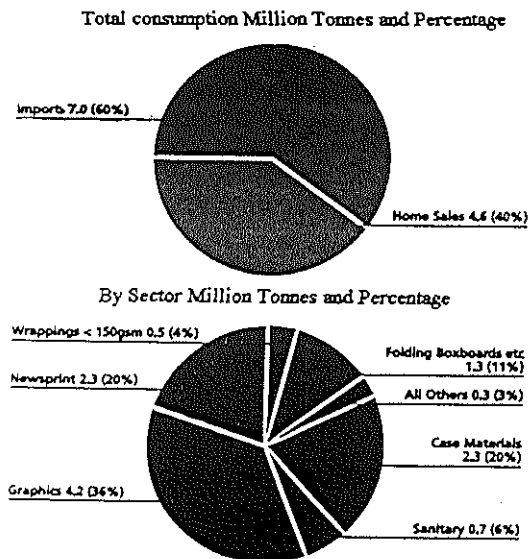
Sometimes the fact that UK paper mills use 57% waste paper (3.7 million tonnes PFGB 1995a+b) is used to illustrate good practice. However, if we look at the overall picture of paper and board consumption given that we import the bulk of our requirements, we find that this UK recycled paper and board accounts for only 28% of total UK consumption. Most imported paper and pulp is virgin (pers. comm, PPIC). Globally, the waste paper utilisation rate was 39% in 1992 (IIED, 1995) suggesting UK utilisation rates are on the low side.

From the above figures we can see great scope for improvement in waste paper utilisation. This is particularly true in the case of printings and writings paper, also referred to as graphics papers (see box 2). In the UK we already use waste paper for packaging (corrugated casings and packaging boards), tissue and newsprint in large quantities (see figure 3). However, printings and writings, the largest sector, accounting for 36% of the paper we use, contains only 6%, mainly pre-consumer waste paper.

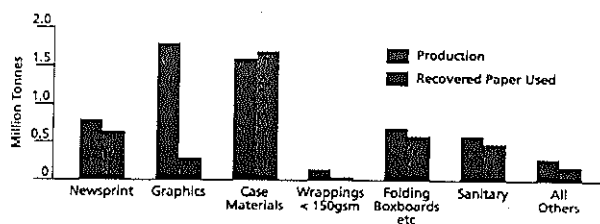
Ironically, we do not use all of the waste paper we collect. In 1994 we exported 420,000 tonnes of waste paper and imported 140,000 tonnes. Export figures are expected to be greater in 1995 as although waste paper prices are high in the UK, they are even higher in continental EC countries (PPIC, pers comm).

Waste paper collection rates of up to 75% are reported for the Netherlands. Friends of the Earth have estimated that up to 4,500 jobs could be created from a similar expansion of UK paper recycling (FoE, 1995). This would also help to reduce the £4 billion deficit to the UK balance of payments created by importing 73% of the paper and board and papermaking raw material that we consume.

Figure 2 - UK consumption of Paper and Board by sector 1994



Source: The Paper Federation of Great Britain



Source: The Paper Federation of Great Britain

Figure 3 - Recovered paper usage in UK production by sector 1994
n.b. Graphics refers to printings and writings papers

Recycling and the environment

Once paper has been used there are currently three main possible fates. It is either:

1. landfilled
2. incinerated
3. recycled

A report by the Warren Springs Laboratory in 1992 found that recycling paper significantly reduces air and water pollution and saves anything from 28-70% of the energy used to process virgin pulp (Ogilvie, 1992). Of course it also reduces pressure on the world's forests and on landfill space if it is dumped.

Some reports by government and consultants to industry suggest that it would be preferable to incinerate waste paper for fuel rather than landfill it, with some even suggesting that incineration is preferable to recycling. Paper has a thermal energy value of $15,000\text{Jg}^{-1}$, which can be compared to oil or gas which have thermal energy ratings of $40,000-50,000\text{Jg}^{-1}$ (IIED, 1995). However, incineration has environmental effects which have not been fully assessed (see section 2) and is therefore not necessarily a good option.

Although recycling paper has been shown to be less environmentally damaging than producing virgin paper, nonetheless it does have environmental impacts which are outlined below:

- collection and transportation of waste paper will involve use of fossil fuels;
- depending on the grades of paper recycled and produced, 10-40% of the waste paper is lost in the recycling process and ends up as a disposal problem (see below);
- some effluent will be produced, which will be increased if the paper is de-inked or bleached. Waste water can be recirculated and treated, but solid wastes (baling wire and other rejects) and sludge will be produced. Solid waste is landfilled, sludge is usually disposed of by landfilling, land spreading or incineration; and
- energy consumed in recycling and de-inking is significant, though less than the energy needed to pulp virgin fibres.

However, there are ways of minimising these impacts. These issues are covered in more detail in Section 2.

The argument against recycling does not stand up to close scrutiny. Studies critical of recycling paper and promoting incineration generally exclude environmental and economic costs such as the cost of producing the wood, and assume that the waste paper will be transported thousands of miles to be recycled if it is not burnt locally. To our knowledge, local recycling of paper has not been shown to be uneconomic.

As mentioned earlier we import 140,000 tonnes and export 420,000 tonnes of waste paper. This occurs because the paper merchant can obtain a higher price elsewhere. This is obviously not a good idea from an environmental point of view, with increased transportation leading to more pollution and other environmental problems, when we could utilise this waste for home production.

Rags - an alternative source of waste for papermaking?

Until a process was developed to pulp wood in the mid nineteenth century, rags of natural fibres, such as flax, hemp and cotton, were the staple papermaking raw material. A very high quality paper can be made from natural fibre rags which are almost pure cellulose. Indeed, a small industry utilising this waste remains to this day in India.

Currently, approximately half a million tonnes of textile waste is discarded annually by households in the UK of which 25% is reclaimed as old clothes for re-use and recycling. In addition, an unspecified amount of waste textiles are produced as trimmings and other waste from garment manufacturers.

However, a spokesperson for The Reclamation Association stated that it would not be possible to use rags today for papermaking because of contamination of natural fibres with synthetics. Today, many fabrics are blends of natural and synthetic fibre and even a polyester thread used to stitch a seam in a cotton garment can preclude it from use in paper making. It is very difficult to tell if there is a synthetic content in waste rags and consequently, even though the rag reclamation business was built on retrieving textiles for paper making, rags are now used to produce wadding for furniture and cars, where a synthetic content is unimportant.

Therefore, as this would seem to be a very difficult problem to circumvent and there are other uses for rags, for the remainder of this study we will concentrate on waste paper recycling alone.

The potential for greater use of waste paper in manufacture in the UK

While it is possible to use high grades for low grade end use, the reverse is not generally true. For example, high grade waste paper is often used to produce toilet tissue, but cardboard is not used for photocopier paper.

Packaging and board - Two thirds of waste paper and board collected in the UK is low grade card and packaging which is recycled back into similar grades. Around 50% of packaging is collected for recycling. Indeed, the recycled content in UK produced packaging is very high at 80-90% (FoE,1995). This is clearly an area where the industry is demonstrating good environmental practice and have a commitment to recycling.

Newsprint and magazines - Only 9% of newspapers, magazines and printed advertising material is recovered from the domestic sector (FoE,1995). If we allow for a good but realistic level of participation in recycling schemes, potentially 75% could be collected and recycled. FoE estimate that this would equate to a further 800,000 tonnes per annum which could be used by the newspaper industry should they choose to print on a paper with a higher recycled content. Indeed the UK newsprint producers and manufacturers have set a voluntary target of 40% recycled fibre in newsprint by the year 2000 (PPIC,1994).

The paper industry has recognised the opportunity here. Aylesford mill in Kent has recently been extended to produce a further 90,000 tonnes per annum (TPA) of de-inked, recycled newsprint. Newsprint manufactured in the UK now has one of the highest recycled contents (74%) in the world (PFGB,1995). However, in 1994, although 0.6 million tonnes of recovered

paper was used in newsprint manufacture only about half of that was UK post consumer waste, the balance being from over-issue newspapers, which are printed but remain unsold, and some imported waste paper.

Printing and writing paper - Chemically pulped and lignin free, this grade of paper is the most expensive and produces the most valuable waste paper. It is used for glossy magazines, printed advertising material (PAMs), computer print-outs and office paper. Office and computer paper is not being collected on a large scale. A recent article in "Materials Recycling Week" states that paper merchants are now looking to office recycling "where the largest uncollected segment of high quality waste paper is believed to be found" (FoE, 1995). Friends of the Earth have estimated that 1.5 million tonnes of high grade office paper could be reclaimed and recycled from commerce, industry and institutions (FoE, 1995). These figures allow for the fact that only 70% will be recycled and that some 10% is likely to go into long term storage.

Printings and writings papers used in the UK make up the largest share of imported paper volume and contain the lowest levels of waste paper of any grade, around 6% for UK produced paper (PFGB, 1995a+b), most of which, as stated before is likely to be pre-consumer waste (also known as mill broke) - see figure 3. Although 1.8 million tonnes of this grade is produced in the UK it is made from imported virgin wood pulp. Friends of the Earth are advocating a minimum target of 60% recycled content in printings and writings papers by 2005. There would seem to be no technical barriers to a higher recycled content as there are 100% recycled copier papers on the market which are guaranteed for use in laser printers and high speed copiers (PUA, 1994).

Technical and logistical considerations when utilising waste paper

There are technical and logistical reasons why recycling efforts have concentrated on packaging and newsprint. Packaging grades can be made from waste that has not been sorted or de-inked and can be collected easily from large commercial organisations. Newsprint does not need very thorough sorting and the addition of a little chemically pulped printings and writings paper will only serve to upgrade it. However, printings and writings grades need to be sorted from newspaper, board and highly coloured printed matter. In addition, collection from many scattered offices, homes and businesses has, to date, been considered expensive.

Legislative & voluntary measures to encourage recycling & use of waste paper

Measures to increase recovery of waste paper and board An EU directive on packaging is being introduced as part of The Environment Bill. This will set in place Producer Responsibility Regulations which will require the packaging industry to recover 50-65% of all packaging by 2000 (PFGB, 1995). As we import a large proportion of our packaging and already utilise a high proportion of waste paper in this sector, this may generate more waste paper & board than can be recycled through home production (PPIC).

In addition, the government have set voluntary targets for overall recycling of waste of 25% by the year 2000. Paper and board is estimated to represent 33% of the domestic waste arisings and is one of the most easily recovered waste materials. From domestic collections the paper recovered is likely to be mainly newsprint and card with a little high grade paper mixed in.

There are other measures which government has introduced to encourage local authorities to reduce waste going to landfill and promote recycling. These include the landfill levy and the recycling credits scheme.

The landfill tax consultation paper issued in March 1995 proposed the formation of private sector environmental trusts to 'clean up old landfill sites and promote sustainable waste management practices'. The proposed trusts would raise their finance from rebated tax, supplemented by payments from the waste industry. It is also proposed that landfill rebates would be available to landfill operators making payments to the trust for specified environmental purposes. The actual figure for the tax has not yet been decided, but it has been suggested that it should be a 50% ad valorem tax (The World Resource Foundation, 1995).

The Recycling credits scheme was introduced in April 1992 "to make available to recyclers the savings in disposal and collection costs which result from recycling household waste". Waste Disposal Authorities (WDAs) are required to pay a credit to Waste Collection Authorities (WCAs) operating recycling schemes (Department of the Environment, 1994).

Measures to boost demand for recycled paper and board The UK newsprint producers and newspaper manufacturers have set a voluntary target of 40% recycled content in newsprint used by the year 2000. Again, home produced newsprint already contains 74% recovered paper, but most newsprint is imported and has a much lower recycled content, bringing down average recycled content to 26% in 1993 (IIED, 1995). Large paper purchasers can specify a minimum recycled content. Her Majesty's Stationery Office (HMSO) for example have such a scheme.

Paper making in our Region - Surrey, Sussex and Kent

Paper has been produced in Kent for hundreds of years - there are no mills in Surrey or Sussex. Eleven mills are producing approximately 1.5 million tonnes per annum (TPA) of a wide range of grades. Two large new facilities have recently been built on to existing mills to recycle 90,000 TPA of newsprint and 100,000 TPA of printings and writings papers. This has led to increased demand for waste paper locally.

In conclusion - benefits of local recycling of paper in the UK

It is clear then, that there would be many benefits arising from the establishment of local recycling of paper, including;

- reduced pressure on the world's forests and landfill space;
- reduction in the £ 4 billion cost to the UK balance of payments brought about by paper imports;
- generation of local employment and increased stability of the local economy;
- reduction of transportation of paper and pulp around the world, with its associated pollution and other costs.

The sector with the most scope for greater recycling and increased recycled content is the printings and writings sector.

1.2 Excessive paper consumption - some food for thought

As discussed earlier, paper consumption in the UK increased by 20% over two years in 1993-94, reaching 200kg per person. Interestingly, this was at a time when the price of paper hit an all time low. Further dramatic increases in consumption of paper would negate any benefits incurred in local recycling and production of paper. Therefore, any strategy to develop a sustainable paper industry would have to include measures to reduce consumption and encourage re-use of paper. Several environmental organisations provide advice on reducing paper consumption. A selection of ideas from Waste Watch, Friends of the Earth and Women's Environmental Network are given below.

Cutting down on stationery use. A reduction in paper intake should be part of any environmental policy for companies and households. Most companies and individuals do not even use the reverse side of a piece of paper. This simple policy could bring about a noticeable reduction in paper use. Envelopes can be used again and paper which has been used on one side only can be used as scrap paper for messages or internal memos for example.

Re-useables instead of disposables. We are now using paper as a substitute for re-useable items which were the norm as recently as the 1950s. A greater use of washable items such as handkerchiefs, serviettes, nappies, towels, tea towels, milk bottles and china crockery instead of their disposable paper alternatives could reduce individual and corporate paper consumption.

Avoiding overpackaged goods. With the advent of supermarkets, convenience food and self service stores, the use of packaging, particularly for wrapping food, has increased dramatically in the last 50 years. Consumers should avoid overpackaged goods, companies could take greater steps to reduce the amount of packaging they use. A Dutch study found that a 10% reduction in packaging could easily be achieved through better design (FoE, 1995).

Cutting down on purchases of heavy newspapers and magazines The weight of newspapers and magazines on sale has become ludicrous, ask any Sunday paper deliverer - do we really need to buy so many of them?

Unsolicited mail Most companies and individuals would prefer not to waste time dealing with unsolicited mail. Registering with The Mailing Preference Service, at Freepost 22, London W1E 7EZ prevents such mail at private households, however, there is no such service for companies.

Increasing the price of paper An increase in the price of paper would lead to reduction in consumption. This increase could either occur through market forces or market intervention. An example of market forces at work is the case of News International - following continuous rises in the cost of newsprint during 1994 the directors instructed editors to reduce the amount of pages in their publications. Market intervention could be accomplished by shifting tax burdens on to natural resources as has been suggested by a number of environmental economists. This would increase the price of virgin pulp, making recycling more competitive.

In the following section the technical aspects of recycled papermaking and perceived problems and attitudes of consumers to the use of recycled paper are discussed.

Section Two Technical Aspects of Recycled Papermaking

In order to decide what sort of equipment is needed to produce recycled paper from high grade waste paper we need to look at the volume of waste available and the grade of paper we want to produce. Then we must weigh this against the economic, technical and environmental feasibility of various systems. In this section we will investigate technical options and consumer requirements, giving ideas of costs where possible.

2.1 The papermaking process - briefly described

Paper is made from cellulose fibres which have been broken down to their ultimate fibre length of around 2-4mm through a mechanical and/or chemical process known as pulping. As this project is concerned with recycled paper, which has already been pulped, we do not need to examine pulping methods.

To make paper, cellulose fibres are suspended in water at concentrations of around 1%. Mineral fillers and various chemical and/or polymeric additives are added depending on the grade of paper to be produced.

In mechanised papermaking the 1% fibres mixture is distributed evenly across the "wire", a fine mesh conveyor belt which stretches across the paper machine. The wire is shaken to evenly distribute the fibres. Water is progressively removed first by natural drainage, then by vacuum, then presses and rollers until a smooth sheet of paper is formed. Steam heated rollers dry the paper further, then the finished paper is wound into huge rolls at the end of the machine. It can be cut down to the sizes required on another machine.

When making paper by hand, a mould and deckle are used. The mould is a hand held frame with a layer of mesh stretched across to "catch" the fibres, but allow water to drain away. The deckle is a frame which fits inside the mould to produce a distinctive edge, known as a "deckle edge", to the paper. The mould and deckle are briefly dipped into the paper pulp mixture, then removed and gently agitated to distribute the fibres evenly across the sheet. Excess water is drained back into the tub, the deckle is removed and the freshly made sheet is inverted onto a sheet of absorbent felt (Jackson, 1991). The sheets of paper on their supporting cloths are stacked in layers between felt and then pressed to remove most of the remaining water. The sheets are then peeled off and allowed to finish drying. Sizing of the paper to give a non-absorbent surface to the sheet can be carried out once the sheet is formed and partially dried (see case study 1).

2.2 Re-pulping and preparing post consumer waste paper for papermaking

Both pre and post-consumer waste paper can be beaten and wetted down to a pulp slurry and made directly into paper using the processes described previously. However, when making paper from post-consumer waste paper, a number of other processes are often carried out. The raw material is similar to bought-in pulp in that the fibres are prepared for papermaking, but contain ink, dye, fillers and coatings and are contaminated with glue (stickies), staples and other foreign objects. Additionally, high grade printings and writings papers, which we are considering as our source of waste paper, contain large amounts of fillers (e.g. clay and calcium carbonate) and coatings in order to produce a smooth sheet. These additives can account for 15-25% of

Case study 1

Griffen Mill - Handmade Papermakers

Griffen Mill make and supply paper made in the traditional way from non-wood fibres mainly for the restoration of old books and documents. The mill occupies a space of approximately 900 square feet on two floors. Their customers include The British Library, Her Majesty the Queen and the US Library of Congress. Chris and Michael Laver-Gibbs established their papermaking enterprise in an Old Mill in Somerset in 1992. Prior to that in 1987, Chris had been making hand made paper from home, initially for stationery, then in 1989 for repair papers.

Chris became interested in papermaking some years ago after a visit to Wookey Hole craft papermaking tourist centre. Chris studied specialist books on the subject and began experimenting with papermaking recipes.

Chris and Michael make paper from cotton, manilla hemp and linen pulp. They make paper to order, matching the customers requirements and produce a tonne of paper a year. They have many overseas orders.

The equipment they use is simple and the method labour intensive. A hollander beater is used to beat the pulp. It took Chris three years to find an old one, though new ones can be bought for around £10,000. Chris explained that in making paper there are different recipes for different paper, the amount of time the pulp is beaten can give tremendous variation in the type of paper produced. The fibres in the pulp need to be beaten not just to shorten the length but also to get the fibres to fibrillate so that they will mesh together to form a strong sheet. They find that one beating of 8kg of pulp will make the equivalent of approximately a 1000 sheets of A4 paper.

When the pulp is judged ready it is transferred to a large vat. The papermaker dips in the mould and deckle, lifts it out, agitates it to mesh the fibres, and, after briefly draining, transfers the paper to a piece of old blanket (couching). The mould and deckle are specially made by a Kent craftsman. There are many different sizes and watermarks available. The Laver-Gibbs tend to produce most sheets in an old Royal size which equates approximately to A2. The sheets are piled up with a piece of blanket between each piece of paper. When the pile is sufficiently large it is transferred to a 120 ton press to squeeze out the water. Then it is hauled up to the next floor where the sheets of paper are removed and placed between sheets of card to be further dried. This method is known as restraint drying. If the sheet is left to air dry, paper takes on an unacceptable "chicken skin" texture.

The paper produced can be sized with starch or gelatine to make the sheet smoother and less absorbent to ink.

While Chris and Michael use high quality virgin pulp to produce high value, extremely specialist papers, the methods used are similar to that which one would employ for any handmade paper mill. Handmade paper making is obviously very labour intensive and hence the cost of the final paper is extremely high. Making paper in this way can only be economically viable for highly specialist markets or high value added products such as top of the range handmade stationery for gift sets.

the waste paper volume. It is possible to leave inks, dyes and fillers in the paper (see case study 3), but usually this means downgrading the end-use. The main technical issues involved in the preparation of post-consumer waste paper for recycling are:

- removal of foreign objects;
- removal of sticky materials;
- de-inking;
- water useage and effluent; and
- disposal of contaminants.

A number of methods and systems have been developed to remove large and small contaminants - inks and stickies in particular. Removal of these contaminants is expensive in terms of installing and running extra equipment. In addition, the mill then has the problem of disposing of 30% on average of its annual input as waste (IIED,1995), with the associated environmental considerations.

Removal of contaminants from waste paper - a typical system

Every paper mill is tailor made to the customers requirements. However, a typical contaminant prevention and removal system (Pierrat,1993; Ferguson 1992; Mjoberg,1993; Rhodes & Ferguson,1993) would include sorting prior to pulping followed by removal of contaminants during repulping.

Sorting prior to pulping can include:

- continuous education of those who are supplying the waste paper i.e. office workers and paper merchants; and
- careful inspection on delivery to the mill to sort and remove any obvious contaminants.

The waste paper can then enter the paper mill.

During re-pulping and cleaning in preparation for papermaking a series of different screens, compactors and flotation and centrifugal methods are employed to remove:

- large contaminants such as plastic bags, string and wire;
- smaller contaminants such as paperclips, staples and pins; and
- stickies and melted plastic fragments.

Ink particles can be detached and removed at various stages during processing by the above methods and in addition, by:

- mechanical means which break down the ink particles to a smaller size and disperse them throughout the sheet, and/or
- using chemical methods, either
 - chemicals which disperse large ink particles to a smaller size removable by flotation or washing or
 - chemicals which agglomerate the particles so that they can be removed by cleaners or screens.

The method of ink removal employed will depend upon the type of ink predominating in the waste paper. For example, office waste paper will contain more non-impact inks (from office copiers and printers) which have their own removal method.

Fillers can either be removed with the inks, especially during flotation de-inking and washing procedures, or retained through the use of appropriately sized filters at the thickening stage prior to the papermaking machine.

Bleaching is typically carried out with peroxide at various stages of processing to improve the brightness of the paper. It is not always necessary and would depend upon the brightness and quality of the raw material used and end-use requirements.

Then papermaking can proceed as described previously. Contaminants removed in recycling and de-inking waste paper typically amount to 30% of the input and are usually sent to landfill (IIED,1995).

2.2.1 Stickies

No matter how well sorted, a variety of sticky contaminants are always found in wastepaper. Sources of stickies include envelopes, tapes, magazine and notebook bindings, pressure sensitive labels and laminated paper. When stickies are present in high concentrations they affect both paper machine operation and product quality (Doshi,1991).

Paper machines contaminated by stickies literally get covered in glue. This causes a number of process related problems, e.g. "blinding" of wires which reduces drainage efficiency and product quality problems, e.g. paper contaminated by stickies can make paper layers stick together after papermaking when they are wound on to the roll, causing holes and defects. This can also cause problems in high speed paper converting and printing operations.

Solutions to this sticky problem include;

- careful sorting of wastepaper prior to pulping;
 - use of auxiliary equipment with the pulpers to remove large contaminants such as bookbindings before they are broken down into small pieces;
 - screening and cleaning with a slotted screen to remove large and medium size stickies said to be the most effective piece of equipment for removing stickies;
 - dispersion to break up remaining contaminants and ink so that they are invisible in the finished paper; and
 - introducing a variety of additives variously to scavenge any remaining stickies, disperse or detackify them.
- An alternative approach is to solve the problem at source i.e. to develop adhesives that do not hinder the recycling process (PIRA).

Office grade waste paper is bound to contain stickies and therefore measures to deal with them have to be included in a high grade waste paper recycling mill.

2.2.11 De-inking and bleaching

It is not necessary to de-ink waste paper as long as you don't mind it being grey! Non de-inked paper is acceptable in the production of boxes and toilet paper but for paper for use in office machinery for example, de-inking is considered essential. In 1990, 17% of the paper recycled throughout the world was de-inked, but this is expected to reach 24% by 2001 (Mjoberg et al, 1993). More than 50% was used to produce newsprint, about 25% for tissue, only 10% was for printing and writing paper.

De-inking increases the environmental impact of recycling. It increases the amount of reject material removed and sent to landfill and the waste water load in effluent discharged. As previously mentioned, large amounts of fillers and coatings such as china clay, calcium carbonate and starch are added to high grade printings and writings papers to produce a smooth sheet. Most of these fillers and coatings are removed with the ink, especially in flotation de-inking and washing prior to papermaking. Fillers and coatings typically constitute 50-65% of the waste removed (IIED,1995), equivalent to approximately 18% of the waste paper input to the mill. Recycled newsprint does not contain fillers, although magazines, which make up 20% of a newsprint furnish do - therefore this problem is less apparent when producing recycled newsprint (Graham Moore, PIRA, pers comm).

Heavy metals are a constituent of certain printing inks and are found in significant quantity in discharges from recycled/de-inking mills. However, most can be removed during primary and biological effluent treatment in place at paper mills and the metal content in sludge is therefore usually lower than municipal sludge. In addition, there is a continuing trend towards the use of metal-free ink (Mjoberg et al, 1993).

Despite the large amount of waste produced and increased load in the effluent, a US paper industry watchdog body, The National Council of the Paper Industry for Air and Stream Improvement, found that sludges from de-inking mills are comparable or superior in quality to municipal wastewater treatment sludges (IIED,1995).

Understanding inks and printing methods

The methods of de-inking required vary according to the waste paper input. A brief explanation of inks and printing methods used is necessary before we can look at de-inking techniques in detail.

There are a number of different printing methods, but basically printing falls into two types;

- **impact printing which is the method that commercial printers generally employ i.e. offset or flexography, and;**
- **non-impact printing which is used in photocopying and laser printing.**

Ink is made from two main constituents - pigments, which give colour, and resins which bind the ink to the paper. A solvent, either water or oil is used to make the ink fluid.

Impact printing

There are a four main impact printing methods which print by contact or impression with the paper, namely, letterpress, offset, gravure (engraved plates i.e. for stamps) or flexography. The two main techniques of interest are offset and flexography.

- Offset and litho printing are the most popular printing methods using mineral or vegetable oil based inks.
- Flexographic printing uses water based ink which does not come off on the hands and has become more commonly used over recent years.

Non-impact printing

Non-impact printed material, although not found in large quantities in the overall waste stream, will be significantly higher in waste paper collected from offices and therefore is of particular relevance to this study.

Fused toner inks are used for non-impact printing. There are three common methods, xerographic (photocopying), laser and ink-jet printing. All three methods work by fusing the ink to the paper by the action of heat.

- In xerography, the ink particles are negatively charged - when copying, the image area on the paper is given a positive charge, attracting the toner particles, which are then fixed by heat.
- Laser printing works in a similar way to xerographic printing. The laser beam forms a neutrally charged latent image on the charged drum. The toner particles are then attracted to the remaining charged areas, transferred to the paper, and fixed by heat.
- Ink-jet printing works by spraying a controlled projection of ink droplets directly on to the paper, guided by a digital image of the original document.

Fused toner inks cause particular problems in recycling and de-inking as they are made up of large particles which are visible in the paper produced, but which are difficult to remove by traditional de-inking methods.

De-inking methods

Flotation de-inking was developed 30 years ago and proved a breakthrough in large scale de-inking of waste paper (Fallows, 1992). It is a chemi-mechanical process which was designed to remove oil based inks by utilising their hydrophobic properties and particle size (5-10m). Larger particles can also be removed using this process but with reduced efficiency. Flotation de-inking works by the attachment of ink particles to air bubbles which rise to the surface and are then removed by a variety of mechanisms. It is not very effective with flexographic inks as they are hydrophilic and are smaller (5m) in size than oil based inks (Cathie, 1990). Flotation de-inking also removes large quantities of fillers. Wash de-inking, a popular method in the USA, is now increasingly being combined with flotation de-inking (Graham Moore, PIRA, pers comm).

Cleaners, screens and washing

Necessary equipment for recycled paper pulping such as cleaners which remove grit and staples, screens which remove stickies and other contaminants and washing, all remove some inks as well. The agglomeration technique in particular makes use of the screens and cleaners, although additional screens may be needed. Washing also removes large quantities of fillers.

Techniques for toner ink

Techniques used for the removal of toner ink are different because of its particular properties. Toner ink particles are released in large flat flakes which are awkward to remove using cleaners and screens or flotation and washing. The flakes can be seen with the naked eye, meaning that they can affect the paper brightness even at very low levels (Ferguson, 1992). There are two chemical methods of removing these large flakes - either to break them down so that they can be removed by flotation and washing or to agglomerate them so that they stick together in large enough clumps to be removed by cleaners and screens.

Liquid ink-jet printer ink is a dye and disperses or even dissolves on re-pulping. It is not readily removed by any de-inking method. However, bleaching does have a good effect and will brighten the sheet. The industry is still working out the best methods of dealing with ink-jet ink (Cathie, Borchardt & Johnson, 1994).

Agglomeration technique for removing toner ink particles

This technique appears promising for our purposes as it removes toner ink particles leaving the fillers and clays without needing to install expensive equipment like a disperser. The process of agglomeration uses a surfactant blend added to the pulper. To achieve the best result, conditions in the pulper need to be alkaline with a pH 10-11.5. At 60°C the toner particles become soft and stick together. The mixture is left for 30-60 minutes. The agglomerated particles can then be removed by forward cleaners. Although this relatively new technique does seem effective, it does have a number of problems associated with it.

In an interesting paper presented at a TAPPI Recycling Symposium, (Rhodes & Ferguson, 1993) a trial of agglomeration at Vancouver Mill in Canada is described. The mill has a 110TPD fine paper wash de-inking system and uses 40-50% recycled grade (up to 25% post consumer). Vancouver Mill want to be able to use more sorted office waste (containing non-impact inks) which is cheaper, but need a cost effective means of de-inking. The mill has been impressed with agglomeration but there have been some problems. They found that not all the agglomerated flakes were removed by their existing cleaners and tended to get distributed within the system creating problems in some, but not all, areas. For example, one pulper became covered in black, glass-like deposits, while another did not. The agglomerated particles also stuck to stickies and plastics and went surprisingly far down the system. However, the mill is sufficiently impressed with agglomeration de-inking to invest in the introduction of some extra coarse and fine screening at earlier stages of processing to deal with these problems.

Dispersion/Kneading

Dispersers and kneaders are machines which process pulp to reduce the particle size of contaminants such as ink or stickies so that they can be removed or so that they are invisible in the finished sheet.

These machines work effectively at pulp solution concentrations of 30%. Cleaning and screening operations used prior to this stage to remove staples and other large and medium contaminants work at a low pulp concentration of 2-4%. This means that extra equipment is needed to concentrate and heat the pulp prior to these processes. A mixing screw with steam injection is usually used. This makes it an expensive operation when combined with the cost of the disperser/kneader (Black Clawson, pers comm). However, one advantage of concentrating the pulp solution at this stage is that bleaching, which follows dispersion/kneading, is very effective.

Ultrasound de-inking

This is an experimental process which can significantly reduce toner particle size. It could be an alternative to the use of a disperser and is more flexible in that it is not sensitive to pulping temperature and is effective in the absence of surfactants and caustic chemicals (Offill & Vendetti,1995). However, the work does not yet seem to have progressed beyond an experimental stage and it is not known whether it will be commercially viable.

Bleaching

Bleaching obviously improves the appearance and brightness of the paper. For environmental reasons peroxide and oxygen bleaching are preferable to chlorine bleaching (WWF,1995).

Hydrogen peroxide comes in a liquid form and fairly high concentrations are needed for effective bleaching action.

The recently developed OXYPRO O_r process (see case study 2 below) bleaches and also de-lignifies waste paper, allowing slightly lower grades of paper to be used. It is no more expensive than traditional bleaching systems if set up as part of a new mill (Inveresk, pers comm).

Case study 2

Inveresk Fine Papers, Alloa, Scotland

- a small recycled fine paper mill using a novel bleaching system

The mill at Alloa, formerly Weir Paper, now Inveresk Fine Papers, produces the well known Repeat 100% recycled paper. Repeat laser copier is guaranteed to run on high speed copiers and laser printers. There are a range of repeat papers including letterhead and watermarked. The mill produces 40,000 TPA (125TPD) of paper on two paper machines. The mill also use virgin pulp.

A 35,000 TPA office paper de-inking system is in operation, half of the de-inked pulp produced is sold as wetlap pulp (50% moisture), the remainder is used to make paper at Inveresk. The yield from the de-inking plant is 70%. The 30% waste removed is mainly clay and chalk, some paper fibres and the ink. The waste is landsread in a controlled way (Inveresk Fine Papers, pers comm).

The mill has installed an oxygen and hydrogen peroxide based bleaching and de-lignification system as part of the de-inking system. The company is very pleased with the success of this new OXYPRO O_r process, as they now consistently produce pulp at 85% or greater ISO brightness and 5 ppm or less TAPPI dirt (Thomas et al,1995) despite fairly wide fluctuations in the quality of the waste paper input. The process is quite novel being the second of its type to be installed in the world and the first in Europe. The main benefit of this system is that it will bleach and de-lignify in a controlled way depending on the quality of the waste paper stock. The advantage is therefore that lower grades can be used and a uniformly bright, quality pulp is produced.

2.2.iii How grey is non-de-inked paper? - a practical experiment

Because of the obvious increased capital and running costs involved in de-inking and the environmental effect of discarding sludge full of useful fillers, it would obviously be preferable not to de-ink. However, all of the paper industry literature we have looked at suggests that it is essential. In order to assess just how grey non-de-inked office waste paper would be, we carried out a practical experiment. We pulped down several different samples of office waste paper in a kitchen blender and made some sheets by hand using a mould and deckle. We also tried adding hemp pulp and bleaching with sodium percarbonate to see if this improved the brightness and quality when judged by eye.



We made five different batches of paper as follows;

1. mixed laser and bubblejet printed material
2. bubblejet printed paper
3. laser printed paper
4. mixed laser and bubblejet with 25% hemp
5. mixed laser, bubblejet, fax and litho printed with 25% hemp and bleached with sodium percarbonate.

Figure 3 - Our papermaking experiment
Sarah Welsh and Sarah Riddlestone prepare waste paper for re-pulping

Results with unbleached waste paper

We found that when the laser printed material was pulped it released large particles of ink which were very evident in the finished sheet. In contrast the ink washed straight out of the bubblejet printed paper producing a greyer

sheet than the laser printed paper and very grey water, but without the large particles. Addition of hemp pulp did not seem to have a noticeable effect on the brightness of the paper, but did add strength and a quality feel to the sheet.

Bleaching

All the sheets produced were varying shades of off-white to light grey. We felt that they would all be unacceptable for use as printings and writings papers without further treatment. Therefore we decided to try out bleaching using sodium percarbonate.

Sodium percarbonate is sold by Ecover as the most environmentally acceptable bleach for use in home laundry. The bleach is in the form of a powder so that it can be stored safely until ready for use. In solution sodium percarbonate is mildly alkaline and breaks down into hydrogen peroxide and sodium carbonate. It activates in hot water at 40°C with the bleaching effect increasing up to 60°C. The hydrogen peroxide bleach converts to water and oxygen. We added 45 grammes of dry shredded paper to 5 litres of very hot, but not boiling, water and blended it into a pulp. We then added two heaped tablespoons of bleach powder. Bleaching action was fairly immediate.

Incidentally, sodium percarbonate costs £750/tonne and would need to be used in a concentration of about 4%, (Mc Gill, Interlox, pers comm). Without capital and labour costs this would add £30 to the cost of producing a tonne of paper.

The resulting paper was definitely brighter. It had a warm, creamy brightness and was judged by several people to be quite bright enough for use in offices for reports and letters. The brightness compared well with recycled papers currently on the market for office use, being brighter than some. Several people liked the overall effect of the spots of ink that were visible, but it was agreed that it was possible that a large ink particle could make a letter or word illegible. However, we tried printing text on it and it was completely legible, with ink particles being obviously part of the background not the text. On photocopying this text on to another piece of paper, a few background ink particles were evident, but again did not interfere with comprehension of the text at all.

Small pieces of the mixed white office waste paper, both unbleached and bleached that we made as part of this experiment can be found on the cover collage of this report.

Conclusions of our experiment

- Office waste paper when re-pulped is too grey for recycling into a similar grade and will need to be further processed to brighten it.
- We found that hydrogen peroxide/sodium percarbonate is an effective bleach, producing a paper sheet of what we considered to be an acceptable brightness.
- When re-pulped; bubble-jet ink washes straight out of the paper, and laser printed and photocopied material release ink particles which are visible to the naked eye, necessitating further processing.
- The addition of hemp pulp at 20% adds strength and a quality appearance.

2.2.iv Water and energy

Water

Large quantities of water are used in papermaking. Such process water becomes contaminated with fibres, fillers and chemicals and cannot be released straight into the sewer or waterway. Recycled paper mills have process water treatment systems to separate contaminants and re-circulate water, reducing the amount of fresh water required and effluent to be treated (Brink, 1993).

Effluent The widely used parameters for measuring the environmental impact of paper mill effluent are Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Suspended Solids (SS) (Canning, 1992). BOD and COD are measures of the amount of organic matter present in effluent. Decaying organic matter consumes oxygen to the detriment of other organisms present in the waterway. A high BOD/COD in a river can have a devastating effect on fish for example. High SS in effluent leads to blanketing of the river bed, disrupting its ecology. Paper mills need to have permits to discharge effluent within predetermined levels which are set and monitored by the NRA. Transgressions are usually dealt with by fining the mill. Permits are granted with regard to the quality and ecology of the particular river involved. Permits for new mills are likely to be more stringent than existing agreements.

Effluent Treatment Effluent treatment is necessary if the effluent discharged to a waterway or sewer falls outside the parameters set by the NRA as described above. Effluent treatment includes primary settlement and biological treatment. An effluent treatment plant for a 30-50TPD mill would cost approximately £1.4 million and would reduce BOD and COD by 80% (Riddlestone & Desai, 1994).

We can be sure that any new paper recycling mill will need process water treatment to remove fibres and contaminants to a level where the small amount of effluent produced could be discharged. Such a system would be tailor made to the mill site, size and other requirements.

Energy

Paper mills consume considerable amounts of energy in the form of electricity and heat to produce steam. Of course, reducing energy consumption also cuts costs, and the paper industry are willing to install energy saving measures as long as the "pay-back" period is reasonable. Detailed below are various energy saving measures with pay-back times of between 1-5 years which have been installed in mills around the world.

- Integration of pulp and paper mills saves energy as the pulp does not have to be dried to allow transportation.
- For power generation in recycled paper mills alternatives to buying mains electricity include:
 - combined heat and power systems using landfill gas; and
 - incineration of pulp sludge using a fluidised bed combustion boiler (CADET, undated).

- Adjustments to the stock preparation, feed and paper making systems can be made to allow for greater energy efficiency (CADET, undated). For example:
 - reducing and replacing equipment to optimise the fibre flow;
 - coating the draining elements of the paper machine with ceramic material to reduce energy requirements in driving the machine and drying the paper;
 - installing infra-red paper drying which penetrates and dries more effectively than the traditional steam heated drying cylinders.

2.2.v Disposal or recycling of contaminants arising during recycling

As discussed earlier, considerable amounts of contaminants are removed during repulping and cleaning of waste paper, more so if de-inking is undertaken. The amounts produced will depend upon the grade of waste paper recycled and on the grade of paper to be produced.

Typically 20%-30% of the waste paper input will be rejected in the process of producing a de-inked paper. Around 7% will be plastics, wires, string, staples and other solid rejects which is routinely sent for landfill (Mjoberg et al, 1993). Re-use alternatives, which have yet to reach mainstream application, include using the contaminants as a filler for concrete or as a gravel substitute for road bases (McBribre, 1992).

The remaining semi-solid waste (pulp sludge) will consist of fibres, fillers and ink. To reduce the volume and allow ease of handling, a variety of conveyers, de-watering and compacting devices are available (McBribre, 1992). This waste is usually incinerated or sent to landfill (Mjoberg et al, 1993). Incineration of pulp sludge can generate energy, but incineration has environmental effects which have not been fully assessed, in particular from dioxins produced and dispersed when incinerating chlorine (WEN, 1991). Therefore incineration does not seem a good option. Landfill space is restricted and as a wasteful option would not be environmental best practice. Therefore we must look for alternatives.

A number of alternative uses are being developed. These include use in building boards, industrial and domestic absorbents, plastic and rubber fillers and seepage control additives (Fosse, undated). An alternative which is already in use is to compost or spread pulp sludge on the land. Landspreading is being carried out as part of the disposal system at Inveresk fine papers in Alloa, Scotland and at the new Aylesford Mill in Kent. In Kent, local farmers are paid a fee to spread it on their agricultural land. A study has been carried out by the Ministry of Agriculture which shows that there are no adverse effects arising from this practice.

2.2.vi Conclusions on preparation of office waste paper to produce quality recycled paper

If waste paper is not treated at all prior to papermaking it produces a grey sheet with visible ink particles of various colours, and holes and imperfections in the sheet due to stickies - the consumer would not be impressed. It is necessary to treat and prepare office waste paper during re-pulping to produce printings and writings paper.

Paper of a quality and brightness acceptable to the consumer could be produced with a preparation process which does not require removal of all the fillers and clays or produce large quantities of effluent/waste. A good system would include:

- sorting the waste paper carefully before re-pulping to remove highly coloured waste and large contaminants;
- removing the large toner ink particles through the application of agglomeration technology;
- use of screens and centrifugal cleaners to remove plastics, stickies and agglomerated ink particles;
- process water treatment and re-circulation;
- bleaching with hydrogen peroxide or an oxygen bleaching and de-lignification system.
- Locally produced non-wood (hemp or flax) fibres (Riddlestone & Desai, 1994) could be added to allow slightly lower quality waste paper to be used, improving strength and giving a superior quality appearance to the sheet (see section 4.3). n.b. virgin wood pulp could also be used to upgrade the waste paper - but it would have to be imported as there are no UK pulp mills which produce a wood pulp suitable for this purpose and none planned to our knowledge.
- Energy saving measures would be incorporated at the design stage.
- Rejects arising during processing could be utilised instead of landfilling or incinerating them. Large and solid rejects could form part of the bulking agent in concrete or in bases for road building. Non-solid wastes i.e. fibres and some clays could be used in the manufacture of building boards or other products, or landspread as is the practice in a number of mills in the UK.

Case study 3

The British Paper Company, Frogmore Mill - a small recycled paper mill.

Founded in 1890, this mill is one of the oldest and smallest paper mills in the UK. Only 100% recycled fibre is used to produce approximately 3,000 tonnes of paper and board per year on a fourdrinier paper machine. The mill employs around thirty people operating 24 hours a day, 5 days a week.

The waste paper is sourced from local suppliers (including charities) and further afield from waste paper merchants throughout the UK. The company utilises a large range of grades of wastepaper. The grades are sorted and stored according to grade and colour.

No bleaching or deinking is carried out at Frogmore. For example, if red paper is to be made, red/pink waste paper is pulped down and dye added to reach the correct shade. To produce white paper, high grade white waste paper is used.

The equipment used at Frogmore is old, but has been updated with modern control systems. The mill uses "Watford Pulpers" to pulp down the waste paper. This process disperses the ink through the pulp. The stock is diluted in the beater where dyes are added if necessary. Next it passes through a series of cleaning systems which remove dirt, plastic and other contaminants. Unless producing blotting or other absorbent papers, starch and size are added to produce a smooth sheet. The paper stock passes to the paper-making machine - a 1.8 metre fourdrinier which runs at 50-200 feet per minute (fpm). At these speeds approximately 0.75 tonnes of 100gsm to 350gsm paper or card can be produced per hour. The paper forms on the wire, water is vacuumed and drained away and squeezed out through press rollers. The newly formed paper then passes through a series of steam heated drying cylinders. Finally it passes through calender rollers to smooth and polish the paper. The paper is then cut into reels or sheets as required.

Steam raised using natural gas is used to power the engine which drives the paper machine. Water is taken from a bore hole and recirculated. A negligible amount of waste water is generated and this is discharged into the local authority sewerage system.

The British Paper Company produce grades and colours of paper and card suitable for a variety of uses such as greetings cards, files and folders, tickets, labels, school exercise book covers and packaging. They are unable to produce paper below the 100gsm thickness currently suitable for office use. This would need a faster and longer paper machine with extra pressing and a size press to condition the sheet after forming to improve its printing qualities (Robert Wallers, Director, British Paper Co, pers comm). For the production of printings and writings papers a machine capable of running at around 500 feet per minute would be needed, equating to a capacity of over 45 tonnes per day (TPD) - approximately 10,000 - 14,000 Tonnes per annum (TPA) depending on the width of the machine and hours in production.

Section 2.3 Paper Making and scale of paper mills

When the recycled pulp has been decontaminated, bleached and prepared it is ready for the paper machine. For the production of printings and writings papers specialised machinery is required and would need to be custom made for the mill.

Scale

A paper machine is made of two sets of frames and rollers. The costs of producing paper machines of different size is similar, therefore larger machines are proportionately cheaper (Mr Szabo, Valmet, pers comm). For the production of printings and writings papers, a machine width is in multiples of A4 (210mm). A width of 3.28m was recommended by one paper machine supplier as the minimum they would advise. It would make no sense to run it at less than full capacity, so this would mean an annual production of 120,000 tonnes (400TPD). In addition, office paper is a commodity grade and therefore in a competitive market. In short, present day paper industry wisdom states that the capital costs of a small mill (less than 400TPD) are too high compared to output to be economically viable in a mainstream market.

However, there are smaller mills than this in business in the UK making printings and writings papers containing recycled paper. For example;

- Inveresk Fine Papers (formerly Weir paper) who make high quality "repeat" copier, including 100% recycled paper, at their 125TPD mill in Scotland (see case study 2);
- Sunderland Paper Mill (63TPD) who make non-de-inked recycled printings and writings, and;
- Wm. Sommerville in Penicuik, Scotland (30TPD) who produce high quality papers;
- British Paper Company in Hertfordshire (13 TPD) produce non-de-inked recycled board (over 120gsm) for printings and writings card (see case study 3).

British Paper Company director, Mr Wallers, advised us that for 80-100gsm printings and writings paper a machine capable of running at speeds of around 500 feet per minute (fpm) would be needed, equating to a capacity of 45TPD for a 1.8 metre wide machine. Depending upon the hours in production this would mean between 10,000 - 13,000 TPA produced. Such a mill would certainly be considered a very small mill by current paper industry standards and would fit in with the US mini-mills concept (see below and case study 4).

Mr Wallers further advised that the production of light-weight papers for use in office machinery is technically more demanding than heavier weights and suggested that any proposed papermill should be very flexible and produce a variety of papers. He emphasised the need to tailor products carefully to meet market demands and that to make a small mill successful one needs hardworking and dedicated owners and employees.

Although all of the mills mentioned above are considered very small by current paper industry standards, a new trend has been observed particularly in the US, that of the "mini-mill".

A trend toward smaller "mini-mills"

The trend has been for paper mills across the world to get larger. However, as recycling assumes more importance in our eco-conscious age, interest is emerging in the concept of the local paper mill, sited close to the "urban forest" of waste paper. In the US there has been a boom in these mills, which the industry calls "mini-mills". Over 30 have been set up or proposed. Not all have been successful but important lessons can be learned.

A mini-mill generally conforms to the following criteria (Pulp and Paper, 1993):

- use of waste paper or sometimes, agricultural waste;
- seen as an eco-friendly facility, producing little or no effluent and with low energy requirements;
- located close to the raw material source and point of distribution in order to minimise transportation;
- sited in an urban industrial park, on a site of up to 3-4 hectares utilising municipal roads, power and sewerage;
- has a capacity of between 100-400TPD;
- employs simple equipment, machines less than 5 metres wide running at under 2,000 fpm, upgraded with computer control systems which can be operated by non-graduate engineers;
- established by entrepreneurs and smaller paper companies in partnership with supportive local authorities and equipment manufacturers; and
- produce mainly brown packaging board, but some tissue and newsprint, or use de-inked office waste for printings and writings paper.

Capital costs of small recycled paper mills

On a 10 year depreciation, the capital outlay for a mini-mill is equivalent to US\$85/tonne which, combined with low raw material costs, gives typical production costs of US\$200/tonne compared to US\$270-370/tonne for virgin fibre mills (Fales, 1993). Based upon these figures approximate capital costs in the UK would be £17.5 million for a 100TPD mill or £44 million for a 250TPD mill. For the smallest size of mill we are considering (45TPD) a capital cost of approximately £8 million would be expected.

A special engineering report on US mini-mills was featured in Pulp and Paper magazine in September 1993. It had a number of case studies, of which we considered the experience of Patriot Paper Corp. as most relevant to our study and is therefore examined in more detail in case study 4. Although we agree with its concept, its execution had not been considered sufficiently thoroughly. Given the need to control variable raw material input, such mini-mills need more careful management than say a mill using uniform wood chips for example. Mini-mills which recycle office waste paper can be successful as in the case of Kieffer Mill, USA, which plans to expand. It produces 110 TPD of de-inked pulp from office waste paper which it sells on the open market.

Case study 4

US Mini-mills

Patriot Paper Corp. - Recycled fine paper mill, Boston, Mass. US

Patriot Paper Corp. run a 170 TPD long established mill. The raw material used is lightly printed and unprinted waste and office papers this is de-inked and converted back to printing and writing paper. It was decided to re-build and upgrade a 20 year old de-inking system at a cost of US\$50 million. The idea behind the upgrading and expansion was that office waste would be collected, recycled and sold back to the producers of the office waste - thereby closing the loop. However, after 30 months in operation in 1993 Patriot had to file for bankruptcy. In late 1993 it was hoped to restart operations following a rescue plan worked out with the support of the local authority and equipment manufacturers (Pulp and Paper, 1993). The main reasons for the collapse as stated in an article in Pulp and Paper magazine are as follows:

1. The company should have got engineering commitments and equipment performance guarantees from suppliers. While this would have added to the original cost of the project, the resulting losses for performance failure were very high. There was a failure with the initial de-inking system design which forced Patriot to use expensive high grade waste paper for a ten month period. They also needed to purchase equipment to remove stickies and spent US\$6 million on an unanticipated wastewater treatment bill. The cash flow difficulties arising from this situation led to late payment of suppliers which limited the suppliers willingness to provide good service and acceptable quality at a reasonable price.
2. The business forecasts should have included a greater level of contingency. For example, a technical failure in the de-ink plant forced the company to buy in expensive higher grade paper and the price of waste paper rose due to increased demand combined with reduced supply.
3. Initially there was no project leader with fundamental communication responsibilities - they needed "a street smart totally focused individual" who can effectively communicate with the wide variety of stakeholders in such an operation, from corporate environmental directors to waste dealers, government officials and environmentalists. By the time such a person was employed, things had started to go wrong.
4. Guaranteed purchase agreements should have been established for specifically sorted office waste and a contingency allowed for handling, storage and re-shipment if they could not use the waste paper for any reason.
5. Simple, automated data collection to monitor individual waste paper suppliers for quality, reject frequency and on-time delivery should have been established. A computer tracking system would not have been expensive and would have allowed the data to be analyzed and good suppliers rewarded with more business. In addition, all staff in the waste paper receiving and handling areas needed to understand their critical role in preventing contamination and hence problems and considerable expense at later stages of processing.

2.4 Consumer requirements

A successful brand of recycled paper needs to meet the demands of office based consumers. At present in the UK 500,000 tonnes of new A4 paper is sold for use in copiers and laser printers each year, of which just 30,000 tonnes is recycled paper (Conservation Papers Ltd). While price is a consideration, this lack of demand for recycled paper is largely due to concerns about its performance, quality and suitability for use in photocopiers and printers.

A number of areas have given reason for concern, namely:

- Surface chalk dust
- Absorbency
- Abrasiveness
- Toner adherence/print quality
- Runability

Are these concerns justified?

The quality of recycled paper has improved and suppliers of recycled paper have aimed to eradicate these preconceptions by providing information on the performance of their papers. In addition, office machines have improved and are able to accept a greater range of paper.

Surface chalk dust

Dust particles found to rub off poorer quality papers can cause jamming of photocopiers and printers, giving rise to greater cleaning and maintenance costs.

There are two causes:

- inadequate bonding of fibres and fillers in the paper; and
- insufficient care taken in the cutting and wrapping of paper.

However according to a report by Waste Watch, "An Office Guide to Recycled Paper and Paper Recycling", recycled photocopy and listing papers pass through ionizing processes to remove dust and are free of this problem - dust is completely removed by suction from the face and reverse of the paper.

Many recycled paper manufacturers offer their own guarantees. Both physical and chemical testing ensures that computer papers meet the laser, dot matrix and daisy-wheel printer manufacturers' specifications.

Absorbency

The more absorbent nature of recycled paper can cause a slight problem with its use in ink-jet printers, as the liquid ink is absorbed more readily and thus may spread on lower grade papers, slightly impairing the print quality. Absorbency characteristics can be controlled with chemical additives, for example, size in the paper or coating the paper (Graham Moore, PIRA, pers comm)

With impact and laser printers, the ink is transferred dry therefore paper absorbency is not a problem.

Abrasiveness

Some papers, both new and recycled, can be abrasive. A concern of many consumers and one highlighted by Brother and OKI, is that damage to the print head by abrasive papers could affect the customers guarantee. Smoothness is a measurable factor; a recycled paper can be selected to meet needs for smoothness, just as it can for size, weight and appearance. Many paper manufacturers test their own papers with the leading brands of office machinery and give guarantees. Surface treatment (including coating) means that there is now an increasing range of recycled paper almost indistinguishable from non-recycled papers (Jan Kuiper, Paperback & HMSO Register of Recycled Paper and paper products, June 1995).

Toner adherence/print quality

Recycled paper can have limitations in terms of print capability, but this is dependent on quality. Definite print characteristics will appear on papers containing a lot of low grade waste. Problems are not necessarily particular to recycled paper, as many virgin papers too tend to show 'hickies' (specks or holes in a solid field of ink) which occur with solid coverage when fibres come loose and transfer onto the rollers. As with any virgin paper, once the printer is familiar with their characteristics and performance recycled papers should not present a problem.

Runability

The nature of the waste used in the production of recycled papers can affect the machine runability of the product. Papers containing recycled fibre are not as "stiff". This can cause runability problems in terms of feed through photocopying machines. n.b. wheat straw pulp has very good "stiffness" properties and if added to recycled paper may overcome this problem (see section 4.3). Waste which has been sorted inadequately leaving stickies affects the performance and quality of the paper. However, this problem can be dealt with by segregating paper contaminated with stickies when collecting waste paper and through processing at the mill as described earlier.

Technical specification for recycled papers

The UK government has produced a technical specification for recycled computer paper stating acceptable levels of brightness, cleanliness and absorbency. A minimum recycled or secondary fibre content of 75% is also stated (Waste Watch, 1991).

Conclusion

Many office equipment manufacturers recommend specific recycled paper brands for use in their machines ie; Toshiba, Konica and Minolta recommend Recyconomic/Bio Top 3, whilst Rank Xerox and Canon produce their own paper. Providing a good quality recycled paper of the correct weight for the printer or copier is used, problems should not be encountered with its performance.

Today, most recycled papers "look, feel and perform the same as new papers" (Conservation Papers Ltd, pers comm). Similar reassurance is given by Bob Eaton of Kodak Copy Products, who has written in his publication "The Complexities of using Recycled Paper in Photocopiers" that there are recycled

papers on the market which can perform equally as well as standard quality virgin-fibre based papers (Waste Watch, 1991).

A further enquiry into consumer perceptions about the use of recycled paper is included in section 3.

2.5 Other options

The 'Unphotocopier'

Conventional paper recycling schemes have proven effective in dealing with office waste paper, although they do present certain concerns. The most substantial problem facing the office paper recycling business is the removal of toner ink, used by most office printing equipment, from paper. Difficult to remove, the presence of toner causes recycled paper to be of poor quality. Recent developments in Japanese technology may hold a solution to this problem.

The Ricoh Company Ltd of Tokyo have developed a prototype 'Unphotocopier' machine which works in the opposite way to a normal photocopier, removing toner ink from used office paper to give clean reusable PPC (plain-paper copier) paper. The Unphotocopier removes the toner ink from printed paper using a peel off solution applied to the paper to weaken the bond formed between toner and paper. An application of heat and pressure transfers the toner ink to a peel off roller, producing clean reusable PPC paper. This new technology could mark a turning point in office waste paper recycling, allowing paper to be 'recycled' without leaving the office and individual sheets of paper to be 'recycled' time and time again until contamination or breakage occurs.

Ricoh are planning to market the Unphotocopier and improve on its recycling speed of three A4 sheets per minute. (Ricoh Techno Show case, August 18, 1993)

The "Abrader"

A similar idea to the unphotocopier, but using different technology has been developed in Hungary by Mr Tibor Nagy.

Mr Nagy's machine works by abrading the top layer of a sheet of paper, so removing any ink on the paper and then restoring the abraded layer with the application of a new glaze layer. It is anticipated that the machine will work in tandem with the office printer, producing recycled paper as the printer demands it. If used in situ in the office it could be of benefit to both office based business and to the environment.

In conclusion, both of these ideas are interesting possibilities, but have yet to reach the marketplace and prove themselves technically and economically.

Section Three

Waste paper situation in Sutton and Greater London

If we are to realise our vision of collecting locally generated office grade waste paper to produce printings and writings papers for local use, we need to examine the feasibility of such a scheme. The following questions shall be considered;

What quantities of waste paper of a suitable grade are generated in Sutton and Greater London?

What is the current recycling situation in Sutton and Greater London?

3.1 Volume of high grade waste paper consumed in the London Borough of Sutton and throughout London as a whole

According to the Paper Federation of Great Britain (July, 1995) the consumption of paper and board in the UK, currently stands at 200kg per capita; of this 36% of consumption is of printings and writings papers (Paper Federation of GB, 1995), giving a per capita consumption of printings and writings paper of 72kg per year.

Sutton has a population of 173,300 (office of population censuses and surveys, mid 1993 estimate); therefore we can estimate total paper consumption at 34,500 tonnes and printing and writings paper consumption at approximately 12,500 tonnes per annum. Office paper is likely to be a third of this figure, say 4,000 tonnes.

A similar calculation for London (population approximately 7 million) gives a figure for total consumption of printings and writings papers of 500,000 tonnes annually.

One would never expect to collect all of this paper, but recycling rates of 75% can be achieved (FoE, 1995).

Total amount of general waste generated in the London Borough of Sutton

In the London Borough of Sutton 100,000 tonnes of domestic and trade waste is collected annually by the local authority, of which 30% is estimated to be paper and card. In addition trade waste is collected by the private sector, the figures for which are difficult to ascertain.

All waste which is not recycled is transported out of the borough by waste contractor A J Bull and dumped as landfill in Bedford. According to the London Borough of Sutton, the landfill tax although not finalised will add an additional £2.60/tonne to landfill charges. Currently it costs £17/tonne for disposal of Sutton's waste to landfill.

Current recycling rates in the London Borough of Sutton

At present the Council estimate a recycling rate of 17% for total household domestic waste in Sutton, which is high by UK and London standards. This success is due to the establishment of schemes which make recycling more convenient combined with awareness raising. Just under 6000 tonnes of paper are collected per annum for recycling - of this, approximately 100-150 tonnes

of office waste paper is known to be collected annually in Sutton, which would seem to be only around 3% of the potential. Some large companies do participate in other recycling schemes, but we were unable to discover the quantities involved across the borough.

3.2 Recycling collection schemes

In order to come to some conclusions as to how a Sutton waste paper collection scheme might operate, it is necessary to look in detail at current schemes in operation throughout the borough and across London.

London Borough of Sutton Recycling Schemes

As part of its Local Agenda 21 plan, the council has set ambitious recycling aims; 25% target set for March 1996, 50% by the year 2000 and 80% by 2005.

Currently Sutton has two waste paper collection schemes and works in conjunction with a third, private enterprise, Green Recycle, for the Borough's recycling.

The council waste paper collection is split between:

- (i) paper banks situated at multiwaste recycling centres in the borough (for high grade waste paper and newspapers, but not envelopes or unsolicited mail); and
- (ii) a kerbside collection scheme for all grades of waste paper (including envelopes) from domestic residences.

There is still great potential to increase paper collection figures from the kerbside service, although in some areas of the borough it is extremely well supported.

It is estimated that 35-40% of newspapers are collected, leaving a lot of paper still going into the dustbin. The council are currently addressing the issue and aim to expand the kerbside scheme by employing 8 people to work 15 hours a week until the end of March '96 to call at domestic residences and promote the service to residents in areas of the Borough with the lowest levels of recycling. It is also proposed that the total number of recycling centres in the Borough will be increased by the end of the next financial year to provide a facility for every 1000 of the population, and on request, "Micro Recycling Centres" will be added to blocks of flats.

Waste minimisation amongst businesses will continue to be encouraged through, the green business club, Business Ecologic, which is supported by the council.

Community support

The need for community support in achieving recycling aims is recognised by the borough and two community schemes are in operation:

- Adopt-a-Bank and Waste Workers

Adopt-a-Bank Is a scheme where local voluntary groups adopt a recycling centre, promote its use to the community and report to the council with any problems which might arise concerning its usage. Over 80 groups currently participate in the scheme. Member groups receive a financial incentive of £6.50/tonne for paper and glass collected.

Waste Workers In this community scheme, operating in specific parts of the borough, the members' brief is to reduce waste by increasing recycling, raising public awareness and encouraging action by residents. In return the community groups benefit financially, being rewarded from the waste disposal savings made. Sutton council would like to see similar groups to Waste Workers formed across the Borough.

Green Recycle

Green Recycle is a private waste recycling enterprise working in conjunction with the London Borough of Sutton. Green Recycle receives a recycling credit of £15 per tonne from the London Borough of Sutton. All material from the council's waste recycling banks is collected and sorted by Green Recycle. This includes paper, cans, plastic, glass (3 colours) and foil.

Besides the collection of paper from the council's paper banks, Green Recycle coordinates a small mixed office paper and card collection scheme which operates in Sutton and parts of Croydon and Reigate. Collection areas are kept relatively local to reduce the need for transportation. In an attempt to increase the total volume of office paper being recycled in Sutton and the surrounding region Green Recycle have aimed to target smaller businesses, who were not previously participating in an existing collection scheme. However with an estimated 30% of businesses being home based, a fair proportion would therefore have no need for such a service, as any waste paper would be taken by the council's kerbside scheme.

Waste paper is collected on demand depending on the individual business and their storage capacity. No charge is made for the collection of office paper. However there is a nominal charge for cardboard. No payment is made to businesses for their office paper which is of various grades. Per week, 2-3 tonnes of office paper are collected and 15-20 tonnes per week of cardboard. Office paper is sorted into white, coloured, mixed and woodfree computer paper and mechanical computer paper. In the future Green Recycle would like to see local office paper recycling schemes, set up in satellite areas and to increase their own collective tonnage through expansion. Graham Bignall, the director of Green Recycle is interested in the potential for an ERI site in Sutton. ERI (Environmental Reclamation International) is an industry consortium offering integrated recycling systems capable of recycling the bulk of municipal waste based on a modular system, selected to serve the needs of a particular community, with contaminated paper, perhaps, being processed into fuel pellets. Such a system would, it is claimed, increase Sutton's domestic waste recycling to 80% overnight. However, a plot of 8 acres would be required for such an enterprise.

Current office waste paper collection schemes operating in London

The following section reviews two office waste paper collection schemes in operation across London.

Paper Round

Paper Round has been in existence for 6 years, providing a free office paper recycling scheme for over 2000 companies within central London. Major clients include The Economist, which recycles 200kg of paper per week and Price Waterhouse from whom Paper Round collects over one tonne of paper per week. Once a business has registered with Paper Round details of office recycling equipment are sent. Free special white sacks (which are reusable) can be used to collect paper or, alternatively, if easier to store, A4 sized photocopier boxes can be used. Office recycling bins are available for purchase.

A collection date can be arranged by telephoning the 24 hour collection hotline. A minimum of 6 x 15kg sacks or 10 full A4 boxes is required. The less frequent the collection visits made by Paper Round, the more efficient is the scheme. Each area has a different day of the week designated for its collection date.

Material collected by Paper Round includes:

- white and cream paper
- photocopier paper
- compliment slips
- business cards
- lined note paper
- white computer paper
- music ruled computer paper

Material not collected by Paper Round includes:

- coloured paper
- anything sticky
- envelopes
- fax paper
- post-it notes
- carbon paper
- newspapers and magazines
- brochures and books
- plasticised papers
- dye line

By using Paper Round, businesses make financial savings as the volume of waste to be disposed is reduced. Paper Round offers a shredding service for confidential documents for which they make a small charge. Shredding takes place at their waste paper merchants security centre.

In addition Paper Round collects laser cartridges for recycling, which are collected along with the waste paper.

Paper Round states that over 1000 tonnes of office grade paper is collected through their recycling scheme. This consists of 80% prime white (headed paper), 7% computer and the remainder mixed grade. Once collected the paper is taken to Paper Round's waste paper merchants from where, it mainly goes

to Kimberley Clark, and to Holland or Italy. Waste paper collection is a very competitive market and prices fluctuate from week to week. As Paper Round use a paper merchant they are susceptible to the price the merchant is prepared to pay.

The company would like to set up a number of satellite operations to enable a greater area of London businesses to be covered with such a service. They receive up to 5 enquiries a week from Sutton businesses.

Papercycle

Papercycle offer a recycling service for office paper, drinks cans and toner cartridges, throughout London. A shredding service for confidential paper is offered at a cost of £2.95 for supply and collection of each 40kgs sack. While the paper collection service is free of charge for companies with sufficient volume, a small charge is made for the collection of separately bagged glossy brochures. In order to be included in a free Papercycle collection round a business is required to have generated 12 full sacks of A4 boxes. For customers outside of central London the volume may be slightly higher and a small charge may be made to businesses with less than 12 sacks to be collected who are limited by storage space. Clients include companies such as the BBC, KPMG, British Gas and Mercury Communications as well as a large number of small companies.

Material collected by Papercycle include the following:

- white paper (with or without type)
- computer paper
- coloured paper (separated from other grades)
- drinks cans and toner cartridges

Material not collected by Papercycle includes:

- anything sticky
- envelopes
- fax and telex paper
- waxed papers (eg. the wrappings on packets of photocopier paper)

To ensure security, paper is processed on the same day as collection. Bins for the collection of waste paper can be rented from the company who have a complete range priced between £3.95 and £70.00 each. Sacks cost £16.50 for 300 which are for white and computer paper only. Businesses are encouraged to continue using the scheme through a newsheet reporting on how much paper has been collected per quarter and on the benefits of recycling to the environment.

Papercycle's can recycling scheme works in conjunction with the Aluminium Can Recycling Association who supply bags free of charge. Papercycle sort the steel from the aluminium at their depot and donate 20p per kilo to a nominated charity.

Electric vehicles The London Borough of Sutton made a commitment in December 1995 to gradually replace all of their vehicles with low-emission models (LBS,1995). They have been especially interested in electric cars and vans. Of course, milk floats have been powered by batteries charged from the mains electricity for many years, but they are very slow, which is acceptable early in the morning, but perhaps not so during the day when they could cause traffic hold-ups.

Sutton Council have tested several electric vehicles, but are finding that there is a limited choice of commercially available right hand drive models. A Ford Fiesta conversion which they tested could only travel 30-40 miles per day when fully charged and as the batteries lost power later in the day, its performance deteriorated badly. It became very slow which made pulling out on to main roads dangerous. During early 1996 they hope to trial other vans from Elmo (Skoda) and Smiths with ranges of up to 50 miles a day and begin purchasing vehicles soon after.

Small electric vans cost £8-9,000 and running costs are comparable with petrol or diesel. They can be charged up overnight with cheap rate electricity and the road fund licence is only £35 annually.

The electric vehicle seems like a good option until you consider that unfortunately all but a fraction of our electricity is derived from power stations which burn non-renewable fossil fuels or from nuclear power. Solar or wind powered battery chargers on the roof of the vehicles garage are a possibility, but the technology is currently quite expensive.

Biodiesel/bioethanol vehicles The London Borough of Sutton are also investigating the use of biodiesel or bioethanol vans, but the government has recently imposed a higher tax on these fuels and they are also difficult to source. Therefore Sutton have discounted this option for the time being.

Renewable biodiesel or bioethanol (petrol substitute) emit almost as many pollutants as a petrol/diesel vehicle - the only emissions that are significantly reduced are sulphur dioxide as described in a report by the Parliamentary Office of Science and Technology (POST,1995). The report also found that if 15% of the UK's agricultural land were given over to the cultivation of oil seed rape for the production of biodiesel just 6% of our current diesel consumption could be met in this way.

Compressed natural gas vehicles This is a competitively priced fuel, which has considerably lower emissions than petrol. It can be used on existing vehicles which have been converted. A network of refuelling stations is being developed, but scarcity of filling stations is a drawback. However, it is not a renewable source of fuel.

In conclusion we found our investigation into low emission vehicles very thought provoking. There is no doubt that we need to reduce our use of fossil fuels - global warming is now proven and fossil fuel resources are not expected to last more than another two generations. In addition, there are many social, health and environmental costs associated with road building, traffic congestion and noise and air pollution. The sooner we begin to tackle this problem the better.

3.4 Paper merchants and grades of paper

Once the waste paper is collected from the source, it is sorted into various grades and then sold on to paper merchants. Waste paper collection is a very competitive market with the paper merchants controlling prices, leaving the collectors vulnerable to fluctuations in the market.

Grading Schemes for Waste Paper

Waste paper can be referred to according to source, of which there are two:

- pre-consumer waste; and
- post-consumer waste.

While there are no generally agreed definition of these terms, typically, post consumer is understood to refer to waste generated after the paper has been used for its intended purpose ie. that from households, supermarkets, etc. Pre consumer waste is waste created while the paper is being transformed into its final form eg, trimmings, faulty sheets of printing.

All waste paper can be given a grade. However the method by which the waste paper was originally produced is important in determining its grade, thus potential usage and market price.

Two technical terms should be outlined associated with papermaking in order to understand recycling grades.

- **Woodfree** refers to chemically pulped wood, a process which removes the woody substances (lignin) from the cellulose, hence woodfree. This produces a high quality paper.
- **Mechanical waste** is not 'woodfree', as mechanical pulping tears fibres apart, but does not remove the lignin. this produces paper with a weak fibre network and little tear strength.

Papermakers buy raw material for recycling mainly from waste paper merchants who collect paper and sort it into grades.

Paper merchants and mills in the UK use the following grading scheme for waste paper, recognised by the British Paper & Board Industry Federation (BPBIF).

- | Group | |
|-------|----------------------------------|
| (1) | Woodfree unprinted |
| (2) | White woodfree printed |
| (3) | White lightly printed mechanical |
| (4) | Coloured woodfree |
| (5) | Heavily printed mechanical |
| (6) | Coloured krafts and manillas |
| (7) | New KLS (kraft) |
| (8) | Container waste |
| (9) | Mixed papers |
| (10) | Coloured card |
| (11) | Contaminated |

The 11 groups have sub-groups, allowing for a total of about 50 groups.

Utilisation of individual waste paper grades in the paper industry

Groups (1), (2) and (4) are woodfree, high quality, high strength papers, suitable for the production of printings and writings papers (office grade).

Groups (3) and (5), mechanically pulped papers, are of a lower quality and strength and are suitable for newsprint and magazines.

Groups (6) to (11) are lower grade papers, and are used by the packaging and board industry.

Recycled paper identification scheme

The Environmental Product Information Centre (EPIC), use the following scheme to explain the type and volume of waste used in a paper product to enable consumers to make an informed choice.

- (A) All Mill Waste. For example, offcuts, damaged stock.
- (B) Unprinted Woodfree Waste. For example, trimmings from envelopes, printers' trim, waste which has left the mill.
- (C) Printed Woodfree Waste. Good quality printed waste. For example, computer print out, used cheques, letterhead, photocopy paper - all of which have been used for print in some way.
- (D) Mechanical Waste. Newsprint and cheaper magazine type qualities, printed or unprinted.

The percentage of each of the grades of waste is indicated when a recycled waste content is given, the remaining percentage will be made up of virgin pulp ie: a product specified as 25A 50B means that the paper contains 75% paper waste of categories A and B and 25% virgin pulp.

Obviously the higher the grade, the higher the quality of the product made. However, usually a degree of 'down cycling' occurs, whereby the product made is of a lower grade than the waste used to produce it, eg the production of newspaper from magazine waste. This can be explained by the fact that every time fibre is recycled it loses some of its essential properties and strength, and can be recycled only up to six times before it is inadequate for papermaking.

Paper made from fibre crops such as flax and hemp with longer staple lengths can theoretically be recycled more times and hence may be more appropriate from a sustainability standpoint (see section 4).

Prices

All grades of office paper are currently in demand, so prices are generally high, however prices do fluctuate frequently and significantly. £80-£200/tonne is the price paid for computer paper as the fibre strength is very good and it can have many end uses.

3.5 Attitudes of Local Businesses to recycling and use of local recycled paper

In order to gain some idea of the attitudes of local businesses, the future clients of any recycling scheme, we distributed a postal questionnaire. We sent it to a random sample of 20 local businesses, ranging from small (estate agents, printers, photocopy shops) to medium (recruitment consultants) through to large businesses (major company headquarters) - see Appendix

The questionnaire asked the following questions:

- whether or not they currently recycle their paper;
- how much waste paper they produce per week and of what type;
- if they currently use any recycled paper in the office;
- their views on joining a local paper collection scheme; and
- their views on buying locally produced recycled paper.

The response rate to the questionnaire was 12 replies out of the 20 sent out. The results are as follows.

Recycling

Five out of twelve businesses already recycle their waste paper (with 2 sorting it into its various types and 4 participating in a free collection scheme) When the remainder were asked why they did not recycle their waste paper, responses included;

- concerns about security of confidential papers
- apathy due to the effort involved
- volume of waste paper generated are not felt sufficient, and
- lack of knowledge about organised collection in area.

Of those who didn't recycle paper 2 had to pay for trade waste collection. An average of 5 black rubbish sacks of waste paper are generated per week per business.

Using recycled paper

Seven out of the twelve businesses used some recycled paper in the office. Of the 5 who do not use recycled paper reasons for not doing so included:

- surface dust jamming photocopiers;
- paper supplied from head office; and
- headed company paper mostly used.

Joining a local recycling scheme and using recycled/local paper

Six out of twelve businesses showed interest in joining a local recycling scheme and buying locally produced recycled paper. The reasons given by those businesses not interested in joining a recycling scheme or buying local paper were similar to those given when asked if they currently recycle their paper.

To conclude, the general attitude to paper recycling is that many businesses will participate in a scheme providing that:

- a minimum of effort is involved;
- security is maintained;
- collection is free of charge; and
- small amounts can be collected.

and that they will use local (or any) recycled paper provided that it is;

- cost effective, and
- of good quality - guaranteed to meet the specifications of office/printing machinery.

It is apparent that a publicity drive would be necessary to:

- promote any recycling scheme in a way which makes it easy to join up, and;
- dispel unjustified prejudices about recycled paper.

In addition it may be necessary to speak to the head offices of many companies which have centralised stationery distribution.

3.6 How is Sutton's waste paper utilised and what is the potential?

Paper merchants who operate in the borough are Severnside (part of the St.Regis Group of waste paper merchants and mills) and SCA (based at Basingstoke).

- Paper and card collected through the council's kerbside scheme is taken to Kemsley mill, in Kent, where it is used to produce board.
- Sutton Council's shredded office paper waste is taken to Severnside, who sort, bale and sell it on. One market is animal bedding.
- Office paper collected by Green Recycle is also taken to Severnside and then on to various mills in the St.Regis Group.
- Newspapers and printed advertising material (pam) collected from the council banks is taken to the new SCA Aylesford mill in Kent, after the removal of any contaminants (eg telephone directories) and is used to produce recycled newsprint.

A new recycling mill is due to begin production in early 1996. Owned by UK Paper, it will de-ink and recycle 350TPD of high grade paper including glossy magazines and white printed card to produce printings and writings papers. It is sited 50 miles from central London in a traditional paper making area in Sittingbourne, Kent. Some of Sutton's paper will go to this new mill.

Estimated volume of high grade waste paper generated in Sutton

In Section 3.1 we calculated that a total of approximately 12,500 tonnes of printings and writings papers are likely to be consumed in Sutton each year. (an estimated 500,000 tonnes of that grade being consumed in the whole of Greater London).

Sutton's weekly domestic door to door paper and card collection will contain a lot of that high grade waste, which is likely to be thoroughly mixed with card, newspaper and other grades. All of this is currently used to produce board (see above).

Printed advertising material, currently going to produce newsprint, could be recycled into higher grade paper, but would need a thorough de-inking.

Green Recycle currently collect two to three tones per week of office waste paper in Sutton, Croydon and Reigate. This is approximately 3% of the office paper consumed in Sutton. More may be collected in schemes we are not aware of, but it is not expected to be a significant amount. We set out to calculate the potential amount of high grade office waste paper which could be collected.

The following shows how we calculated the amount of office waste paper which could be collected in Sutton:

The estimated total employed population in Sutton is 58,834 (SOLOTEC, 1995).

The estimated weekly total of office grade waste paper generated per office worker is 1kg (Graham Bignall, director Green Recycle and Penny Spirling, Waste Minimisation officer for the London Borough of Sutton, pers comm).

**Table 1 - Per cent of Sutton's labour force employed in each sector
(Figures from LBS Economic Regeneration Section, 1995)**

	SUTTON	GB	CHANGE IN SUTTON 1981-1991	CHANGE IN GB 1981-1991
Main Economic Sectors				
Utilities	0.6	2.0	-22.0	-38.8
Primary Manufacture	1.4	3.0	-45.0	-29.2
Metal Goods Manufacture	4.0	9.5	-46.5	28.2
Other Manufacture	6.6	8.7	-15.9	-17.9
Construction	9.9	4.5	+71.4	-10.9
Distribution	20.3	21.5	+0.5	+13.0
Transport & Communications	4.3	6.1	+24.8	-5.4
Business & Financial	20.0	12.1	+119.7	+51.0
Other Services	32.8	31.2	+7.3	+14.8

We assume that the Business and Financial employment sector will be the largest (and most collectable) sector generating office waste paper as all employees are office based. Using table 1 we can see that 20% of Sutton's workforce is employed in this sector. If each worker generates 1kg of paper per week we can estimate that 11.7 tonnes of paper is generated weekly or 585 tonnes annually.

Returning to table 1, of the remaining 80% of the labour force, we can make a conservative estimate that 10% of these are office based and producing 1kg of paper a week. Using these figures we can estimate that 4.7 tonnes of office waste paper is generated weekly or 235 tonnes annually.

This gives us a total estimate of office waste paper generated in The London Borough of Sutton of 820 tonnes. This is somewhat lower than estimates made earlier in this section (using average figures) of 4000 tonnes expected consumption of office paper for the population of Sutton.

Graham Bignall of Green Recycle has advised that, of this total, a maximum of 50% can realistically be collected due to 10% being held in long term storage and the remaining 40% being non recoverable. This gives us the concluding figure for a collectable office waste paper resource in the London Borough of Sutton of approximately 400 tonnes per annum. Disappointingly, 400 tonnes is only 10% of the 4,000 tonnes of office paper likely to be consumed in Sutton annually. If multiplied by the total population of the UK this figure gives us a total of only 133,333 tonnes of collectable office waste for the entire country. Friends of the Earth have estimated that there is an estimated 1,500,000 tonnes of collectable office waste paper in the UK (FoE, 1995). This is more than ten times as much. Therefore perhaps up to 4000 tonnes per annum (a third of high grade paper estimated to be consumed in the borough) could be collected in Sutton. On this basis we can estimate that up to 150,000 tonnes of office paper could be recycled in the Greater London area as a whole.

3.7 Conclusions

From information gathered in this section, we see that;

- 100-150 tonnes of office paper are currently collected in Sutton annually and that it is being sent to Kent. Unspecified amounts of similar high grade paper are being used to produce animal bedding and when mixed with other grades is sent to Kent to produce board and newsprint.
- In total at least 6,000 tonnes of paper/card of all grades is collected annually for recycling in Sutton from an estimated 34,000 tonnes generated annually.
- There is potential to increase levels of recycling and use of recycled paper through a publicity drive.
- Between 400 and 4000 tonnes of office grade paper could be collected for recycling annually in The London Borough of Sutton - this is between 3% and 30% of likely consumption of high grade printings and writings papers in Sutton.
- Based on the above calculations between 15,000 and 150,000 tonnes of office grade waste paper could be collected from Greater London.

As we discussed in Section 2.3, a small scale mill for high quality recycled printings and writings papers could be viable from 45TPD up to 400 TPD (10,000 - 125,000 TPA).

Therefore, we can see that we do not produce enough high grade office paper in Sutton itself to feed the smallest viable high grade recycled paper mill. However, if half of all London boroughs or all of South London and/or parts of North-West Kent or North Surrey joined a collection scheme, between them they should be able to generate 7,500 - 75,000 tonnes annually from within a 20 mile radius, enough to feed a mill of between 30-240 TPD. Based upon figures used in Section 2.3, such a mill would have an estimated capital cost of between £5-£40 million.

Smaller, craft scale papermaking of perhaps 1 TPA would be possible for the production of high added value stationery - although of course, this would not make a significant contribution to sustainable paper production.

Section Four A sustainable paper cycle for the South East

When considering the environmental impact of paper, it is not only the sources and methods of obtaining raw materials and of processing them that must be considered. We also need to look at transportation, recycling and disposal. Indeed the whole life-cycle must be examined within the social and economic context if we are to move towards sustainability. We promote a model of development which we call "Bioregional Development" - we will outline this first before looking at how this relates to a sustainable paper cycle.

4.1 Sustainability and bioregional development

The modern global economy is supported by the unsustainable use of natural resources. At the same time communities are disintegrating in the face of rapid and global economic changes. Sustainable development, "development which meets the needs of the future without compromising the ability of future generations to meet their own need" (WCED, 1987 - the Brundtland Report), is advocated as the way forward. This immensely complicated issue has economic, social, political and technical aspects.

Bioregional development is a pragmatic and simple approach towards the goal of sustainable development. It is based on the concept of "bioregionalism" which recognises the benefits of meeting needs from local resources in a way that is sensitive to the ecology of the area (Sale 1991). In summary, bioregional development seeks to:

- revive traditional sustainable land use, and
- regenerate local industry, by
- introducing clean, viable appropriate-scale technologies, to
- build healthy regional economies supplying local needs from local production.

A fuller account is given in "Bioregional Surrey" (Desai, 1993). Figure 5 shows the natural regions of the UK (Ecologist, 1984).



Figure 5 - natural regions of the UK

4.2 Imperatives and opportunities for change

The current situation with regard to UK paper production and consumption and how it relates to global sustainability issues as discussed in section 1 is summarised below:

- In the UK we import 73% of the paper, board and pulp products we consume, mainly from Canada, North America and Scandinavia at a cost of £4 billion annually.
- Much of the virgin paper we consume derives from unsustainably managed sources. Between 20-30% of pulp and paper produced in Canada and North America comes from old growth forests.
- UK paper production accounts for around 40% of the paper and board we consume - 10% is exported.
- Paper consumption has risen 20% in the last two years to 200kg per person in the UK. For sustainable and equitable distribution of paper globally we must reduce consumption in the UK by 65%. Any strategy to develop a sustainable paper industry would have to include measures to reduce consumption and encourage re-use of paper.
- Recycling paper significantly reduces pollution and save resources when compared to using virgin paper and landfilling or incinerating waste paper, despite the fact that recycling paper does have an environmental impact.
- Paper can only be recycled a limited number of times before the fibres disintegrate. Therefore we will always need a supply of virgin fibres. Non-wood fibres of flax and hemp, or straw are alternatives to wood which could be added to waste paper to upgrade it (see section 4.3).
- Waste paper and board are being utilised heavily in UK paper and board production (62% of raw material is waste), primarily in packaging and newsprint grades.
- High grade graphics or printings and writings papers (36% of the paper we use) made in the UK contain less than 6% waste paper (which is usually pre-consumer waste). The pulp used to produce it is imported.
- Office waste paper is the largest uncollected segment of high quality waste paper, an estimated 1.5 million tonnes could be collected.

In Sections 2 & 3 we discovered the following facts about the potential for greater collection and recycling of office paper in Sutton & Greater London:

- From our small survey we found that the majority of consumers are willing to join recycling schemes as long as convenience and security are considered, in addition schemes need to be more widely publicised and customers actively sought.
- Consumers are quite willing to choose recycled and local paper as long as price is similar and the quality adequate to function in their printing or copying machinery. There are 100% recycled copier papers on the market which meet these requirements.

- In the London Borough of Sutton approximately 6,000 tonnes of the estimated 34,000 tonnes of mixed paper grades generated annually is collected and recycled, mainly into packaging board or newsprint in Kent. Between 100-150 tonnes of office paper is known to be collected from an estimated total of 4000 tonnes consumed annually in Sutton.
- A commercially viable high-grade recycled paper mill which utilises all waste generated and has a minimal environmental impact could be established in the region. To be viable it would need to produce between 10,000 - 125,000 tonnes of paper per annum. This is considerably more than Sutton produces, but could be supplied from a twenty mile radius in a built up area such as London & the South-East.
- For the whole of the UK - 30-40 such mills producing 125,000 TPA could supply our entire current printing and writing paper consumption - and if mixed with 45% virgin, perhaps non-wood, fibre could do so from UK sourced, sorted high grade waste paper on a sustainable basis. These figures assume that 70% (3 million tonnes) is collectable and some 20% is lost during repulping and recycling.

These findings show an opportunity for the future which would benefit not only the environment here and in Canada and Scandinavia, but also create wealth and jobs through sustainable industry.

4.3 Alternative fibres for paper

So far in this report we have recommended the addition of non-wood fibres to upgrade waste paper but not discussed the pulping or use of non-wood fibres in any detail. However, we have researched this subject thoroughly as part of our ongoing Bioregional Fibres project (Riddlestone & Desai, 1994). A brief introduction to the current situation and potential follows.

The Bioregional Fibres project aims to see a revival of the cultivation and processing of our traditional fibre crops, flax (*Linum usitatissimum*) and hemp (*Cannabis sativa*), to produce textiles, paper, board, oils and other products in our bioregion. This would provide a sustainable local alternative to imports of wood pulp, cotton and mineral oil based synthetics.

Annual fibre crops for papermaking

Although today 95% of the world's paper is made from wood, the original paper making raw materials were annual plant fibres. Wood based paper developed after the introduction of a process to pulp wood in the nineteenth century, at a time when there was a plentiful supply of wood from virgin forests. However, non-wood fibres such as wheat or rice straw, bagasse (sugar cane waste), hemp and flax are still used to make paper. Hemp and flax fibres, as by-products of a textile industry, were the original papermaking raw material in Britain and indeed are still used to produce the highest quality papers such as cigarette, banknote and bible papers. The fibres of hemp and flax are lower in lignin, higher in cellulose, stronger and finer than wood fibres. Therefore they can be pulped using less energy and fewer chemicals to produce a higher quality paper.

As part of our research we have identified clean, novel, small-scale pulping methods which would be ideally suited to the production of non-wood fibre pulps locally on a sustainable basis (Riddlestone & Desai, 1994).

Figure 6 - Volunteer harvesting hemp for BDG's 1994 textile trial

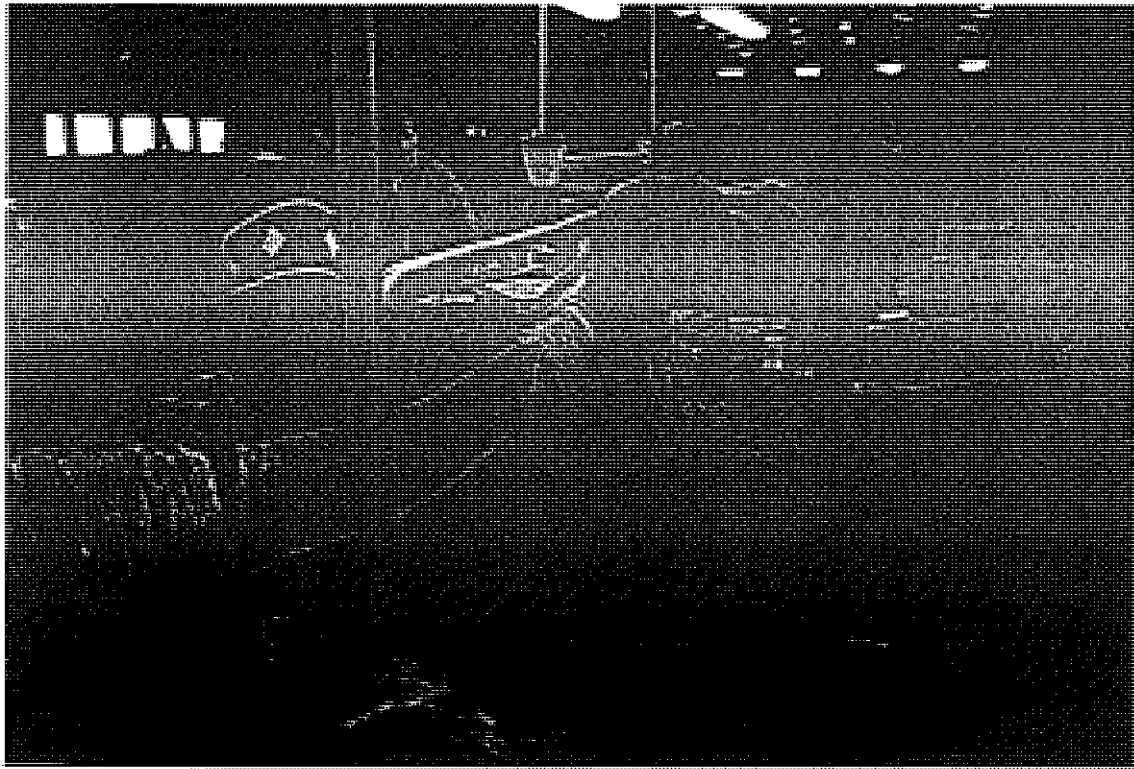


Figure 7 - Flax scutching in Belgium

Hemp and flax in the UK

Considerable areas of flax and hemp are currently being cultivated in the UK. The valuable fibre is not usually utilised as the crops are mainly grown for linseed oil in the case of flax, or the woody core in the case of hemp. Flax and hemp are both low input annual crops yielding around 7 tonnes per hectare in the UK - hemp can easily be grown organically as it grows so fast it smothers weeds. There is tremendous potential to expand flax and hemp growing and processing as part of a revived textile and paper industry, especially in the South-East because the climate is suited to "dew retting", a cost-effective processing method (see section 4.5).

Hemp Some 1,000 hectares of hemp were grown in 1995, primarily to produce horse bedding from the woody core (also known as hemp hurds), with some of the fibre being pulped to make cigarette paper. Research is underway to produce a textile from the fibre produced. The growers expect to plant 1,500-2,000 hectares in 1996 due to increased demand for horse bedding and would welcome other outlets for the fibre being produced annually, amounting to approximately 3,700 tonnes in 1996.

In 1994, as part of the Bioregional Fibres project we initiated a practical experiment, "Hemp for Textiles", where working with farmers and industry we produced the first UK grown, machine processed pure hemp fabric for generations (Riddlestone et al, 1995) - see figure 6. However, one conclusion we drew from our work was that the traditional decorticating processing method (scutching) was more suited to hemp for textile production than that currently used to extract horse bedding. A finer, stronger yarn was produced from the scutched material. Hemp textile production could begin immediately in South-East England if scutching machinery were established. The shorter fibre by-product of textile production could be used for paper making.

Flax Two distinct types of flax are grown in the UK, linseed and fibre flax. Linseed is the shorter, more branching variety of flax which is grown for linseed oil production. The straw is too fibrous to be ploughed in, so is currently allowed to be burned even though it contains valuable fibre. Linseed has experienced a boom in the UK over the last few years, with 62,000 hectares cultivated in 1995. A MAFF LINK project has been examining ways to utilise the straw, resulting in the production of a decorticating machine to extract the fibre. Commercial trials have begun with a prototype producing one tonne of fibre/day for various applications including paper and non-wovens (eg. for car interiors).

In addition to linseed flax, 17,000 hectares of long fibre flax were cultivated in 1995, partly as a dual purpose crop to yield linseed oil and fibre, but partly because farmers are experimenting with growing flax as a non-food crop. Unfortunately, there are no processing facilities to extract fibre, leading some farmers to send their crop to Belgium or France (see figure 7), where there are thriving fibre flax industries, to be processed and sold on as paper and textile fibres. Again, scutching machines could be established in the UK to produce fibre for textiles and paper, with the by-product woody core (shiv) as an ingredient for building boards.

4.4 The potential to produce high grade paper from locally derived waste

From the amount of linseed and flax grown in the UK in 1995 we can calculate the amount of fibre available, knowing that most of it will not have been utilised or was sold on abroad.

Table 2: Potential Yields from flax and hemp crops grown in UK (1995)

	Hectares grown	Straw yield tonnes/ha	Fibre yield (25%)	Woody material yield (50%)
Linseed	62,000	2	31,000 tonnes	62,000 tonnes
Fibre flax	17,000	7	30,000 tonnes	60,000 tonnes
Hemp	1,000	7	1,750 tonnes	3,550 tonnes* (*used for horse bedding)

Figures from MAFF

Based on the figures in table 2 we can calculate the total amount of fibre which could be extracted from crops currently grown annually which could be used for papermaking.

- 1,750 tonnes of hemp fibres (will be doubled in 1996)
- 31,000 tonnes of linseed fibres
- 30,000 tonnes of flax fibres

This gives us a grand total of 62,750 tonnes which could be used for papermaking annually in the UK.

Using modern pulping technology, yields of 75% can be obtained - therefore in theory 47,000 tonnes of pulp could have been produced in 1995. If added, at a proportion of 1:9 to waste paper (i.e. 10%), 470,000 tonnes of high grade printings and writings paper could have been home produced. This is equivalent to over 11% of current printings and writings paper consumption. At £3.00/ream (wholesale prices) this paper would have had a value of over £500 million from what would have otherwise been wasted.

In addition, if the woody material from the flax and linseed had been utilised, 120,000 tonnes of board making material could have been generated. This would be equivalent to 200,000m³ of wood - which is over 2.5% of UK consumption of board panels (FICGB,1995).

The figures for linseed growing in Kent alone as calculated for 1993 (Riddlestone & Cox, 1995) showed that 3,000 tonnes of linseed fibre pulp could have been produced, which if added to prepared waste paper could have generated between 15,000 and 30,000 tonnes of high grade paper. Leaving aside capital costs and the value of environmental and employment gains, such paper would have had a value of approximately £15 to £30 million.

Wheat and oil seed rape straw

We have concentrated on the potential to utilise the very high quality fibres of flax and hemp - but there are also estimated to be 11-13 million tonnes of wheat straw and 2 million tonnes of oil seed rape straw produced annually (FoE,1995), which since the ban on straw burning is mainly being incorporated back in to the soil. This seems to be an excellent idea as farmers have reported an improvement in soil quality as a result.

However, straw is a very good papermaking raw material bringing stiffness to the sheet and improving opacity. Straw is different to flax and hemp fibres as it has lower yields if pulping for high grade papers (30% as opposed to 75-80%), but if pulped for the production of a brown packaging grades yields would be higher and the stiffness would be beneficial. Indeed, a mill in Wales is pulping straw for such a purpose (Riddlestone & Desai, 1994). A particular drawback with straw is the high silica content which leads to accumulation of glass-like deposits on the machinery which causes expensive wear and tear and maintenance problems. The use of alcohol pulping may overcome this, as it is a different type of pulping process to that normally used and retains the silica in the paper adding certain beneficial qualities.

As we can see significant amounts of high grade paper could be produced without any additional cultivation. Figure 8 shows a possible scheme for use of these wastes.

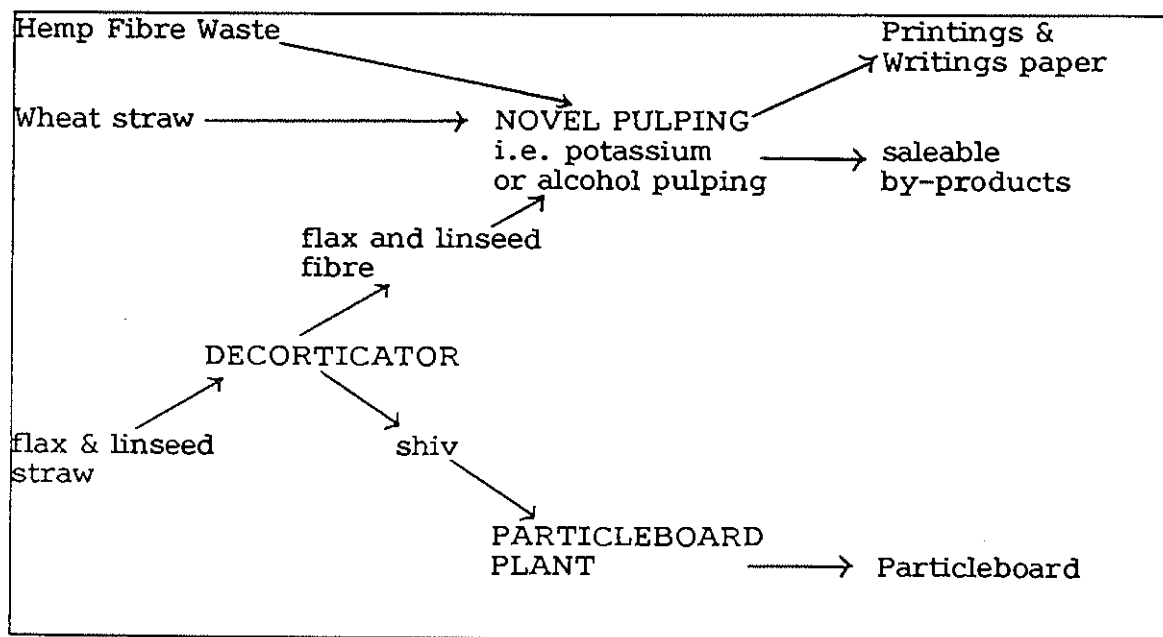


Figure 8 - Paper and board from agricultural waste

4.5 Integrated fibre processing plant

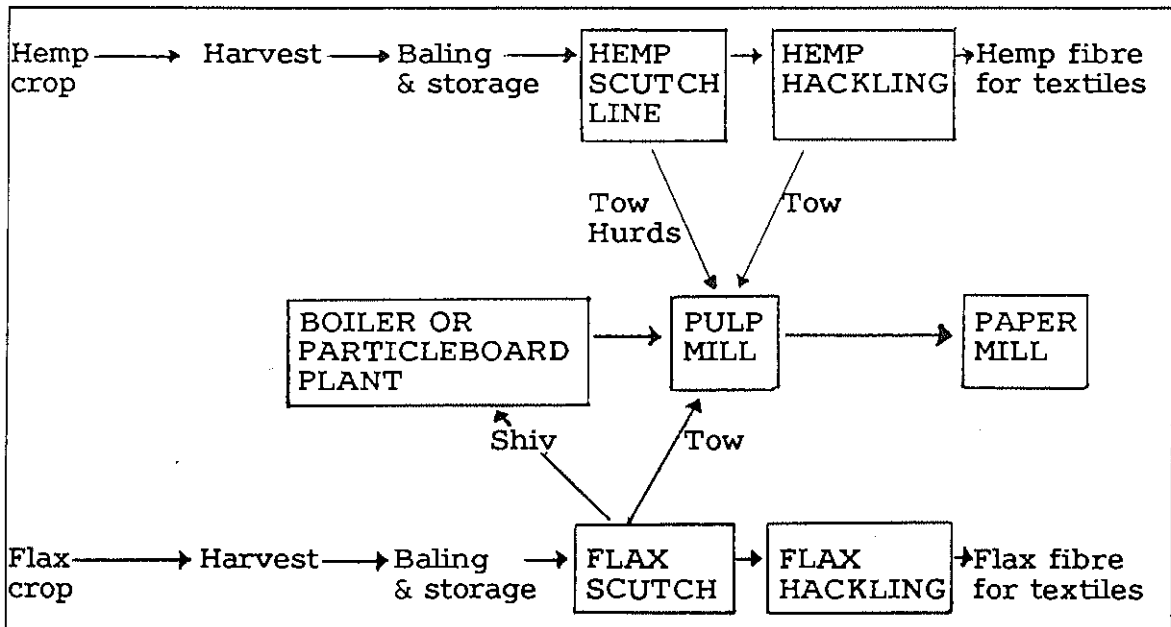
Although large amounts of high grade paper could be produced without additional cultivation, an even greater tonnage of paper could be produced as part of a revived textile industry as outlined in our previous report, "Bioregional Fibres - the potential for a sustainable regional paper and textile industry based on flax and hemp" (Riddlestone and Desai, 1994). Reviving a local textile industry can offer a natural fibre alternative to imports of cotton which have serious environmental problems associated with their growing.

There are currently no pulp mills in the UK which can produce pulp from hemp and flax for printings and writings papers. We see the establishment of pulping of short/waste fibres of hemp and flax as part of an integrated fibre processing plant as shown in Figure 9.

We envisage regional cultivation of flax and hemp, with the crop being processed at the local processing plant into fibre ready for spinning and weaving into cloth. The shorter, waste fibres would then be sent to the paper pulping mill. The woody core of hemp can be pulped for paper or sold for animal bedding. Both hemp and flax core can be used to make particle board. The high grade pulp would then be mixed with locally/regionally collected waste paper to produce the paper which we need.

Our bioregion, the South-East of England is particularly suited to the cultivation and processing of flax and hemp for textiles and other products because of the climate. Both flax and hemp need to be "retted" prior to processing to allow the fibres to separate from the woody core and outer stem. The simplest and most cost effective method of retting entails leaving the crop to lay on the ground in late summer for 3-12 weeks, turning once or twice. This is common practice in the modern flax industry. In other parts of the UK, where the climate may not be conducive, expensive methods such as tank retting would be necessary.

Figure 9 - Integrated fibre processing



4.6 "Local Paper" in the UK and overseas

If locally collected recycled paper can be mixed with locally grown non-wood fibres, then we feel this would be a positive contribution to a sustainable paper cycle. Of course, locally grown and processed wood fibres could provide an alternative local virgin fibre source, but the added advantages of higher quality, low energy pulping and possible textile fibres would be lost.

There are marketing advantages to be gained by promoting a green product (MORI, 1995). We believe that increasingly issues of transportation and local purchasing will come to the fore and therefore suggest a market for "Local Paper" will develop. This may be particularly the case as the recommendations of Local Agenda 21 working groups throughout the country - developing local initiatives to move towards sustainability - are put into action (LGMB, 1994). The environmental credentials of a recycled/non-wood fibre Local Paper will be very high and should be able to capture a significant share of the market.

Other countries have different circumstances and different locally available raw materials. Nonetheless the concept of Local Paper can still hold. For example, cotton, rice straw or bagasse waste will be plentiful in tropical climates and could be used as a source of virgin fibre to upgrade waste (Paavilainen, 1993). In addition, the local population may not need a high specification paper if they are not using photocopiers, etc. which would allow for smaller, less expensive paper mills.

4.6 Conclusions and recommendations - a sustainable paper cycle for South-East England

Based upon the background research in previous sections, we propose the following scheme to develop a sustainable paper cycle for high grade paper in the South-East;

1. A continuing public information campaign initiated through local authorities and local waste paper collection schemes to:
 - increase participation in existing office waste collection schemes, leading to expansion, with continually improving customer service;
 - raise awareness and commitment toward reducing paper consumption through realistic, practical advice;
 - increase the use of recycled paper and introduce and promote the concept and use of "Local Paper" (locally or regionally collected and recycled paper upgraded with locally grown and pulped virgin fibres).
2. Office waste paper collected would be delivered to a central collection point where it can be sorted carefully by grade and to remove contaminants - we would like to see collection using low emission vehicles such as electric, ethanol or human powered.
3. Transport of the paper to a local or regional recycled paper mill of the smallest possible scale viable to produce high quality recycled paper (approximately 10,000 tonnes per annum) with equipment designed to;
 - remove contaminants, stickies and some inks whilst leaving most of the fillers;
 - bleach with oxygen or hydrogen peroxide;
 - recirculate and conserve water; and
 - conserve energy where possible.
4. Waste materials arising from recycling can be utilised rather than landfilled or incinerated eg. solid rejects as a gravel substitute in road bases and non-solids for building boards or other uses.
5. Addition of 10%-25% virgin fibre flax/hemp or straw pulp to upgrade the paper and extend its range of uses.
6. Local paper pulping could be allied to local textile and particleboard production from our traditional fibre crops, flax and hemp.

Local paper can make a significant contribution to sustainable development and serve as a model which could be replicated elsewhere. Such a scheme would reduce pressure on the world's forests and on landfill space. It would also generate employment and wealth in the region thereby bringing greater social stability.

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Appendix

RECYCLING QUESTIONNAIRE

NAME OF BUSINESS:

ADDRESS:

TEL:

(1) Do you recycle your paper? Y/N

(Y) - If so which collection scheme do you use?

Do you sort it? Y/N

Do you pay for collection per tonne/bag? Y/N

Cost £

(N) - If don't recycle, why not?

- Do you have to pay for trade waste collection? Y/N

Cost/kg £

(2) How many sacks/kg of waste paper do you produce a week?

(3) Do you currently use any recycled paper in the office? Y/N

(4) What type of paper do you use?

What do you use it for? copying/printing/general

(5) Would you be interested in joining a local collection scheme? Y/N

-which would entail some care in types of paper put in the recycling bin
ie not envelopes/fax/highly coloured/shiny paper

-white and buff headed/copy paper-ok

(6) Would you buy locally produced recycled paper Y/N
(price depending - what price do you pay for your paper now?)

PLEASE PRINT NAME:

THANK YOU

Useful Addresses

British Paper Company, Frogmore Mill, Hemel Hempstead, Herts. HP3 9RY.
Tel: 01442 231234
Small recycled paper mill

Brox Corporation Ltd, PO Box 12, Manchester M44 6DZ Tel: 0161 775 4977
Manufacturers of bicycle collection vehicles

EPIC, 228, London Road, Reading, Berks. RG6 1AH. Tel: 01734 665 665
Environmental information for paper buyers

Edwin Amies & Sons, 33, Amsbury Road, Coxheath, Maidstone, Kent ME17 4DP
Mould and deckle makers (for hand-made papermaking)

Friends of the Earth
26-28, Underwood Street, London N1 7JQ. Tel: 0171 490 1555
Advice for reducing paper consumption, especially at institutional level

Interox, PO Box 7, Warrington, Cheshire. Tel: 01925 651277
UK sodium peroxide specialist suppliers

Chris and Michael Laver-Gibbs
Griffen Mill, The Old Mill, Crosscombe, Nr Wells, Somerset BA5 3QN
Tel: 01749 - 330117
Handmade papermakers

Paper Round
3rd Floor, 42, Kingsway, London WC2B 6EX. Tel: 0171 404 4848
Office waste paper collection scheme

PIRA International, Randalls Road, Leatherhead, Surrey KT22 7RU
Tel: 01372 376161
Paper industry research, information service and library

Pulp and Paper Information Centre
Papermakers House, Rivenhall Road, Westlea, Swindon. SN5 7BD
Tel: 01793 887468

Waste Watch Waste Line Tel: 0171 248 0242
Advice on waste reduction and recycling

Women's Environmental Network
Aberdeen Studios, 22 Highbury Grove, London N5 2EA Tel: 0171 354 8823
Environmental information & ideas for reducing individual paper consumption

WWF, World Wide Fund for Nature UK,
Panda House, Weyside Park, Godalming, Surrey GU7 1XR Tel: 01483 426444
Reports and information about environmental problems in the paper industry