THE OPEN UNIVERSITY

# ALTERNATIVE TECHNOLOGY GROUP

RECYCLING OPPORTUNITIES FOR

NEIGHBOURHOODS AND COMMUNITIES.

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## 1 Introduction

Increasingly in recent years concern has arisen over our approach to solid wast management. Whether it be due to pollution from an incinerator, shortages of 'holes' suitable for landfill sites or because of concern over resource shortage and energy wastage, this concern has led to some development of systems and approaches to waste management based on treating waste materials as resources and attempting to recover some value from them.

Currently in Britain we dispose of over 170 million tonnes of waste materials every year. Of this, 110 million tonnes is mining and quarrying wastes and 15 million tonnes from power stations and building work. This leaves about 23 million tonnes of general industrial waste and 25 million tonnes of household and commercial wastes. It is the last group that this paper is mainly concerned with. Management of these wastes is the responsibility of local authorities. Currently less than 2% are reclaimed for recycling; the rest is mainly disposed of to landfill (89%) or incinerated (9%).

The resource potential in household waste is considerable; nearly 6 million tonnes of waste paper, 2 million tonnes of glass containers, 2 million tonnes of ferrous metals, mostly 'tin' cans, and over 0.5 million tonnes of rags, are disposed of every year. However, before this potential can be fully exploited, a major development of both reclamation and recycling services and industries will be required.

In this paper I consider the potential for developing recycling activities for domestic waste materials on a 'community-scale'. The reasons why a community industry or community technology approach is considered particularly relevant to recycling activities are outlined later.

Community technology is defined by Boyle (1978) as:

> "A range of tools and techniques that ..... are designed to serve the needs of, and be amenable to, direct democratic control by, the citizens of a small community occupying a specific geographic area".

In addition, community technology should conform, as far as possible, to Robin Clarke's criteria for 'soft' technology, quoted in Dickson (1974). Included in the list of thirty-five are characteristics such as ecologically sound, low specialisation, communal units, innovation regulated by need, science and technology integrated with culture and performed by all.

Boyle (1978) defines the <u>community</u> to which community-scale technology relates as having a population of a few thousand, up to ten thousand people. Such a community will probably comprise a number of <u>neighbourhoods</u> with populations of a few hundred, up to a thousand, and will itself be part of a larger social group or <u>district</u> with a population of a few tens of thousands, up to one hundred thousand. I shall consider in this report those recycling technologies, which are relevant to neighbourhoods and communities. Where these activities are referred to in general as 'community-based', this is intended to imply either neighbourhood or community based.

In Section 2 of this report I shall look at some of the arguments presented in favour of developing a community technology approach to recycling.

Section 3 reviews community-based repair, renovation, reuse and recycling activities that exist in Britain today, giving a brief overview of the type and range of small businesses engaged in these activities.

Finally, in Section 4, I attempt to determine the size of community to which the recycling activities discussed in Section 3 are most appropriate.

## 2 Community Technology Approach to Recycling

Recycling is one group of activities often referred to in discussions of appropriate or alternative technologies and the development of community industries. John Davies (1978), includes the principles of recycling in his list of objectives for appropriate technology, and a wide range of recycling activities are highlighted as special opportunities for small businesses. These cover repair and renovation, reclamation, recycling and reuse. SERA (1976) gives a list of categories for 'appropriate' manufacturing industry, compiled by ITDG (Intermediate Technology Development Group), which includes waste material separation and reprocessing, second life durables (i.e. repair, renovation and manufacture from used components) and waste material processing for energy production. Newman (1980), in the report 'Community Enterprise', written as part of the Trinational Inner Cities Project, concluded that:

> "Community-based enterprises, combining refurbishment and recycling activities. could be established in every community in Britain".

Seldman (1978) puts the case for community-based recycling more forcefully.

> "resource availability will reflect our ability to have an open, demoncratic society or one centrally managed through resource allocation ..... the more we close the loop to waste generation and the reprocessing of new products the closer we are to self reliant communities. Communities can supply the basics of a sound, environmentally safe economy: this is one of the major implications of the low technology approach".

The development of recycling activities has also been repeatedly proposed to create jobs and help alleviate high unemployment. Martin Timbrell (1980), in a discussion of Government action to alleviate high unemployment, stated that:

> "Local authorities should have access to agreed sume of Government subsidy for each job created in ..... waste reclamation".

This concern is often combined with a desire to create jobs which benefit rather than destroy our environment.

Friends of the Earth have been advocating the development of environmentally sound technologies (including waste recycling) for many years. Green and Webb (1977) maintain that through such technologies "the application of environmental principles can meet real social and economic needs within the community and in the process create new jobs". And in a more recent publication, Barbier (1981) considers the employment potential of four environmental policies - loft insulation, paper recycling, cycle way construction and an allotments programme - concluding that:

> "The employment creation potential of the environmental policies decribed, and their revitalising effects on the various industries concerened, make them essential in a time of economic recession and overall industrial decline".

Other arguments put forward both to explain and to propose further development of community-based recycling, centre on four factors:

diseconomies of scale in certain (large scale) industrial recycling processes;
transport costs;
the dispersed nature of waste arisings;
the instability of many waste material markets.

Added to these are the associated benefit of reduced dependence of imported materials and the environmental benefits that can be achieved through recycling.

Thomas (1979) discusses (in Chapter 2) the environmental benefits which accrue from a wide variety of recycling processes. These include (assuming recycling activities substitute for production from virgin raw materials are not used to increase consumption) reduction in the exploitation of natural resources and in the amounts of waste to be disposed of; less polluting emissions and lower energy demands. It can also be argued that the environmental benefits are increased through community-based, decentralised recycling activities, compared with more centralised large-scale recycling operations. In particular, the adverse effects of transport, through polluting emissions and energy use, will be lessened.

One example of diseconomics of scale in a recycling process can be seen in the paper industry, described by Western (UNIDO, 1979). Over the past seventy years, the size of paper-making machines has increased from approximately 2 metres in width to 10 metres; operating speeds from 100 metres per minute (m/min) to 900 m/min, and annual productive capacity from 5,000 tonnes per annum (t/a) to over 150,000 t/a (that is, from 15 tonnes per day (tpd) to over 400 tpd). Western, retired chief executive of Reed Engineering and Development Services, and consultant to the Intermediate Technology Development Group (ITDG), maintains that increasing size has been outpaced by increasing cost, and that concern has developed within the industry that the desirable maximum has been exceeded and diseconomies of scale have crept in.

Work carried out by Western (UNIDO, 1979) shows that the intrinsic cost of (paper) machines per unit of production increases disproportionately above a given width and still further above a given speed. These cost increases are not compensated by reductions in overheads or labour costs. Increased width and speed have required increases in sophistication material cash and ancillary costs for plant and increased costs for distribution, because of the greater volume involved. The inflexibilities of large plant also creates inefficiencies in matching production to demand in a fluctuating market.

Western also attempted to assess the optimum machine capacity in terms of capital cost per unit of production, and concluded that the lowest capital cost per tonne of product was for machines between 2.2 and 4.5 metres wide, and that the most efficient in terms of productive or operating efficiencies were also around 2.5 to 3 metres wide. He recommends the development of a standard paper machine around 2.5 metres wide, operating at up to 200 m/min, producing between 20 and 60 tonnes per day as the optimum sized plant for developing countries. His analysis, though, is based on costs and efficiencies of the paper industry in developed countries and therefore, one can conclude that this scale of paper production is also an optimum size for Britain - a size much smaller than those favoured by the British Paper Industry in recent years.

The relatively low value of many reclaimed materials relative to transport costs, makes the latter a significant factor in the economics of relamation and recycling. Considering the widely dispersed nature of household waste arisings, it becomes apparent that large scale, more centralised recycling activities will suffer a penalty from increased transport costs. This is supported by the conclusion reached by Klein et al (1978), in a feasibility study of small-scale cellulose insulation industry in Tompkins County, New York:

> "Transportation energy is the second largest factor (in energy conservation; the first is choice of raw material) favouring a decentralised industry such as cellulose (insulation manufacture) which would use fifty times less energy in transport compared with a highly centralised insulation industry".

It has been argued by Bower (1977) that a limited number of uses for a reclaimed material can cause instability in the market for that reclaimed material; a situation which may be improved by diversifying the range of uses, and hence outlets for that reclaimed material. Certainly, one of the major obstacles to increased reclamation is the instability or simple lack of market outlets for waste materials, if collected. To encourage more reclamation and recycling, more and more diverse uses for these wastes need to be found. Community-based, small recycling business could play an important role here.

## 3. A review of Community-based Recycling Activities

This review of "recycling" (including repair, renovation, reuse and recycling) activites, shows that a significant amount happens already on a community-scale in small businesses.

Section 3.1 and 3.2 give an indication of the range of repair and renovation and reuse businesses currently found in Britain. I have not attempted a comprehensive survey of these activities; just to give examples of each type of activity cited. These are taken from three recently published directories of co-operatives in Britain:

Co-ops: a directory of industrial and service co-operatives: Co-operative Development Agency (CDA) (1980).

Directory of Common Ownership Co-operatives: Industrial Common Ownership Movement (ICOM) (1980)

In the Making: an annual directory of co-operative projects

The development and extent of community-based co-operative activity is fairly well documented in these and other publications. The same is not true of the small privately owned firms and businesses - which probably far outnumber co-operatives - carrying out recycling activities, about which little information is currently available.

Section 3.3 looks in greater detail at some specific examples of community scale recycling activities, involving the manufacture of goods from waste materials. The emphasis in this section falls on developments in recycling technology and opportunities for increasing community-scale recycling, rather than on existing recycling activities. The reason for this is that relatively few community-scale manufacturing recycling businesses exist today.

This review does not cover reclamation of wastes unless accompanied by some recycling activity. Reclamation is dealt with in another ATG Report entitled "Reclamation Opportunities for Neighbourhoods and Communities". Reclamation refers to the intermediate stage between the consumer and the recycling process or industry, and involves the collection, storage, and possibly sorting, baling or crushing, and sale of waste materials for recycling.

### 3.1 Repair and Renovation

(i) Furniture renovation

The past ten years has seen a considerable growth in small businesses carrying out furniture renovation, including re-upholstery work and stripping down and renovating furniture made of wood. This commercial sector, found in almost any town, is fringed by groups who have taken up this activity as a job creation or community service activity. Pearce and Cassidy (1980) describe one such project, 'Goodwill', in Glasgow, established by the Council for Voluntary Service. It employs thirteen people in a workshop to collect, refurbish and sell discarded furniture, as well as clothing, bric-a-brac and books. Goodwill was set up to run as a financially self-sufficient venture, although initially, with the support of Manpower Services Commission (MSC) money; and to provide employment for disabled people, alcoholics and ex-mental hospital patients.

(ii) Consumer appliances

Repairing electrical and other consumer appliances is an activity which is predominately carried out in the community by individuals (often in an informal way) and by small shops and businesses (often as a sideline activity). Some large manufacturers offer repair services for their products, but increasingly product design is such that repairs can cost more than replacement. This situation is exacerbated by the lack of availability of spares for many appliances making repairs more difficult; a form of built-in obsolescence, described by Packard (1963).

The repair of consumer appliances, especially electrical goods, has formed the basis for the development of a number of community-based businesses, including the following two examples. The Oxfam Wastesaver Scheme described in more detail in Thomas (1979), included an electrical goods repair shop, where discarded appliances were repaired and tested before resale in the Wastesaver Shop. Brass Tacks, in the East End of London, employs twenty people on MSC funding, in a community workshop for recycling unwanted electrical appliances and furniture. The project, set up by the Mutual Aid Centre in April 1980, sells the repaired items in its shop, the profits going to local charities, and offers a repair service, as well as help, to individuals wanting to carry out their own repairs.

(iii) Buildings

Building renovation and repair is another area traditionally dominated by small businesses. Many small building firms undertake repair and renovation work, some as a deliberate policy, others because it is work offered. In recent listings of co-operative buildings groups in CDA (1980) and In the Making (1980/81), six co-operatives are mentioned as specifically concerned with renovation repair and refurbishing work. Action Area Builders, Altham Workers, Co-Op, Artemis, Bristol Community Building Co-op, Experimental Community Workshops, Keskidee Building Co-Op. These are all small businesses, employing between two and ten workers, and represent only a very small proportion of building firms, both co-operative and private businesses, that engage in this type of work.

(iv) Vehicles

Cycle repair has supported the development of some small businesses in recent years, not surprisingly in view of the current revival of interest in cycling. Both Recycles in Edinburgh and York Cycleworks, are small co-operatives that combine cycle hire with repair work. Recycles opened in 1977, just doing cycle repair work and have since expanded and switched their emphasis to cycle hire, for economic reasons. They now employ about six people, hiring bikes, selling bikes and spares, and doing repairs.

The majority of car repairs are also carried out by small businesses, whether by garages, individuals, or repair firms. Again, this area has seen a growth in community-based activity, with a few vehicle repair co-operatives emerging. The Metropolitan Motor Cab Co-operative repairs taxis and cars and Major/Minor Repairs in Leeds, offers a repair service similar to other repair firms. The MKOK Garage in Milton Keynes, is a motorist 'Do-it-Yourself' Repair Centre, which offers to members of the public the opportunity to carry out repairs to their cars in a controlled and well-equipped environment, with experienced mechanics on hand to give advice. Opened in 1979, it is a consumer co-operative, with over one thousand members.

## 3.2 Reuse

Repair and renovation could also be labelled as reuse, since a waste product is being made available for use again in the same form, or for the same function. This section considers two additional types of reuse activities which support small businesses.

(i) Most reuse associated with the first group occurs within the home, business, or institution, not as a separate or distinct productive activity; for example, reusable linen, cutlery or crockery. In some cases, though, the processing necessary for reuse to be possible is a distinct activity carried out by a separate business or industry. Bottle washing and laundering services are two examples of this, and both activities support some small businesses. I am aware of only a few bottle wasing firms operating in Britain, buying in mostly wine and some screw-top bottles, washing and sterilising them for resale to the wine, beer, and soft-drinks bottling industry.

An interesting example of a community-based bottle washing business comes from California, USA, where the Berkely Ecology Centre started ENCORE, or Environmental Container Reuse. Described in Compost Science/Land Utilisation (1979), ENCORE predominantly washes wine bottles for which there is a large market. ENCORE has grown into a thriving small business now employing around nine people, handling 20,000 cases of bottles a month (about 80 tonnes of glass), with a turnover of over $125,000 per annum. Also recently incorporated into the process is an experiment in the use of solar energy to heat the water for washing.

(ii) Secondhand shops

Nearly-new clothing shops and second-hand goods shops and dealers, selling almost everything from cookers to cars, books to building materials, exist today in most towns around Britain. In fact, they are so much a part of everyday life that they are often overlooked when considering recycling activities.

## 3.3 Recycling

Manufacturing goods from waste materials, or recycling, covers a very wide range of activities, including the production of papers and board from waste paper, the use of waste glass in producing glass fibre, re-refining lubricating oils, de-tinning tin-plated steel, and many others.

However, the majority of these recycling activities are carried out in 'large-scale' centralised plants, and examples of community-based or small-scale businesses engaged in the manufacture of goods based on recycling are not very common. This is in contrast to the substantial development of community-based, small businesses in the reuse, repair and renovation, and poses the question of what has limited a similar growth in manufacturing recycling activities. Both the lack of appropriate technological development, and financial constraints, play major and interactive roles. However, in precisely what way the roles interact varies from activity to activity, and a detailed analysis of each specific recycling technique is necessary before this question can be answered.

Some of the opportunities for community-scale recycling of paper have been (and are being) investigated in this way, in my current research work with the AT Group. In particular, I have been working on the technical and economic feasibility of neighbourhood scale paper recycling. For this reason, the following section on paper recycling contains considerably more information than those on glass, plastics, or metals. This reflects my research interests, rather than the relative importance of - or, indeed, scope for - recycling the different waste materials reclaimed from household wastes.

Discussed below, under the headings paper, glass, plastics, metals, referring to the material recycled rather than the recycling process, are examples of existing community-based recycling businesses, and technological developments considered appropriate to community-scale recycling activities. Although they account for the majority of household wastes, these categories do not cover all the materials that could be reclaimed from this source. One other important waste material for which I have not yet investigated the opportunities for community scale recycling, and hence not discussed below, is textile wastes, or rags.

(i) Paper

Waste paper can be recycled into a variety of products, with the most obvious and by far the most common being paper and board. Probably the next major use of waste paper is the production of insulating materials, including a loose fill cellulosic insulant and insulating wall-boards. Both these areas of recycling activity are described below. Other possible uses, not covered below, include shredding newspapers for animal bedding, animal feedstuffs, soil conditioner for land reclamation, peat block substitutes, artificial 'wood' logs and roofing materials. Further discussion of these uses for waste paper can be found in CSAWS (undated) and Franklin (1973).

(a) Recycled paper and board

About 5% of the waste paper in household waste is currently recycled, in Britain, in paper mills, with production capacities between 20 and 200 (or more) tonnes per day. Recently there has been some interest in developing smaller recycling units, as a way of stimulating demand for waste paper and hence increasing its reclamation, whilst recognising the downward spiral that the UK paper industry is in. Facing a serious and continual decline through competition with pulp and paper mills abroad, the UK paper industry has, in many cases, found the capital investment of many millions of pounds in new large-scale recycling plant prohibitive.

A number of people and organisations have shown interest in the potential for community-based paper recycling, including the Wandsworth Employment Research Project, CAITS (the Centre for Alternative Industrial and Technological Studies, NE London Polytechnic), Leicester Inner Area 1 Youth Employment Committee, SE London SERA (Socialist Environment and Resources Association), Conservaction in Newcastle Upon Tyne, and the Childrens' Trash Bank in Ipswich.

A common scenario proposed by these groups involves using locally collected waste paper to produce a range of writing and drawing papers for use in local schools. It has been suggested that a move towards a more closed loop system in this way could reduce the quantity of wastes for disposal, whilst providing local employment producing for a local market.

Technically, a wide range of product output from 1 tonne per day (tpd) to hundreds of tonnes per day for recycling paper is feasible. However, the economic viability of the smaller production capacities is largely unknown, particularly for scales where the equipment is neither readily available nor in use in Britain today, hence causing many of the important parameters in the financial analysis to be uncertain. This certainly applies to anything under 20 tpd.

Twenty - fifty tpd capacity (as explained earlier) is considered small scale by the British Paper Industry, and there has been some revived interest in this size of plant. However, the capital costs for a 20 tpd plant is still several million pounds, placing it beyond the scope of a community-based industry. An appropriate paper recycling technology for community-based enterprises, must therefore involve plant capacities of less than 20 tpd, probably much less, with much lower capital costs. Some equipment is available that fulfil these criteria, but virtually all of it has been developed for Third World Countries, and hence its appropriateness for use in Britain is untried.

Pulp Packaging Units producing from less than 0.1 tpd to 1 tpd of egg boxes or other moulded pulp products; a range of Indian paper-making equipment for plant capacities from 1 tpd to 15 tpd or more; and the 'Melbourne' plants producing much less than 1 tonne per week, are all examples of small-scale paper recycling plant operating in Third World Countries. Other designs have been, or are being, considered, including a 5-12 tpd recycling plant designed in 1975 (but not built) by Allen W. Berry Limited, in conjunction with ITDG, and a 2 tpd plant being designed by Parsons Limited, a paper machinery manufacturer in Manchester.

Capital costs of this equipment ranges from £1,300 for the 'Melbourne' to an expected £150,000 for the 2 tpd plant being developed by Parsons Limited. A 0.1 tpd Pulp Packaging Unit costs in the region of £50,000, and a larger unit producing around 1 tpd, about £250,000. The Indian Coromandel Paper Plant costs around £20,000 - 30,000 for 1 tpd capacity.

The Pulp Packaging Units were developed by Tomlinsons (Rochdale) Limited, on behalf of I.T. Development Techniques Limited, to satisfy a need in developing countries whre the total demand for egg boxes was smaller than that produced by other commercially available plant. Newsome (November, 1978) describes a unit, designed to convert waste paper into egg boxes or trays, as comprising of modular machines of three types: a pulp preparation machine, a moulding machine and a product drying unit. By varying the mould shape, a wide range of products can be produced, including fruit or meat packing trays, packaging for wine bottles, seed pots and insulating ceiling tiles (with the addition of fire retarding chemicals).

The other plants mentioned above produce either sheets or rolls of paper or board. The smallest scale production units are the 'Melbourne' range of paper recycling machines, which were developed by Anthony Hopkinson, and are marketed by "Third Scale Technology" (3ST) Limited - see 3ST (undated), Hopkinson (August, 1977), Hopkinson (December, 1978) and Paper (December, 1977). They are sheet forming machines, with the 'Melbourne 5' producing sheets 600 x 420 mm suitable as writing, drawing or packaging papers. The 'Super Melbourne' produces larger but rougher quality sheets, 850 x 650 mm in size, and suitable only as packaging papers. Rated to produce between 60 and 100 sheets per hour, giving a maximum output of 0.04 tpd, they could both employ one, two or three operators.

After experimenting for some time with a very small-scale continuous (Fourdrinier type) paper recycling machine, as described in MRW (July, 1979), capable of producing up to 0.5 tpd, Anthony Hopkinson abandoned its development due to a lack of finance and to technical difficulties, in favour of promoting an already proven design for a '1 tpd' plant, operating in India. The Coromandel paper plant (see 3ST, undated) is a cylinder mould machine which can use a variety of raw material, including waste paper, to produce sheets of writing, printing and packaging paper, 1110 x 660 mm. It is considered to require sixty to seventy-five workers to operate if run on a three-shift basis. Other similarly sized paper mills are to be found in India, many of which are hand-made paper mills, producing high quality papers, much of it for export.

Moving to a slightly larger scale, Western (ITDG, 1979), in his report on small scale paper-making in India, describes a typical 5 tpd recycling paper-mill. A continuous, Fourdriner-type machine is used to produce writing and printing paper 1.25 metres wide. It is estimated in the report, that this type of mill would employ in India one hundred and eighty workers. A 15 tpd mill, using straw, rag and waste paper, is also described. Employing two hundred and sixty-five workers, this again is a continuous, Fourdinier-type process. Both mills work a three-shift system.

(It is not known whether these examples of small paper mills drawn from Indian experience could be operated by a smaller labour force in circumstances where labour costs were proportionally much higher than in India, such as in Britain.)

A British paper-machinery manufacturer, Parsons Limited, is reputed by Hopkinson (1981) to be developing a design for a paper-making plant with a capacity of approximately 2 tpd. The plant, a cylinder-mould machine, is being designed for export to Third World countries. However, it will be more highly automated and hence less labour intensive than the Indian-designed plants, employing only about twenty people in a three-shift operation. Compare this with the Coromandel 1 tpd cylinder-mould machine employing sixty to seventy-five workers - and two hand-made paper mills in India, one discussed by Westen (UNIDO, 1979) producing 0.25 tpd, employing one hundred and twelve people, and the other producing 1 tpd, employing ninety people (Westen, ITDG, 1979).

Insufficient data is available to assess the operating costs, and hence expected profitability of these plants. However, some tentative conclusions can be drawn from the information available. In Britain, the product value from a '1 tpd' paper-making plant, producing writing/printing papers, would be in the region of £100,000 per annum. This is obviously insufficient to cover manufacturing costs and support sixty or more jobs, demonstrating that the Coromandel plant would not be an economically viable proposition in Britain. The Parsons '2 tpd' plant would produce approximately £200,000 of paper products per annum, which could, however, feasibly support twenty jobs, dependent upon the extent of manufacturing costs, other overheads, and capital depreciation. The output per employee of the Parsons plant is expected to be about 0.1 tpd/employee. This compares with an average of 0.2 tpd/employee in the British paper and board industry in 1979, a figure derived from data given by Barber (1981) on labour and productivity in the British paper and board industry.

Further research will be required to investigate the economic viability in Britain of the Parsons plant. Similarly for the Pulp Packaging Units. Some years ago IT Development Techniques (1976) concluded, in an economic analysis of the UK operating costs for egg box production in their Pulp Packaging plant that, based on the market price of 2.55 per unit, a profit of up to 1.53p per unit, and a gross profit of over £400 per week were possible, at that time. What the position is today though is unclear.

It is useful to compare the capital investment per workplace of these paper recycling plants. This criteria was used in Schumacher (1973) as a definition of intermediate technology:

> "If methods and machines are to be cheap enough to be generally accessibe, this means that their cost must stand in some definable relationship to the level of incomes in the society in which they are to be used. I have myself come to the conclusion that the upper limit for the average amount of capital investment per workplace is probably given by the annual earnings of an able and ambitious worker. That is to say, if such a man can normally earn, say, $5000 a year, the average cost of establishing his workplace should on no account be in excess of $5000. If the cost is significantly higher, the society in questions is likely to run into serious troubles".

Capital investment per workplace for the Parson's plant will be in the region of £7,500. The £50,000 pulp packaging unit employs 5 people, giving a cpital investment per workplace of £10,000. Both these figures are higher than the probable annual earnings of the workforce, but not substantially so.

However, a capital investment of £150,000, needed for Parsons plant, or £50,000 for the Pulp Packaging Unit, represent, however, a relatively high investment for a community-based enterprise. This, then, poses the question of whether a smaller, cheaper, plant could be operated successfully in Britain, independent of whether the Parson's plant or Pulp Packaging Unit are viable.

The only small scale paper mills that actually operate in Britain today, are hand-made paper mills. In the Two Rivers Mill in Lancashire, R. W. Partridge makes a living producing about 500 sheets a week, size 600 x 420 mm, of high quality 'art' paper from bought-in pulp. Peter Bower runs a hand-made paper workshop in St. Albans, making 'art' paper from high quality recycled pulp. He and Bruce Glasser have been making paper on this scale for some time as a part-time activity, and sell their papers for 40p or more a sheet. Both these paper mills (or workshops) however, rely on producing high quality papers from high quality materials for their financial viability, and could not operate economically using lower quality reclaimed paper as their raw material.

The Melbourne machines fulfil the criteria of small, cheap, equipment, but can they be operated in an economically viable way in Britain? The Melbourne 5 is theoretically rated to produce between two thousand and three thousand five hundred sheets per week. Sold at a similar price to hand-made 'art' paper, 40p a sheet for instance, would give a product value of £800 to £1,400. However, the paper produced by the Melbourne machine is not of the same quality as hand-made paper, particularly if post-consumer waste paper is used as a raw material. If the Melbourne was used to produce sugar paper, a low quality drawing paper used in schools, the weekly production of between 0.1 and 0.2 tonnes, would only be worth £40 to £80. The latter figure could obviously not support one or two jobs; however, if an intermediate value product, between 'art' paper and sugar paper, or a product mix to achieve this were aimed at, the Melbourne could feasibly become a financially viable concern.

Practical experience, however, of operating a modified 'Melbourne 5' shows that the actual production output is far lower than that predicted theoretically. The results of a series of experiments I have been carrying out, including working with a group of young, unemployed school-leavers on a Youth Opportunities Programme Scheme, suggest that only about 0.1 of the rated output of the Melbourne 5 could be achieved. With a production of only two hundred and fifty to three hundred and fifty sheets per week, it is unlikely that the Melbourne 5 could support a community business, on purely financial terms.

(b) Cellulosic insulation

Cellulosic insulation is a loose-fill 'fluffy' material, produced from waste paper, usually newspapers. Its production involves shredding and hammer-milling the waste paper, and the addition of chemicals to provide fire retardancy. It is installed by blowing or pouring it into place. It is generally considered to have good insulating properties and not to be toxic or a significant fire hazard.

Figures quoted by the US Department of Housing and Urban Development (1975) shows a better 'R' value for cellulosic insulation than rockwall or glassfibre, as shown in Table 1. (R value is thermal resistance, and equal to 1/U value.)

Table 1: Comparative Insulation Value of Cellulose, Rockwool and Glassfibre

| Overall R-Value* | Inches of Loose Fill Insulation Material Required | | |
|---|---|---|---|
| | Cellulose | Rockwool | Fibreglass |
| R - 11 | 3" | 4" | 5" |
| R - 19 | 5" | 6"-7" | 8"-9" |
| R - 22 | 6" | 7"-8" | 10" |
| R - 30 | 8" | 10"-11" | 13"-14" |
| R - 38 | 10"-11" | 13"-14" | 17"-18" |

* R-Value (thermal resistance) $= \frac{1}{\text{u-value}}$

Source: US Department of Housing and Urban Development (1975)

Some debate has surrounded the questions of fire retardancy capability, attractiveness to vermin, and the possibilities of corrosion from added chemicals, of cellulosic insulation, and criticism levelled on all 3 respects. However available literature on this subject is very sparse, and hence it is difficult to draw firm conclusions. Prevailing opinion though seems to favour the conclusion that cellulosic insulation is not a hazardous material.

In their preliminary report on Shelter Shield cellulose insulation, produced by Diversified Insulation in Scotland, The Agreement Board (1977 and 1978) concluded that:

> "the thermal performance of Shelter Shield treated cellulose fibre is equal to that of material presently used in this area of building insulation (such as glass or mineral fibre) and that installation of the treated cellulose fibre should not result in a

significant increase in the fire hazard which exists in a normal loft situation."

This conclusion is supported by Rogowski and Sutcliffe (1980) of the Building Research Establishment in their work on fire performance in loft insulating materials.

Although a relatively new product in Britain, the use of cellulosic insulation in the USA is well established, with - according to Bendavid-Val (1978), over two hundred manufacturing plants, accounting for around 30% to 40% of the residential building market. The suitability of this technology to community-based production is summed up in this quote from a feasibility study of cellulose insulation production carried out by the Tennessee Valley Authority (1977):

"Because cellulose insulation is produced from waste paper that is treated with fire-retardant chemicals, the product can be produced and marketed by small, local, mills that require relatively low amounts of capital investment. Because the finished product is very light and bulky, it is not economically feasible to ship it great distances, thus lending itself to local production."

Bendavid-Val (1978) carried out a study for the Institute for local Self Reliance in Washington, USA, of the potential for community-based business to establish themselves in the cellulosic insulation field. The report, contradicting the statement above, concluded:

"Our analysis of the available data about manufacturing cellulose insulation leads us to recommend that a community-based business should not attempt to manufacture cellulose insulation initially; instead, it should first establish itself as an installation enterprise. Manufacturing cellulose insulation requires an initial capital investment of as much as $300,000 to $500,000. This is a relatively high level of capital investment per job created - as much as $25,000 to $50,000 which may be too high for communities stressing job creation. In addition, a community-based enterprise may not be able to market the volume of output necessary for financial success. A small manufacturing plant can be forced out of business overnight if a large manufacturer with a built-in distribution network moves into the same market area. Furthermore, setting up a cellulose fabrication plant requires substantial technical and business skills: obtaining these skills, performing the necessary equipment and marketing research, and getting the equipment ready for operation will require a delay of many months.

"We recommend that a community-based enterprise begin operation by combining a cellulose insulation installation service with a recycling service. In the course of operating this business, staff members would develop a thorough knowledge of market and supply conditions that would serve as a sound basis for expanding into manufacturing, if they choose to do so."

Their analysis was based predominatly on the cost of turn-key plants (that is, complete equipment packages) assuming a minimum capital investment of around $300,000, to produce 400 tonnes per annum, employing ten to twelve people.

Another feasibility study of small-scale cellulose insulation industry came to a different conclusion. Klein et al (1978) considered a 'medium' scale and a 'small' scale operation.

The medium scale plant was a turn-key plant, costing $150,000 for capital equipment and start-up costs to produce 3,500 tonnes per annum and employing eight people. The small scale plant was based on the Mid-Sioux Opportunity Inc. plant, which was developed around agricultural equipment, in particular a corn-feed grinder. The small scale plant evaluated in the 'Tompkins County' study had essentially the same design, but used two corn-feed grinders, to produce 1,200 tonnes per annum, employing five to six people, for a total cost of S50,000 (capital, plus start-up).

It was concluded that both the medium and the small scale plants were viable operations, with the smaller operation taking far less capital to start, employing more people per unit of product, but having a smaller profit margin. The medium scale, therefore, has some economic advantages, balanced against the smaller scale operation's advantage of being easier to start, and promoting more local co-operation and self-reliance.

(ii) Glass

Household waste glass or cullet can be either directly recycled to produce more glass containers, or used in the manufacture of other products, such as an aggregate in road surfacing; in building materials with cement or clay; with cement or resin in tiles; in reflective paints as glass beads; as abrasives in glass paper; and to produce foamed glass fibre insulating materials. There is extensive literature covering the research and application of these and other recycling opportunities for cullet, particularly in the USA, where most of the work in this field has been done. Research papers on this subject are gathered in: the Proceedings of the Symposium on the Utilisation of Waste Glass in Secondary Products, New Mexico University (1973); the Proceedings of the Mineral Waste Symposium, US BoM (bi-annual, 1970). Reviews can be found in Bate (1976); Clough (1974); Thomas (1979); Breakspear and Heath (1977).

Although technically feasible in most cases, the economic viability of community-scale application of these cullet recycling processes is, as yet, largely unknown. One exception is the work carried out at University College, Cardiff, which has led to a process for converting waste glass containers to decorative floor, wall and working surface tiles, which have properties of high resistance to scratching and scuffing, are hard wearing and show good skid resistance. The glass is first crushed, classified by size, then mixed either with a polyester resin (80% glass, 20% resin), or with cement (40% glass 35% sand, 15% cement), set in a mould, cured and polished. Any colour combination possible, as it is easy to adhere pigments to glass pieces (surface coat), or glass dust can be used to give single colour tiles. The mixture can also be set in plaster mould to make products such as soap dishes and pipe flanges.

Economic analysis by Wheatley (undated) has shown that the production cost per square metre increases with decreasing capacity or size of plant.

A plant capable of producing 7000 tonnes per annum, or 300,000 $M^2$ of tiles would have required a minimum selling price (to cover costs) of £3.90 per $M^2$ in 1978, whereas a 700 tonne per annum plant would require £7.17 per $M^2$. A capital investment in the order of £50,000 would be required for a glass/resin tile plant producing 700 tonnes per annum, employing 9 people. A capital investment per workplace of £5,500. Cement/glass flooring production laid, in situ, would probably be cheaper to establish.

Despite attempts by the Research Group to secure industrial support for establishing a tile production business in Britain, nothing has emerged so far. However in Liege in Belgium, a firm called Mineral Products has developed the process into a business employing thirty people, producing resin/glass tiles for street paving and moulded products such as waste bins, lamposts and bollards, complete with the City's emblem.

The production of foamed glass from waste glass, described by the Midwest Research Institute (undated), seems to offer some potential for community-based manufacture. Ground glass is mixed with sewage sludge and fired to about 700$^{o}$, when the glass softens and the sewage gasifies, creating bubbles in the glass. The resultant material can be made into blocks, and used as an insulating material. Glass fibre, or glass wool, insulating materials can also be produced on a small scale; the process involved and some information on the commercial potential are outlined in MRI (undated, USBOM (1972) and Industrial Recovery (1974).

(iii) Plastics

Waste plastics recycling is one area of recycling manufacture that is primarily carried out in small production units. Many plastics processors operate their own reprocessing or recycling machinery, or sell to specialised reprocessors who granulate, blend, extrude, cool, and pelletise the waste material, providing it is segregated into separate polymers. However, domestic plastics waste is a mixture of polymer types, as Table II shows, and mixed plastics waste present many more problems for recycling.

| | 1968 | 1974 | 1980 | 2000 |
|---|---|---|---|---|
| Total plastic | 1 | 2 | 5 | 9 |
| Weight per household per week (kg) | 0.1 | 0.2 | 0.7 | 1.5 |
| Weight per year (million tonnes) | 0.2 | 0.4 | 1.2 | 3.0 |
| Composition of plastics waste in household refuse, 1970: | | | | |
| Polyolefins 63% | | | | |
| Polystyrene 19% | | | | |
| Polyvinylchloride 11% | | | | |
| Cellulose 4% | | | | |
| Others 3% | | | | |

Source: Bridgewater (1980)

Reprocessing a mixture of polymers where some polymers are incompatible can produce a material with few useful properties. Mixtures can, however, be adjusted if the approximate composition is known, and even domestic plastics wastes are of reasonably predictable composition, such that their properties can be predicted. Reprocessing of recycling mixed plastics wastes, however, is minimal at the present time. A number of processes that have been developed are discussed by Marshall and Shaw (1975) and Thmoas (1979). These include:

- The 'Reverzer' process was developed by the Mitsubishi Corporation In Japan. It can handle all commonly used thermoplastics in any mixture, and has a high tolerance to non-plastic waste contaminants. The mixed waste is injection moulded into a variety of shapes. Laport Industries Limited installed the Reverzer process at its plant at Widness to produce cable drums, fence posts and stakes under the trade name Analplas.

- Reclamat International Limited (subsidiary of National Freight Corporation) which produced 'Tuftboard', a building board, from solid and film plastics waste.

- Plastics Recycling Limited produced 'Star Board' from mixed thermoplastics waste, with up to 50% contaminants, to produce shoesoles, toys, bicycle saddles, etc.

- Kabor Limited produced a variety of products including furniture, agricultural building materials and pallets from polyethylene and waste paper.

The capital cost of such plant in 1975 varied from £15,000 to £150,000, with most equipment costing below £50,000 for an output of 30-50 tonnes per month (on average). Marshall and Shaw (1975) studied the opportunities for thermoplastics reclamation in the NE of England, and carried out a financial viability analysis, based on a reclamation and recycling process for single polymer wastes. This showed a breakeven point of 30 tonnes per month, with 50 tonnes per month giving a reasonable profit. Capital investment was in the order of £20,000 to £50,000, and eight people would be employed. Processing mixed plastics waste would present a different picture, but probably not dramatically so.

(iv) Metals

Metals show the best record for recycling in Britain of any materials, mainly due to our lack of indigenous raw materials for primary smelting, and the ease with which most scrap metals, unless highly contaminated, can be recycled. Nearly all the metal in household waste is tin-plated steel cans and aluminium, and attempts to increase its recycling have tended to concentrate on improving reclamation techniques. Once reclaimed, these scrap metals are presently recycled in a few centralised plants; the tin-plated steel processed first in detinning plants, and then the steel resmelted in steel furnaces; and the aluminium to secondary smelters. Very little interest has been shown in Britain in developing a small-scale recycling industry for these materials. Seldman (1975 and 1978) reports that in the USA, where the quantity of aluminium scrap in household waste is higher than in Britain, some community-based recycling groups, such as Resource Recovery Systems (Connecticut) and the Recycle Aluminium Company (California) operate small aluminium smelters. Resource Resource Recovery Systems' aluminium smelter cost in the region of $5,000 in 1975 and handles around 2 tonnes per day. In this way they are able to increase considerably the value of the scrap aluminium that they reclaim. They have considered developing this further by manufacturing finished products such as window frames, from the recycled aluminium to improve their profitability.

A traditional small-scale metals recycling activity is the Blacksmith's craft. Once every village supported a blacksmith, whereas today, few working forges exist. At the Centre for Alternative Technology in Machynlleth, Wales, they have established a blacksmiths forge to resmelt the cast equipment and components needed at the Centre.

## 4 How Appropriate are these Recycling Technologies to Neighbourhoods and Communities

Although this report has been discussing in general terms the question of how appropriate recycling technologies are to 'community-based' businesses or industry, it has not attempted to match the scale of each particular process with the size of 'community' to which it could be considered most appropriate. One measure of this appropriateness related the recycling process to the size of the community by the quantitites of waste used or generated by each. I am assuming for this discussion that a recycling technology or process is appropriate in a particular. size of community if that community could generate sufficient waste material, through a source separation reclamation scheme, for it to operate.

An analysis of waste products generated by neighbourhoods and communities is carried out in my ATG paper on 'Reclamation Opportunities for Neighbourhoods and Communities', which calculated the projected yields of recyclable materials from neighbourhood and community based source separation schemes.

Working from calculated waste arisings for neighbourhood and communities, and making assumptions about the likely household participation rates and yields of recyclable materials, it is possible to calculate how much a source separation scheme might reclaim. Table III summarises two such calculations. In these I have assumed a participation rate of 35% and yields of: (1) 20% and (2) 29%.

The 20% overall yield represents that achieved by the Oxfam Wastesaver scheme, and breaks down as 33% yield of available paper, 36% of both glass and metals, and 51% of textiles. The yield of reclaimed paper achieved by Oxfam is, however, low in comparison with other reclamation schemes. The average yield appears to be 60%, and if this figure is combined with the yields for glass, metal and textiles, achieved by Oxfam, an overall yield of 29% is reached.

Table III: Projected Yields of Recyclable Materials for Neighbourhood and Community Source Separation Projects

| | Total Household Waste (in tonnes pa) | Projected yields of materials from source separation scheme (in tonnes per annum) | |
|---|---|---|---|
| | | (1) | (2) |
| Neighbourhood (popn. 500) | 185 | 12.9 paper 7.0<br>glass 2.3<br>metals 2.3<br>textile 1.2 | 18.7 paper 12.8<br>glass 2.3<br>metals 2.3<br>textile 1.2 |
| Community (popn. 5,000) | 1,850 | 129.0 paper 70.5<br>glass 23.3<br>metal 23.3<br>textile 11.6 | 187.0 paper 128.2<br>glass 23.3<br>metal 23.3<br>textile 11.6 |

Matching the information in Table III with the quantities of waste required by the recycling process discussed in Section 3.3, the results shown in Table IV are obtained.

Table IV: <u>The Scale of Recycling Technologies</u>

| Size of Community i.e. popn | | Recycling process/equipment | |
|---|---|---|---|
| ↑ | 100 | | |
| Neighbourhood | | Melbourne paper recycling plant | |
| ↓ | 1000 | | |
| ↑ | | | |
| Community | | Pulp packaging unit | |
| ↓ | 10,000 | | |
| ↑ | | | |
| District | | '1 tpd' paper recycling plant | |
| | | '2 tpd' paper recycling plant | small-scale cellulose insulation manufacture |
| | | '5 tpd' paper recycling plant | |
| ↓ | | | |
| | 100,000 | Medium-scale cellulose insulation manufacture | Glass/resin tile production |
| | | Mixed plastic recycling | |
| | 1,000,000 | | |
| | | Small-scale aluminium smelting | |

Most of the small scale recycling techologies discussed earlier in this chapter could, as Table IV shows, only be supported by communities of 10,000 people or more. The Melbourne paper recycling plant is the only recycling technology discussed in this paper suitable for a neighbourhood scale, and the ITDG pulp packaging unit, the only one to operate at a community scale. A population of 10,000 would be necessary to provide the raw material for a 1 tpd paper recycling plant; 50,000 for a 5 tpd paper recycling plant, and 35,000 for the small-scale cellulose insluation plant. All these technologies appear appropriate to district scale operation.

Of the other recycling processes discussed, tile production from waste glass, mixed plastics waste recycling, and medium scale cellulosic insulation manufacture, all requires communities of around 100,000 people to provide them with sufficient raw material. Small-scale aluminium smelting proved to be the 'largest scale' recycling process discussed, needing at least two and a half million people to provide its raw material.

This analysis considers only one aspect of relating a process to the size of community to which it appears most appropriate. Others might include demand for the products, the number of people employed, and the capital investment required. However, it is a useful measure, giving an indication of the size of the reclamation scheme that these waste recycling industries would need to draw on, using household waste as their raw material. As such, it provides a useful framework for initially assessing the appropriateness of a recycling technology to neighbourhood, or community development.

Only two of the recycling processes discussed appear from this analysis appropriate to neighbourhood or community scale industries. It should not, though, be concluded that these are the only recycling technologies appropriate to neighbourhood or community scale industry, as I have only attempted here to highlight some of the possibilities. An extensive and comprehensive survey of opportunities for small scale recycling would involve further research work.

Neither does the analysis in this report consider in any detail the financial viability of these processes. There is a need for further investigation of their operating costs and profitability; these factors being as equally important as their technical feasibility.

The economics of the 'Melbourne 5' plant was briefly covered, casting doubt on the viability of its use in a community enterprise. However, a more detailed analysis is needed, not only looking at product capabilities and operating costs, but considering the wider aspects of the social costs and benefits of community recycling activities.

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