fpdc

Federation of Plastering
and Drywall Contractors

Diverting plasterboard waste from landfill in the UK

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Foreword

Modern plasterboard systems are produced largely from desulphogypsum, a by-product of the power generation industry that is processed and transported to minimise environmental impact. However, the Federation of Plastering and Drywall Contractors and its members are committed to further reducing the environmental impact of the sector and actively support the reduction of gypsum waste and the construction industry's move towards sustainable development.

Energy, materials, waste and pollution are the key tenets of a sustainable development strategy. Whilst all four areas may be a direct issue for manufacturers, waste minimisation and recovery are important issues within the direct control of specialist contractors, with distributors also having a part to play.

The legislative changes to the Waste Acceptance Criteria in July 2004 precipitated the requirement to consider gypsum waste minimisation. The Federation welcomes Oakdene Hollins' production of a thorough and comprehensive study that investigates the enablers and barriers to reducing the land filling of plasterboard waste.

The most important enabler is the requirement to design products which generate less waste in use, and result in less process and end of life waste. Poor design and specification results in avoidable waste production during installation.

The Federation of Plastering and Drywall Contractors anticipates that the report's recommendations will stimulate further debate and dialogue within the sector, resulting in an increase in the diversion of waste from mixed landfill in the future.

President
Federation of Plastering and Drywall Contractors

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OAKDENE HOLLINS

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Federation of Plastering and Drywall Contractors

The Federation of Plastering and Drywall Contractors is a contractor led trade association providing business support and representation for plastering and drylining specialist contractors.

For further information visit **www.fpdc.org** or email **admin@fpdc.org**

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Contents

1 Executive Summary

This study considers both the enablers and barriers to reducing the quantities of waste plasterboard sent to mixed landfill. The study shows that both subsidised and self-supporting recovery systems are in place, demonstrating that waste can be diverted from mixed landfill. However, recovery volumes are currently quite modest and current systems favour the large construction companies. The following recommendations are made to increase the diversion of waste from mixed landfill:

1 Minimise the yield losses within the construction sector

Minimisation of waste arisings can be achieved through such activities as:

- Designing out waste. For example, board trimming accounts for circa 70% of plasterboard waste. Focus areas include:
  - Architects and designers aligning the (standard) sizing of rooms with the supply of (standard) board sizes.
  - Encouraging the greater uptake of the bespoke service offered by plasterboard manufacturers.
- Improved on-site storage of plasterboard.
- Improved waste monitoring and target setting.

A reduction in waste arisings of 50,000 tonnes is considered a realistic short-term target, reducing losses from 15% currently to around 13%. This would deliver savings to the construction industry of £7.2 million in purchasing costs and £2.5 million in disposal costs. Additional savings would be made in the reduced cost of managing new and waste board.

2 Review the barriers to recovery

Although this study assumes that the '10% rule' will remain, three issues directed at the Environment Agency are identified:

- Has the '10% rule' prevented the UK from delivering on its European Landfill Directive obligations?
- Can the waste licensing procedures be fast tracked to positively encourage the uptake of investment in gypsum recovery?
- Can clarity be provided on the legality of load modification at landfill sites and does the 10% limit refer to sulphate containing wastes or the actual sulphate content of those wastes?

3 Focus recovery on the 'low hanging fruit'

Current recovery systems favour the large construction companies: these are most likely to have CSR policies in place and hence be seeking ways of diverting waste from landfill, they generate significant quantities of clean plasterboard waste and they have the sites that can be serviced using existing recovery methods. It is therefore recommended that the initial target is to maximise plasterboard recovery from these companies.

As in many industries, the medium sized businesses typically adopt the role of imitators, looking to their larger counterparts as benchmarks to ensure a comparative service provision. These companies are likely to be benefiting from the '10% rule' but will come under pressure to recover plasterboard as clients begin to specify material recovery in contracts. It is therefore recommended that these be ranked second in terms of recovery opportunity.

We estimate that around 126,000 tonnes or 42% of construction industry plasterboard waste can be realistically collected from the large and medium sized construction companies using existing skip or bag type systems. An estimated 70,000 tonnes is generated by medium-sized companies not in a position to use existing recovery systems. An alternative recovery system is proposed within the study recommendations.

Partitioning and ceiling boards are regarded as the two best opportunities for the recovery of strip-out or demolition board. Heavily coated board, especially tiled lining board, represents the most difficult to recover.

4 Develop regional recovery facilities

The South East, London and the North West currently represent the regions with the largest recovery capacity deficit. Although a Canadian model proves the viability of transporting gypsum wastes as far as 350km, these three regions represent the most significant opportunity for investment in UK recovery facilities to encourage local recovery and reprocessing.

To conclude

It is acknowledged that the '10% rule' restricts the economic viability of recovery of plasterboard from small construction companies, and that the complexity of recovery hampers the diversion of some demolition waste. However, significant opportunity exists for waste minimisation across the whole of the construction sector. Assuming that the recovery system is simple and not labour intensive and that the cost of diversion is not prohibitive, we conclude diversion of plasterboard waste can be achieved within the medium and large construction companies and selected demolition waste.

2 Background

This study investigates the alternatives to the landfilling of plasterboard waste, namely waste minimisation and recovery. It includes a review of construction waste arisings to determine the significant causes of waste plasterboard arisings, a review of existing plasterboard recovery systems and the identification of the type of sites serviced. The barriers to increased recovery are investigated and alternative recovery systems are developed to overcome these barriers.

2.1 Study objectives

1. Identify the significant causes of waste plasterboard arisings from construction sites.
2. Evaluate the existing plasterboard recovery infrastructure.
    - Identify and analyse the different types of recovery systems
    - Determine the gaps in the existing infrastructure in terms of the types of companies or sites
    - Identify the current barriers to recovery.
3. Develop recommendations for plasterboard recovery.
    - Waste minimisation options
    - Address the gaps in the existing recovery infrastructure.

The study will not evaluate the merits and demerits of the alternative end markets. Reprocessors and end markets will be assessed only in terms of the factors that influence the design of the collection systems, for example:

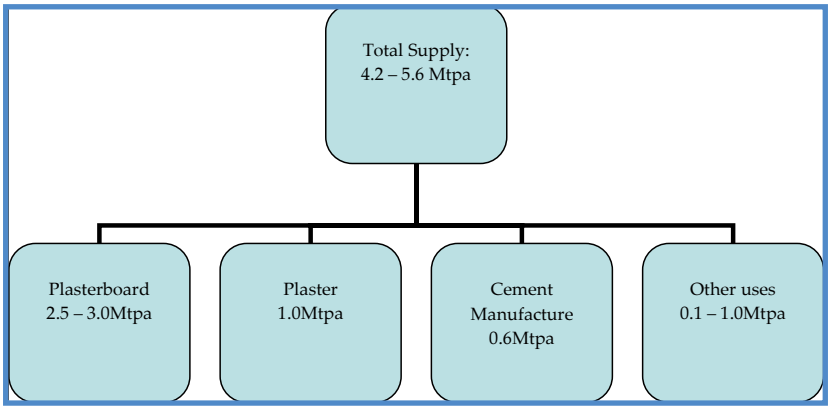
- Process capacity
- Geographic location
- Required specification
- Gate fee.

In addition, the study assumes that the '10% rule' will remain, and recommendations are made on this premise.

2.2 The size of the market

Figure 1 shows a breakdown of the primary end markets for gypsum consumed in the UK with the plasterboard industry accounting for 2.5 to 3.0Mt of the total 4.2 to 5.6Mt per annum.

Figure 1: UK Markets for Gypsum 2004.



Source: WRAP: Review of plasterboard material flows and barriers to greater use of reprocessed plasterboard. January 2006.

WRAP, Lafarge and the FPDC estimate that plasterboard wastage within the construction industry can be anything from 10% to 20%. One major housebuilder reported the findings of an internal study which highlighted yield losses of 19% for apartment type developments and 15% for house type developments. Based on these yield losses the plasterboard waste arisings within the construction sector range from 300,000 to 600,000 tonnes per year. The industry uses a 10% waste allowance as the standard for calculating the quantity of plasterboard required per job but this is ultimately used as a scrap allowance for each build unit and additional allowances are applied to cater for more general on-site losses.

In addition, due to the nature of the waste arisings WRAP[a] makes a more speculative estimate that within the demolition industry 500Ktpa to 1,000Ktpa of waste plasterboard is generated. This places the total waste arisings from the commercial and demolition sectors at between 0.8Mt and 1.6Mt.

Landfilling has historically been the prominent disposal route for waste gypsum, being the cheapest and simplest option. However, changes in legislation resulted in predictions of significant diversion activity.

2.3 Legislation

On July 16th 2005 a further step in the implementation of the EU Landfill Directive (99/31/EC) was taken in the UK with a change in the Waste Acceptance Criteria (WAC) for landfills. The Landfill (England and Wales) (as amended) Regulations 2004 (SI2004:1375) requires hazardous and non-hazardous materials to be disposed of in separate landfills. In addition, high sulphate non-hazardous wastes such as gypsum and other high sulphate bearing materials must also be separated from biodegradable wastes, i.e. must be disposed of in landfill mono-cells where no biodegradable waste is accepted. There are only one or two such mono-cells currently in operation in the UK, with gate fees ranging from £90 to £135 per tonne. (A major waste management company in the UK reported that they were unlikely to set up mono-cells for plasterboard since they saw asbestos as a more lucrative market requiring such facilities.)

This range of gate fees corroborates the pre-legislation predictions made by Plasterboard Recycling UK (PBR UK) that the cost of landfilling gypsum waste will nearly double as a direct result of the change in the WAC and will steadily increase as a result of the landfill tax escalator (Table 1).

Table 1: The estimated increase in the cost (£/tonne) of disposing of plasterboard waste to landfill.

Year	2004	2005	2006	2007	2008
Landfill Tax	£15	£18	£21	£24	£27
Landfill Tipping Fee	£27	£75	£80	£80	£80
Transport	£17	£18	£19	£20	£21
Total	**£59**	**£111**	**£120**	**£124**	**£128**

Source: www.pbruk.co.uk/prices.htm

[a] Julian Cope WRAP Plasterboard Stakeholder Forum 26th July 2005.

However, these predictions were made prior to the issuing of guidance on the WAC by the Environment Agency. Instead of imposing an outright ban on the disposal of gypsum waste to conventional non-hazardous landfill, the Environment Agency has placed a maximum limit. In their guidance[a] they state:

"We consider gypsum-based and other high sulphate-bearing materials to be wastes with more than 10% sulphate in any one load. There is no specific research to inform a limit value. Our interpretation is therefore based on the intensive investigations and consultation at two landfill sites in Wales"

This '10% rule' has been met with mixed reactions from stakeholders both in terms of its clarity and the impact it has on the diversion of waste from landfill.

2.3.1 Clarity of the '10% rule'

The two main areas where clarity is sought are:

- The legitimacy of modifying loads.
- Does 10% refer to actual sulphate content or the permitted quantity of total sulphate containing wastes?

The legitimacy of modifying loads

The legitimacy of modifying loads, or "dilution", is one aspect of the rule which needs clarification since it has a significant bearing on the quantities of waste permitted to be sent to mixed landfill. The phased nature of both construction and demolition projects means that plasterboard waste represents a significant arising, well above the 10% threshold, at specific phases in the project. A ruling that the modification of loads at landfill or waste transfer sites was illegal would, assuming enforcement and adherence, result in a significant reduction in the quantities that could legitimately be sent to mixed landfill.

Does 10% refer to actual sulphate content or the permitted quantity of total sulphate containing wastes?

The guidance would appear to refer to actual sulphate content, in which case a load can contain nearly 20% of plasterboard and still not exceed the 10% "sulphate" limit. From a practical standpoint the monitoring and enforcement of the '10% rule' on a sulphate content basis is much harder than on a broad material basis since knowledge of the relative sulphate content of each material is needed. Guidance is therefore needed on how to apply the '10% rule' at practical / ground level.

[a] Environment Agency: A better place: Guidance for waste destined for disposal to landfills.

2.3.2 Impact on diversion from landfill

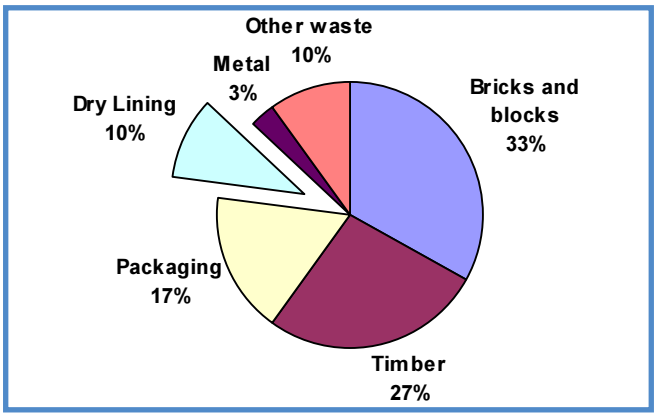
The findings of a survey published by the Agency shows a construction site waste skip comprises an average 10% dry lining (plasterboard). This implies that in theory all plasterboard waste from the construction industry could fall under the '10% rule' (Figure 2).

From an international perspective, a number of Canadian Provinces faced a similar dilemma and the case of the Greater Vancouver Borough Council[a] is of particular interest. They established that a 5% limit was unworkable since it was extremely difficult to judge the level of gypsum in each load. They therefore decided on an outright ban on gypsum sent to non-hazardous landfill.

It is considered unadvisable for the UK to adopt such an approach without the undertaking of a detailed impact assessment. Factors to be considered include:

- Impact on small businesses. After the announcement of the '10% rule', the Federation of Plastering and Drywall Contractors[b] (FPDC) suggested that this ruling is likely to benefit the small plastering and drylining contractors who may be able to continue disposing of gypsum in a general site skip on the proviso that it falls below the '10% rule'. Such businesses will generate small quantities of waste board which can be difficult to collect from both an economic and practical standpoint. Reliance on the disposal of wastes to mono-cells would result in a significant cost increase. WRAP[c] undertook a cost comparison to show the cost benefit of sending plasterboard waste to a mixed landfill under the '10% rule' compared to a dedicated mono-cell. The results showed the gate fee to be £42.50 per tonne at a mixed landfill and £113 per tonne at a mono-cell.
- Demolition waste. Due to the nature of their waste the demolition sector would find it particularly difficult to divert all gypsum waste from landfill without incurring significant additional costs.
- How would sulphate containing concrete and plaster be managed?
- Current lack of alternative capacity. A rapid capacity build in terms of both recovery infrastructure and monocells would be needed to accommodate the additional demand.

Figure 2: Construction site waste skip composition.



Source: www.environment-agency.gov.uk/commondata/acrobat/1201_overview_652203.pdf

[a] Rick Laird, GVRD.
[b] FPDC.Specialist Building Finishes. Summer 2005.
[c] WRAP. Review of plasterboard material flows and barriers to greater use of reprocessed plasterboard. January 2006.

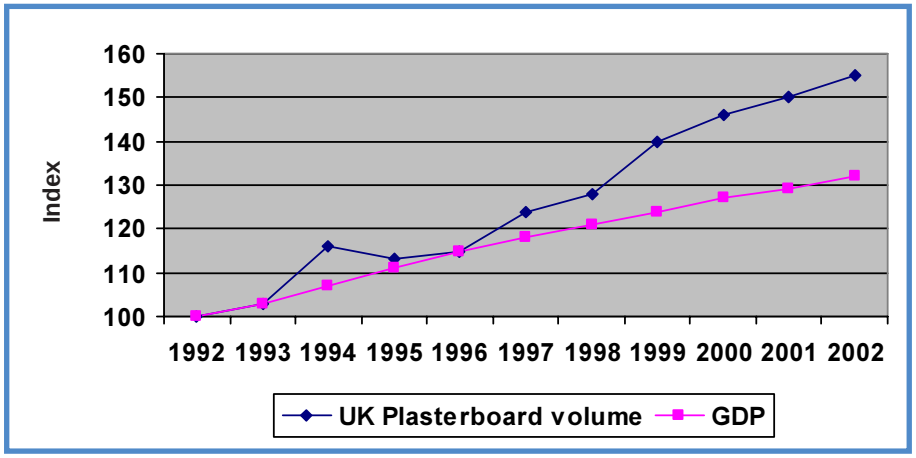
3 Plasterboard waste arisings

Historically, plasterboard waste arisings have not been monitored in the UK and hence the absolute trends in waste arisings cannot be quantified. Plasterboard waste arisings from the demolition sector are particularly difficult to quantify and hence the current broad range of estimated waste arisings from 0.5Mtpa to 1Mtpa. It is assumed within this study that in the short term this range will remain representative of the level of waste arisings within the sector.

For the construction sector it is assumed that waste arisings are directly linked to the overall performance of the plasterboard industry: since 1996, UK plasterboard growth has increased at a much faster rate than GDP (Figure 3).

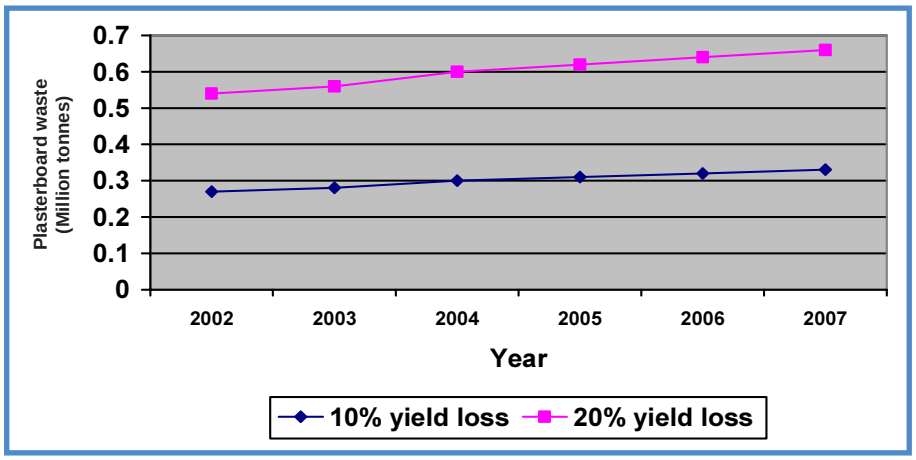
Figure 4 uses this growth rate to project plasterboard waste arisings forward to 2007, using the minimum and maximum yield rate estimates of 10% and 20%. This shows that waste arisings will reach between 0.33 and 0.66Mt by 2007. This section examines factors that will influence these trends.

Figure 3: Economic growth in UK plasterboard, indexed, 1992 = 100.



Source: John Colley, British Gypsum, 2003 investor presentations. www.bpb.com/bpb/presentations1/investorpres/2003-10-07.pdf

Figure 4: Projected growth in UK plasterboard waste arisings.



3.1 The housing sector (long term outlook)

The housing sector accounts for nearly two-thirds of the new plasterboard used in the UK with the remaining third used within the commercial sector[a]. This therefore represents a significant sector with regard to potential plasterboard growth.

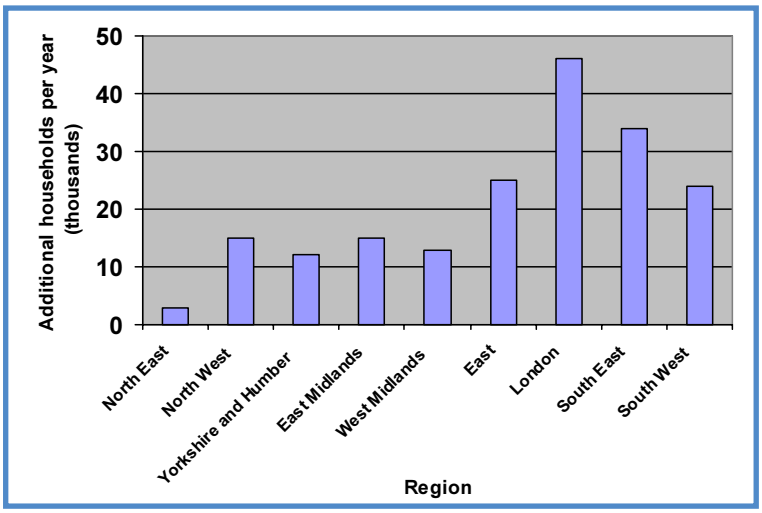
3.1.1 The rate of new build in the housing sector

Since the 1960s the total number of homes built annually in the UK has been on a downward trend. In February 2003 the Deputy Prime Minister announced a target of building an additional 200,000 homes by 2016[b]. This was followed by the Barker Review[c] which set out a series of economic, social and demographic justifications for tackling the UK's long term lack of supply and responsiveness of housing. Taking into consideration such factors as population growth, changing patterns of household formation and rising incomes, which all increase housing demand, the Barker Review reported that at the 2001 build rate of 140,000 units there would be a shortfall of 15,000 units per annum. A further report by the Treasury in July 2005[d] estimates that the shortfall will be nearer 45,000 units per annum. The Government have put in place such initiatives as the Sustainable Communities Plan to help fund the delivery of the 200,000 additional homes in the Thames Gateway and other growth areas by 2016.

Figure 5 shows the projected annual increase in households by region. Areas already experiencing the greatest demand for housing (London and the South East) are expected to see 80,000 extra households per year to 2021.

Based on estimates made by drylining contractors, an average 700kg of plasterboard waste is generated per new house build and hence 45,000 additional units per annum equates to an additional 31,500tpa of waste plasterboard, assuming that current usage rates are maintained.

Figure 5: Projected annual increase in households, 2001 to 2021.



[a] Information provided by Duncan Barker, Jewsons.
[b] Sustainable communities: building for the future. ODPM 2003.
[c] Review of housing supply – securing our future housing needs. Interim report – Analyses. Kate Barker 2003. HM Treasury.
[d] Housing Policy: an overview. HM Treasury and ODPM July 2005.

3.1.2 Legislative changes

The introduction of the Building Regulations, especially Part E – acoustics in 2004, resulted in the need to specify denser boards. Skanska report that regulations on acoustic ratings, especially within schools, have resulted in an increase in the quantity of waste generated due to the need to box in girders etc. Hence their investigation into alternative materials, mentioned in Section 3.3.

3.2 The construction industry (short term outlook)

The Construction Products Association (CPA) publishes three year forecasts on the construction industry: Table 2 shows the forecast made in June 2005. This shows that a slowing down in the overall construction industry is forecast and the Chief Executive of the CPA, Michael Ankers, states[a]:

"Private sector construction activity is forecast to fall over the next two years in response to weakening economic growth. In particular, slower growth in disposable income, higher mortgage rates and a cooling of the housing market are now tempering related construction areas such as housing, retail and leisure premises. Overall the construction industry is forecast to avoid recession, but continued growth will be critically dependent upon the delivery of promised government investment".

Although the long term forecast is for higher growth in new house builds, discussed in Section 3.1, Table 2 shows that a slow down is forecast in the short term. Michael Ankers continued:

"One of our major concerns remains the housing sector where we are forecasting housing starts in each of the next three years to be below those in 2004, and significantly lower than the long term supply the Barker Review said was needed to address the housing problems in this country".

Table 2: Construction industry forecasts – summer 2005.

Construction output – change year on year	2003 Actual	2004 Forecast	2005 Forecast	2006 Forecast	2007 Forecast
New Housing	12.8%	14.1%	1.7%	-2.7%	1.8%
Public Non-Housing	20.8%	15.1%	2.5%	5.5%	4.4%
Infrastructure	-9.5%	12.3%	-2.3%	3.3%	5.9%
Industrial	7.0%	10.1%	1.0%	-1.0%	1.0%
Commercial	-4.7%	5.5%	4.9%	1.6%	4.8%
Total RM&I	6.6%	-0.1%	-1.2%	0.7%	3.2%
Total Construction	5.1%	3.6%	0.6%	0.9%	3.5%

Source: Construction Products Association. Press release 20 June 2005.

[a] Construction Products Association. Press release 20 June 2005.

3.3 Plasterboard usage

The activity of the plasterboard manufacturers is probably the best measure of anticipated trends in the plasterboard sector and all three manufacturers have entered into significant expansion. British Gypsum are expanding their Sherburn plant, Knauf is adding a second line at their Immingham facility and Lafarge have announced that they will be building a second plant in the Midlands having secured a source of synthetic gypsum in the region (Flue Gas Desulphurisation (FGD) from the Cottam power station). Reducing the reliance on costly importing is an objective from Lafarge's perspective but the underlying reason for all three to be capacity building is the expected continued growth in demand for plasterboard.

Plasterboard or dry installation has replaced a significant proportion of the wet plastering business and factors that have been cited include:

- Speed of build. The drying times of plastering puts it at a significant disadvantage.
- Skill level. The skill level of dry wall is lower than that of plastering. This is a key issue in areas of skills shortages, e.g. London where there is a high level of build activity but a shortage of plasterers.
- Cost. The reduced skill level and the increased speed of build have a direct impact on build costs. In addition, stud walling reduces build costs considerably.

3.3.1 Alternative materials

The construction industry is dynamic with regard to the development of new materials and alternative materials are on the market or are currently being developed that may supersede plasterboard in some applications. Skanska report[a] that fair-faced concrete could represent a substitute for plasterboard in some commercial builds since it eliminates the need for plastering or boarding: paint can simply be applied to the face of the concrete. Skanska have also tested heavy duty plastic for boxing in girders etc since it was found that plasterboard wastage was significant in these areas.

3.4 Section conclusion and discussion

Demand for plasterboard has grown at a significant rate. The Barker Review and the Government's drive to address the inflationary nature of the housing market signal that, in the medium to long term, this growth is likely to continue. Capacity building by all three plasterboard manufacturers reaffirms the outlook that demand for plasterboard is set to increase further. However, the UK is currently experiencing a short term weakening of economic growth which is likely to impact on the construction industry in general.

[a]Meeting with Neil Moore and Matthew Janssen in August 2005.

4 Waste minimisation

Five factors that can result in high wastage were identified within this study:

- Trimming losses
- Lack of drylining contractor accountability for waste arisings
- Over-ordering
- Stairwells
- Weather damage.

4.1 Trimming losses

Figure 6 shows the results of an internal survey undertaken by a large housebuilder. This shows that circa 70% of plasterboard yield losses are due to either board height or width trimming and hence represents a significant area of opportunity.

Figure 6: Analysis of waste losses in a typical new house build.

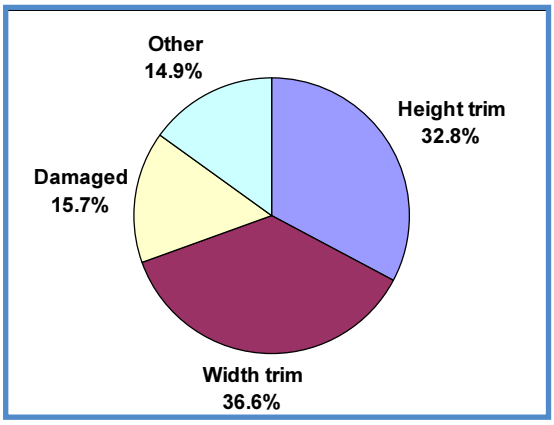


Figure 7 shows a typical dry lining of a wall in a new house build. The ceiling height is a standard 2290mm whereas the board used is a standard 2400mm resulting in a 110mm or 4.5% board off-cut. Figure 8 shows that these uniform off-cuts are usually discarded rather than utilised.

Figure 7: Typical wallboard installation in a new build house.

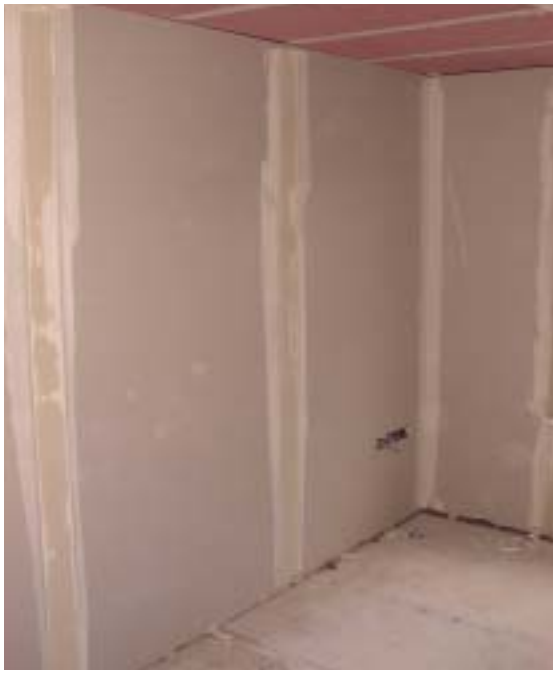


Figure 8: Off-cuts from wallboards awaiting disposal.

Architects and designers have begun the dimensioning of rooms based on the dimensions of raw materials such as bricks and blocks. This not only reduces the waste arisings but also reduces the cutting required, which both speeds up the build rate and reduces labour costs. However, less attention has been given to the designing out of plasterboard waste since to date it has been considered a low specification material. Room dimensions such as ceiling heights can vary between commercial and residential builds, between developers and even between the ground floor and first floor of a development. This results in "standard" board sizes generally being set to accommodate variability rather than being made to measure, which guarantees there will be waste arisings from trimmings.

Plasterboard manufacturers offer a custom-sizing service but this service is currently under-utilised. The minimum order quantity of 2,500m^2 represents a medium sized build using circa 12 pallets of wall boards. A possible reason for the modest uptake of this service is that 89% of board is purchased through merchants, i.e. either specialist distributors or general builders' merchants, rather than direct from the manufacturers. However, Lafarge[a] state that although the board is ordered through the merchants they actually supply 30% of board direct to site: these are mainly the large orders, which are ideal for customisation. In addition one of the major specialist distributors, CCF Ltd, state that the handling of bespoke boards for large orders would not represent a problem to them[b].

The low uptake of the service could be due to the perceived low cost of plasterboard disposal, resulting in the benefits of the service being viewed as insignificant. In addition, one Site Engineer stressed a reluctance to use such a service, being concerned that if the wrong size were specified then the level of waste generated would completely undermine the potential saving. However, this was regarded as an example of the "just in case" mentality adopted by some within the industry. The reduced labour cost and time cutting the boards had not been considered, nor had the costs associated with managing the waste off-cuts.

It is a recommendation of this study that designers and architects be encouraged to consider the minimisation of plasterboard within their design remit. Where standard sizes cannot be used the bespoke service offered by the plasterboard manufacturers should be championed by the likes of WRAP and Envirowise. Awareness of the companies, both manufacturers and suppliers, providing the service should be promoted.

In terms of waste reduction opportunity, a study by CIRIA[c] concluded that the ordering of plasterboard to size can reduce on site waste from 12% to 3.5%. It is recommended that the large one-off builds and the large housebuilders be initially targeted since they are best positioned to utilise such techniques in terms of the quantities of plasterboard used and the benefits that can be gained from designing out waste.

[a] Bob Curd, Lafarge Plasterboard. WRAP Plasterboard Stakeholder Forum, January 2006.
[b] Andrew Harrison, CCF Ltd. WRAP Plasterboard Stakeholder Forum, January 2006.
[c] CIRIA. Demonstrating waste minimisation benefits in construction 2001. Publication number C536 case study report C536/6.

4.2 Lack of drylining contractor accountability

Interviews with both drylining (specialist) contractors and main contractors highlighted the purchasing and disposal mechanisms in operation on typical sites. Although the main contractor may specify the preferred board supplier, on typical sites drylining companies are responsible for the purchase of the plasterboard and the main contractor is responsible for all site waste. In many cases, no feedback loop exists to monitor and control the quantity of waste being generated. This lack of feedback means that minimising purchasing costs is the primary incentive for the sub-contractors to minimise the quantity of waste being generated. This incentive appears to be of greater importance to small companies who do not command the same buying power as larger companies and hence material costs are more tightly monitored. In larger drylining companies plasterboard can be perceived as a low value commodity and other factors such as the insurances associated with over-ordering, discussed in Section 4.3, can override these incentives.

Some companies, especially the large commercial and housebuilders, are beginning to monitor waste arisings. Companies such as Wastefile and MRL provide a service identifying and tracking the quantities of waste generated within specific sites. This represents the first stage in setting targets to drive down the quantities of waste being generated.

In addition, companies such as Overbury are including sub-contractors within quality systems and are working with them to ensure such systems are in place and are adhered to.

4.3 Over-ordering

Historically over-ordering has taken place as a "just in case" measure to ensure sufficient material is ordered and on site. The general philosophy adopted is that it is better to have four sheets per development too many than to be one sheet short since the cost of delivering the one sheet to site will be far greater than the circa £12 it cost for the four sheets. However, since the 'spare' sheets are commonly regarded as waste rather than taken to the next development, this argument does not take into consideration the additional cost of disposing of the four sheets. In addition, there is no regard to the cumulative effects of this action. (For example, in the case of a house builder producing 10,000 homes per annum, with each home treated as a single development this could equate to £120,000pa in terms of purchasing costs alone.) The discounting associated with bulk purchasing and rounding up to full pallet loads have also played a significant part in the level of over-ordering.

Over-ordering is more common on large developments, especially one-off commercial developments, since it is difficult to estimate accurately the number of boards required. However, call-off systems are being introduced whereby merchants make more frequent deliveries of smaller quantities. As in the case of other production processes where this "just in time" stock-driven system is widely used, the benefits include:

- The system is not reliant on estimates but instead stocks of boards are replenished on a when-needed basis.
- The size of the on-site storage area can be reduced significantly.

- The quantity of material damaged on site can be reduced significantly since there is usually a direct correlation between the length of time the material is on site and the amount of damage that occurs.

The merchants benefit from this arrangement since they are likely to see an increase in customer loyalty or repeat business. The perceived additional costs and trips associated with the increased delivery frequency are often unfounded since the merchants would be delivering other materials to the site or other sites in the area.

4.4 Stairwells

In typical housebuilds the stairs are fitted prior to drylining, resulting in the need to cut the board to fit the angle of the stairs (Figure 9). At an angle of 42.5° this leads to off-cuts of 23% of boards, with a shape which makes them difficult to utilise elsewhere. Fitting the drylining before installing the stairs would minimise wastage, however this would require a significant change to the build schedule.

Figure 9: The drylining of a stairwell.

4.5 Weather damage

Plasterboard is typically delivered on site to each build unit with the required number of boards being left outside each unit (Figure 10), or is delivered to a central location (Figure 11) and transferred to the build unit by the on-site forklift when needed. The system used depends on the size of the development (whether there is sufficient space for a central store) and the supply chain used: direct supplies from the manufacturer tend to be larger than the deliveries from the specialist distributor or merchant who often is more local.

Figure 10: Boards stored outside the unit being developed.

Figure 11: Boards stored in a central location.

In both systems boards are stored outside prior to use and hence rely on covers to prevent water or moisture ingress. However, a Site Engineer for a major housebuilder reported that plasterboard waste arisings often double during inclement weather. Significant factors include:

- **Inadequate covering of packs by manufacturers.** Figure 12 shows a pack where the cover was too short leaving the bottom five boards exposed.

Figure 12: Boards exposed in a pack delivered to site from the manufacturers.

- **Inadequate covering of packs by on-site material handlers.** Figure 13 shows a pack where the shrinkwrap has been split and the side of the pack has become exposed. Figure 14 shows three packs that have become fully exposed to the weather and will be disposed of during site clearance at the end of the development.

- **Inadequate covering of packs by drylining contractors.** Figure 15 shows a pack with 12 boards which were not fully covered overnight. In addition, damaged full boards are often used to prevent covers from being blown off in the wind: occasionally these boards are minimally damaged and could have been used in the build.

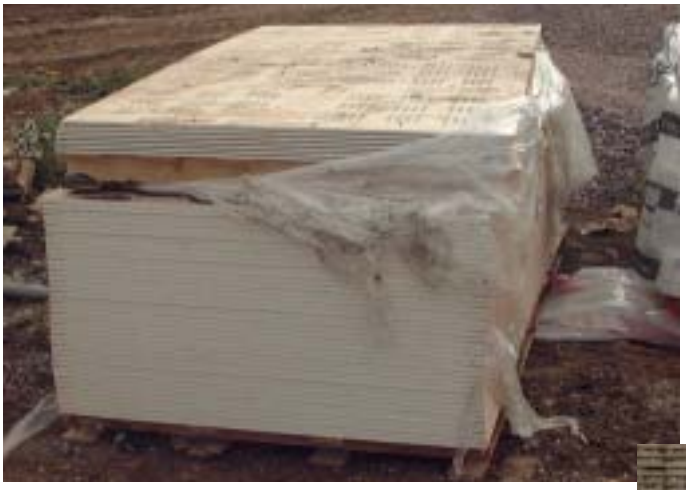


Figure 13: An example of poor covering of packs after splitting of the shrinkwrap.

Figure 14: An example of packs that have become fully exposed.

Figure 15: An example of packs that have become fully exposed.

- **Build programme issues.** Drylining may be done before buildings are watertight, causing problems during times of wet weather.

A Site Engineer on a site with an outside store estimated that two boards in every pack of 72 are rejected due to water damage, which equates to nearly 3% of boards. Although improved on-site discipline would reduce the quantity of water-damaged boards, an additional recommendation is to investigate the potential benefits of more robust hoods. Purpose-made re-usable tarpaulin type hoods could significantly reduce the quantity of boards wasted. In addition, pallet covers would prevent moisture ingress through the pallet.

4.6 Section conclusion and discussion

There is a significant opportunity for minimising the waste plasterboard being generated (currently estimated at between 10% and 20%). Increased intervention at the design phase can reduce plasterboard trimming waste significantly and the bespoke service offered by plasterboard manufacturers can minimise waste at the procurement phase. The study also identified the poor external storage of material as a much overlooked reason for waste arisings.

It can be argued that waste minimisation is not in the interest of the plasterboard manufacturers who are driven by throughput and turnover and hence it is up to the construction industry itself to drive forward initiatives. Plasterboard manufacturers may assert that they are more proactive than this statement suggests and in the interest of good customer relations would embrace waste minimisation.

In terms of the financial benefits of waste minimisation a reduction in waste arisings of 50,000 tonnes is considered realistic through increased designing out of waste, greater utilisation of the bespoke service offered by plasterboard manufacturers, improved on-site storage, and a reduction in over-ordering. It is estimated, based on an average purchase price of £1.20 per m^2 and an average weight of 8.35kg per m^2, that saving 50,000 tonnes of board represents a saving of £7.2 million on purchasing. In addition, based on a disposal cost of £50 per tonne, a further £2.5 million would be saved on direct disposal costs. Additional savings would arise from the reduction in material handling, storage etc.

5 Existing recovery infrastructure

The section focuses on three key areas: existing collection systems, reprocessing capacity and end markets.

Main contractors, drylining contractors, waste contractors, trade associations (FPDC) and the plasterboard manufacturers were contacted, and site visits and interviews undertaken, to develop a detailed understanding of the existing recovery infrastructure.

5.1 Existing collection systems

The existing collection systems focus predominantly on new construction waste, and the recovery of demolition waste is currently limited due to such factors as:

- The higher contamination rates when compared to the waste generated within construction.
- The increased complexity of recovering segregated waste.
- The plasterboard manufacturers being key drivers of the collection schemes within the construction sector.
- The '10% rule'.

The two main collection methods are:

- Bulk bag system. This system is operated through the suppliers of the plasterboard using the conventional delivery vehicles.
- Skip system. This system is operated through waste contractors and involves the use of skips of various sizes.

Having a local, cheap disposal route for in-process waste (mill waste), which accounts for circa 4% of output, is a common reason for plasterboard manufacturers to set up or form local recycling partnerships with the surplus capacity being used to process construction and in some instances demolition waste. However, other incentives for participation do vary. The two main incentives are:

- To broaden the service portfolio offered to customers and hence increase market share.
- To reduce feedstock costs.

5.1.1 The bulk bag system

Figure 16 shows the bag system used in the scheme operated by British Gypsum (BG), the largest recovery scheme in operation in the UK. BG was the first of the three plasterboard manufacturers to set up a recovery scheme in the UK and a primary reason was to expand their portfolio of services to customers. The system focuses solely on the collection of wastes originating from BG boards using a source segregated closed-loop system (Figure 17).

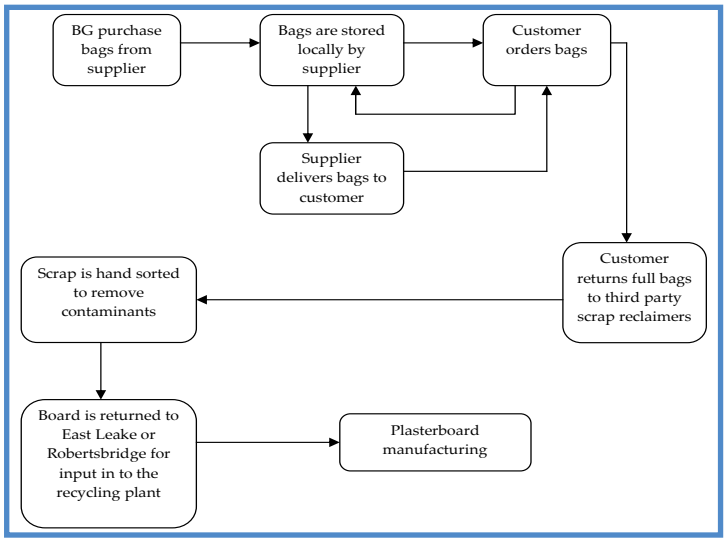
Figure 16: The bag collection scheme.

The price customers pay for the bags varies although BG stresses that:

"The system is run on a commercial basis and costs are therefore recovered within the pricing."[a]

Major account holders generating large quantities of waste are in principle less problematic to service and the service provision is more cost effective. In such cases the provision of the service is included into plasterboard purchase agreements and hence the cost of providing the service represents an embedded cost and in some way can be regarded as an advanced disposal fee. On the other hand, small contractors do not have the same buying power, have sites that are much more problematic to service, i.e. small volumes of waste generated in a confined area, and hence pay for the additional complexity.

Figure 17: A schematic of the BG plasterboard collection system.



Source: Adapted from John Colley, British Gypsum, 2003 investor presentations.

[a] Brian Andreas, personal communication

Table 3[a] shows the analysis of the cost of the system for small and medium sized businesses based on costings received from a medium sized housing developer and a small dry lining company. Contamination rates and fill rates were obtained from a waste contractor. NB: a large housing developer reported that the service was free to the business although, as discussed above, the price would in fact be incorporated within the purchase agreement of the board. The analysis shows that if the system is optimised with zero contamination, 100% bag usage and maximum tonnage per bag (0.35 tonnes), then the cost per tonne falls well below £100 per tonne. However, like any such service if misused then the cost can escalate dramatically with smaller businesses potentially incurring a cost approaching £300 per tonne.

Table 3: Analysis of the bag system.

Size of business		**Small**	**Medium**
Cost per bag		£25	£15
Bags purchased and used		80 to 100%	
Tonnage collected per bag		0.15 to 0.35 tonnes	
Contamination rate		0 to 30%	
Cost per tonne of plasterboard	Min	£71	£43
	Max	£298	£179

Table 3 highlights an additional service that can be provided to customers, namely feedback on the quantities of waste produced and the contamination rates for specific developments or sites. Companies such as Wastefile and MRL provide such a service and the data is gathered at the point of hand sorting, shown in Figure 17. This service could lead to more companies monitoring waste arisings and setting targets for waste reduction.

Key points of this scheme are:

For	**Against**
The upfront payment for the bags can act as an incentive for the waste producers to return the bag rather than to put the bag to alternative uses.	The full bags are often stored outside and hence the board is exposed to the elements. This could be a problem for some reprocessors and end markets.
Empty bags are easily stored and can be manually carried.	Bags are difficult to pack and they do go missing.
Bags can be collected using conventional delivery vehicles.	The bags are one trip and hence add to waste arisings.
	Due to the nature of the scheme this is not appropriate for the collection of demolition waste.
	Contamination rates have been known to be very high.

[a] NB: the service is not offered to all users due to system constraints such as proximity to a recovery centre, quantity of waste generated, etc. These figures therefore are representative of the system in sites where it is viable.

A general waste management company reported that whenever the bag collection services have been tried in the waste industry they have always suffered from inherent problems to do with the round density, the weight that they can carry and the value of that weight. The British Gypsum system overcomes some of these issues by placing a minimum bag limit on collections. A Bellway Homes development reported that they have a minimum collection of 10 bags, and one large Taylor Woodrow (Bryant) site stores up to 25 bags at a time. This can be regarded as a trade-off since it raises the issue of the availability of space on site to accommodate the full bags for collection. In addition, geographic location is also a key issue due to proximity to reprocessors: even large construction companies have reported that they have found it difficult to set up recycling in some geographic areas, e.g. Scotland.

British Gypsum did not wish to divulge the quantities of materials recovered through this system but the system is well used especially by the large housebuilders such as Wimpey, Taylor Woodrow and Bellway. For example, Taylor Woodrow reported the recovery of 4,831 tonnes of plasterboard or 72% of their plasterboard waste arisings in 2004[a].

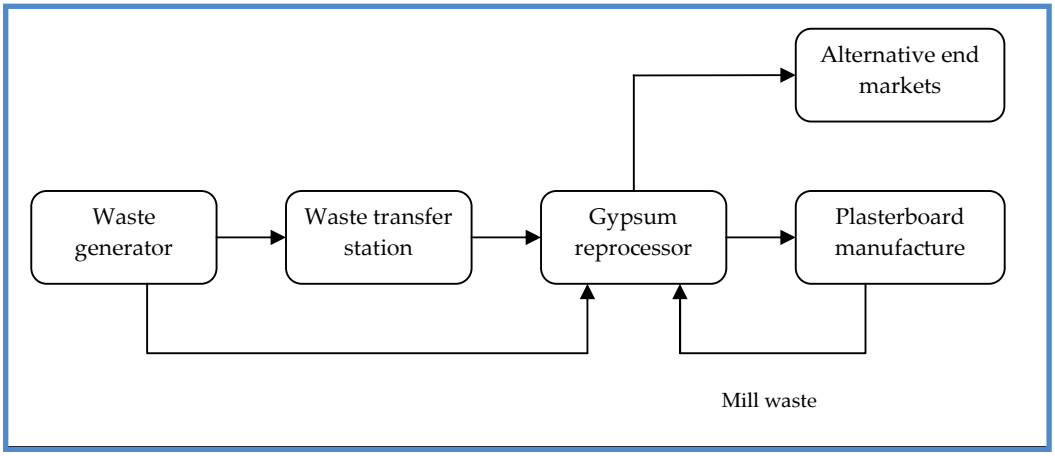
5.1.2 Skip systems

Unlike the BG collection scheme, material is predominantly traded on the open market. Figure 18 shows a schematic of the system. The upstream route the waste takes is dependent on the quantity of waste being generated and the proximity to a plasterboard reprocessor. The smaller the loads and the longer the distance from the reprocessor the more likely the use of a waste transfer station to bulk up the waste.

There are three basic skip systems in operation:

- Segregated skip system
- Part segregated
- Mixed.

Figure 18: The processing of gypsum through the waste management route.



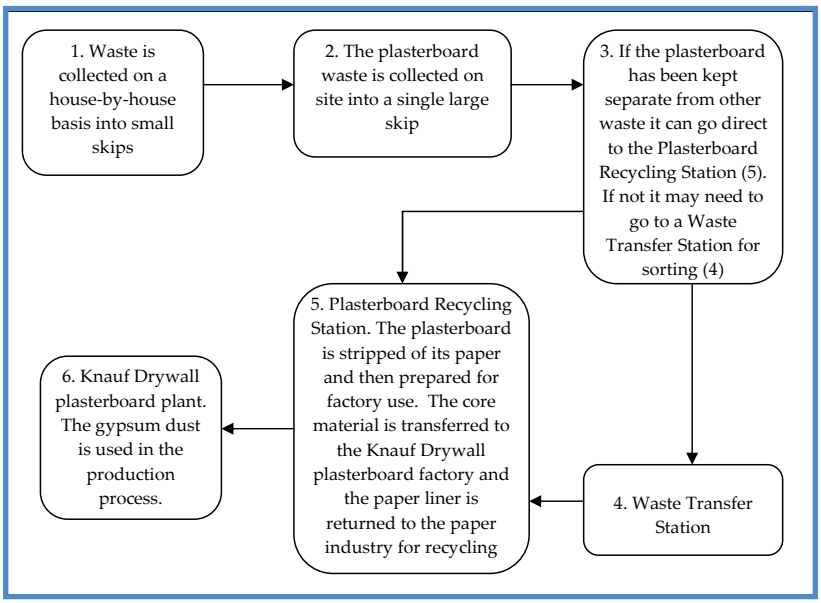
[a] Taylor Woodrow. Corporate Social Responsibility Report 2004.

Segregated skip system

Figure 19 shows the schematic of the Knauf process with source separation of plasterboard waste being the preferred route.

The small transfer skips are typically colour-coded to assist in the segregation process. Figure 20 shows a tipper skip system on a housing development with red skips for plasterboard and blue for other materials.

Figure 19: The schematic of the Knauf plasterboard collection scheme.



Source: Knauf Drywall. Gypsum Waste Management: Caring for the environment. May 2005

Figure 20: The tipper skip system. The red and blue skips are located outside each development.

The system is most used in large commercial one-off builds where space is not an issue. Skanska have operated such systems in a number of their developments.

The key points of this system are:

For	Against
Benefits end markets that require traceability. For example, Knauf are only accepting waste generated from their own boards whilst they are developing their systems to integrate the recovered feedstock into the manufacture of new board.	Space on site. This can be a particular issue if other waste materials are handled in a similar way since it can result in a large number of different skips on site.
Requires minimal sorting by waste handlers.	Skip availability. If skips are not emptied regularly then contamination rates can quickly escalate.
	Staff training.

Part segregated system

This system works in a similar way to that of the segregated system, in terms of the use of tipper skips to transfer material from source to the consolidation area. However, to reduce the number of different skips required on site the materials are grouped. The consolidation skips are sent to a waste transfer station where the materials are sorted and sent on to the respective end markets.

Three companies surveyed operated this scheme, of which Barratts were the largest.

Key points of the system when compared with the segregated scheme are:

For	Against
Reduced site space required when compared with the segregated scheme.	More costly due to the increased sorting required by waste handlers.
Simpler system to use in terms of skip movements.	

Mixed skip system

This can be regarded as the business-as-usual model whereby all waste is disposed of in the same skip, a common practice within the industry prior to the changes in legislation. Although this suits the general builders whose waste does not exceed the Environment Agency's 10% threshold on gypsum waste and hence can be landfilled, it is also adopted by one of the larger housebuilders (Persimmon) who has an agreement with a skip hire and transfer station operator to recover some materials from the waste.

Table 4 shows the costs associated with the collection of builders' and 40 cu yard skips. The costs have been split to highlight the impact the changes to the WAC has had, i.e. it shows the costs of hiring a skip with less than 10% gypsum and those with more than 10% gypsum. Small builders are the more likely users of builders' skips and the analysis shows that the mean cost differential varies from £18.9 (£33/1.75tonnes) for contract-price skips to £31 per tonne (£55/1.75tonnes) for spot-price skips. In a cost-driven market this provides small builders with the incentive to ensure all loads fall under the '10% rule' and hence discourages recovery through source segregation. Medium and large builders are unlikely to enter into spot-price agreements and hence the contract costs associated with the hiring of 40 cu yard skips is of greater significance. This analysis shows that an additional £19 per tonne (£161/8.5tonnes) is incurred due to the change to WAC.

Table 4: Analysis of skip costs.

Skip size	**Builders' skip**			**40 cu yard skips**		
	Min	Max	Mean	Min	Max	Mean
Weight per skip (tonnes)	1.5	2.0	1.75	7	10	8.5
Spot price on skips with less than 10% gypsum (£)	138	155	145	457	696	570
Spot price on skips with more than 10% gypsum (£)	168	235	200	597	1096	840
Difference between spot prices (£)	**30**	**80**	**55**	**140**	**400**	**270**
Contract price on skips with less than 10% gypsum (£)	82	93	86	273	416	340
Contract price on skips with more than 10% gypsum (£)	100	140	119	357	655	501
Difference between contract prices (£)	**18**	**47**	**33**	**84**	**239**	**161**

Source: a national skip hire company.

Table 5 shows the information in terms of cost per tonne. This shows that the cost has not increased to the £111 per tonne mark, as predicted in Table 1, except in spot-priced builders' skips with more than 10% gypsum. The use of spot priced builders' skips is not commonplace and hence the cost increase has not been significant. This is due to the subsequent introduction of the '10% rule' and the competitive nature of the skip hire market.

Table 5: Analysis of skip costs (cost per tonne).

Skip size	Builders' skip			40 cu yard skips		
	Min	Max	Mean	Min	Max	Mean
Weight per skip (tonnes)	1.5	2.0	1.75	7	10	8.5
Spot price on skips with less than 10% gypsum (£/t)	92	77.5	82.9	65.3	69.6	67
Spot price on skips with more than 10% gypsum (£/t)	112	117.5	114	85.3	109.6	98.8
Difference between spot prices (£/t)	**20**	**40**	**31.1**	**20**	**40**	**31.8**
Contract price on skips with less than 10% gypsum (£/t)	54.7	46.5	49.1	39	41.6	40
Contract price on skips with more than 10% gypsum (£/t)	66.7	70	68	51	65.5	58.9
Difference between contract prices (£/t)	**12**	**23.5**	**18.9**	**12**	**23.9**	**18.9**

5.1.3 Analysis of existing collection systems

The existing recovery systems are generally more appropriate for large construction companies, being either targeted by the service providers, cheaper for such businesses to apply or being easier for these companies to implement due to the generally larger sites and waste quantities being generated. It is estimated that circa 90% of plasterboard waste generated by these companies could be collected using existing skip or bag schemes.

For medium sized main contractors the system constraints are more significant. For example, sites can be too small to accommodate 40 cu yard skips or the waste arisings are too small for viable collection via the bag or skip system. Some medium and large specialist contractors would like to be responsible for the disposal of waste from such main contractors but some current schemes are only available or are tailored to main contractors. It is estimated that 20% of the medium sized main contractors can adopt existing collection schemes due to these constraints.

Small companies would find it even harder to implement such systems, but are less likely to move away from landfilling which is likely to remain the cheapest option while the '10% rule' is in place. It is therefore estimated that no small businesses are likely to take up an existing scheme.

Table 6 summarises the potential participation in the existing recovery schemes assuming that focus will remain on the provision of such services to the more economically viable larger companies. The yield loss of 10% has been used, i.e. total construction waste arisings of 300Ktpa, as this takes into consideration the waste minimisation opportunities that exist and that should be given priority. Figure 21 shows this information graphically.

Table 6: Gypsum waste arising by business size and waste management route.

Size of business	Size of firm (by No. employed)	No. of Non-residential and Housebuilding businesses	Total employed	Plasterboard waste generated (tonnes)	Waste arisings by size of business (tonnes)
Small	1	13,570	13,570	13,430	104,077
	2 to 3	12,644	31,610	31,283	
	4 to 7	6,330	34,815	34,455	
	8 to 13	2,397	25,169	24,908	
Medium	14 to 24	1,329	25,251	24,990	72,440
	25 to 34	473	13,954	13,809	
	35 to 59	497	23,359	23,118	
	60 to 79	153	10,634	10,524	
Large	80 to 114	150	14,550	14,400	123,483
	115 to 299	208	43,056	42,611	
	300 to 599	46	20,677	20,463	
	600 to 1199	21	18,890	18,694	
	1200 +	23	27,600	27,315	
Total			**303,133**	**300,000**	**300,000**

Source: DTI Construction Statistics Annual 2005 + estimates based on consultation with stakeholders.

Figure 21: Estimated potential of existing plasterboard recovery systems by size of construction business.

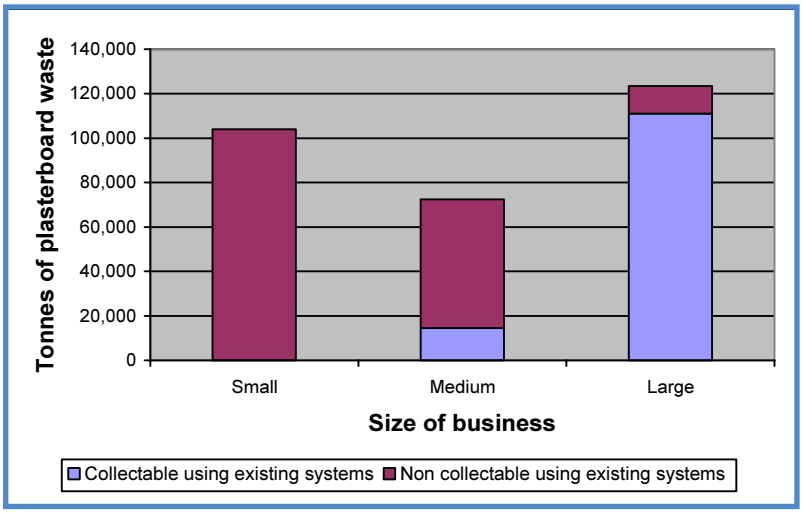


Figure 21 shows that an estimated 125,600 tonnes or 42% of the 300,000 tonnes of plasterboard waste arisings from the construction industry can be recovered from the medium and large construction companies using the existing systems. The 104,000 tonnes generated by small businesses is regarded as the most hard to reach since recovery systems would have to compete directly with the mixed landfill option under the '10% rule'. This leaves circa 70,000 tonnes primarily from the medium sized companies with no current means of recovery.

A key driver to the engagement of companies is Corporate Social Responsibility (CSR). Numerous large companies, such as Skanska, Taylor Woodrow and Overbury have moved recovery or landfill disposal from a legislative necessity to a key product differentiator as part of their CSR policy or Environmental Management Systems. Overbury has stressed that clients such as Barclays, Reuters and PWC are now beginning to specify environmental parameters as part of contract agreements. Middle-sized companies are likely to follow this lead to prevent gaps in service delivery from either appearing or getting bigger. It is therefore considered appropriate to investigate alternative collection systems that can collect modest quantities of plasterboard waste from sites that have limited space.

5.2 Reprocessing capacity

Reprocessors have taken four approaches to the location of facilities:

- Near plasterboard mills
- Mobile recycling plant
- Near construction and demolition (C&D) waste arisings
- Extension of existing facilities.

Reprocessing companies such as New West Gypsum Recycling (NWGR) have made a

business decision to locate facilities near plasterboard manufacturers and enter into agreement to reprocess all the mill waste. This gives such facilities a base input load and a dedicated outlet. Additional capacity is used to process C&D waste. NWGR have such an arrangement with Lafarge in Bristol and have set up a facility near the Knauf plant in Immingham and they hope Knauf will start taking material sometime in 2006.

Gypsum Recycling International (GRI) has a similar arrangement with Knauf at Sittingbourne although their recycling system varies in that it involves mobile recycling plant servicing recycling facilities located near source using a milk round approach, i.e. material is stockpiled in warehouses and the recycling plant is transported to each of the warehouses to process the material. GRI have recycling facilities at Sittingbourne, Middlesbrough and Swindon and aim to have plants in the West Midlands and Sheffield open by June 2006.

Plasterboard Recycling UK (PBR UK) has adopted a different approach, locating near the source of the C&D waste plasterboard in London, and are investigating the viability of similar facilities in Manchester and Birmingham. This approach simplifies the logistics of getting the material from source to reprocessor but means that they do not have such a strong tie with end applications.

Roy Hatfield Ltd have installed a gypsum reprocessing plant at their existing site in Rotherham. The reprocessed material is used in products Hatfield make themselves, such as cement based products, which results in Hatfield's needing to find consumers rather than end applications.

Table 7 shows the current throughputs and capacities of the four aforementioned businesses. This shows that the current throughput is 70,000 tonnes: there is currently a surplus capacity of 105,000 tonnes and all four are looking to increase capacity in the future. Further capacity will be likely to come on line from new market entrants e.g. Wastefile which is investigating the market opportunities. Also the capacities of the British Gypsum in-house systems have not been included which, based on the quantities of material being handled through the system described in Section 5.1, could be significant.

The difficulty in obtaining a waste license was cited as a potential barrier to increased reprocessing capacity. One company stressed that the time it took to obtain the license was prohibitive and another stated that the guidance provided by individual Environment Agency staff was inconsistent.

Table 7: Summary of current and proposed UK gypsum recycling capacity.

Company	Current throughout (Ktpa)	Current UK capacity (Ktpa)	Indicated future UK capacity (Ktpa)
New West Gypsum	~55	~110	~220
Gypsum Recycling International	Not Known	3 UK warehouses capacity not known	~90
Plasterboard Recycling UK	~10	~15	~45
Roy Hatfield	~6	~50	~56
Totals	**~70**	**~175**	**~400**

Source: WRAP. Review of plasterboard material flows and barriers to greater use of reprocessed plasterboard. January 2006.

Note: capacities are estimates calculated on the basis of 1 shift, 5 days per week.

Table 8 shows a regional assessment of reprocessing capacity based on the current reprocessing levels shown in Table 6. The waste arisings are calculated using construction output as a proxy. The table shows that regions such as the South East, London and the North West have the largest deficit between waste arisings and current reprocessing capacity. This indicates the regions that would most benefit from recovery facilities from the perspective of the provision of local solutions.

Table 8: Analysis of the regional reprocessing infrastructure.

Region	Construction output (£bn)	Waste arisings ('000t)		Reprocessing capacity ('000t)	Reprocessing deficit ('000t)	
		Min	Max		Min	Max
Scotland	8.6	68.8	111.7	0	68.8	111.7
North East	3.4	27.5	44.7	0	27.5	44.7
North West	11.0	88.1	143.1	0	88.1	143.1
Yorks/Humber	8.9	71.1	115.6	105	(33.9)	10.6
E Midlands	7.0	56.1	91.2	0	56.1	91.2
W Midlands	8.8	70.5	114.6	0	70.5	114.6
Wales	4.2	33.5	54.4	0	33.5	54.4
E of England	9.7	77.5	125.9	0	77.5	125.9
London	14.3	114.6	186.3	15	99.6	171.3
South East	15.3	122.1	198.4	0	122.1	198.4
South West	8.8	70.1	114.0	55	15.1	59.0

Source: Construction output data taken from the DTI Construction Statistics Annual 2005.

Although local solutions would be the preferred option, NWGR report that in Canada waste plasterboard is transported 350km in 30 tonne loads at a cost of $42.50 (Canadian dollars) per tonne. Figure 22 shows the 30 tonne truck being loaded and Figure 23 shows the storage bay at the waste transfer station. Using the conventional 10 tonne load, the 40 yard containers commonly used to transport waste gypsum in the UK would cost $100 (Canadian dollars) per tonne making the system economically unviable. In Canada such systems are only used for short haul journeys of less than 50km and Figure 24 shows a waste transfer station which uses such a system.

Figure 22: The long haul 30 tonne truck system used in Canada.

Figure 23: The storage area at the waste transfer station accommodating 30 tonnes of gypsum waste.

Figure 24: The 40 yard skip system used in Canada.

5.3 End applications

The recovery of gypsum in the UK is in its infancy and stakeholders are generally guarded as to the size and type of end market being serviced. Currently closed-loop recycling is the main recovery route. The incentives for both Knauf and Lafarge to recover plasterboard are to compete in terms of service provision with BG and to benefit from the cheap feedstock which recycled plasterboard can represent. Prior to the late 1980s British Gypsum was the sole UK manufacturer of plasterboard and has not only been the only manufacturer with access to UK mined gypsum but has also been the main processor of synthetic gypsum of UK origin; hence Knauf and Lafarge are heavily reliant on the import of gypsum. Importing gypsum is a costly process and Knauf reports that it costs around £30 to £40 per tonne to import synthetic gypsum from Brindese in Italy, compared to the cost of £5 to £10 per tonne for synthetic gypsum sourced in the UK. Recovered gypsum is viewed as a cheap alternative feedstock by both companies, although Knauf are yet to use it in their two mills in the UK.

A potential threat to this market is the predicted growth in the quantities of Flue Gas Desulphurised (FGD) gypsum from coal fired power stations. This is currently displacing more expensive imported feedstock but could in time restrict the market for recovered gypsum. FGD is a cheap form of gypsum that is generated in much larger quantities than recovered gypsum. However, reprocessing plants located adjacent to mills are currently considered a good means of managing mill waste with the recovered gypsum being fed back into the process. If a decision is made to limit or stop the use of recovered gypsum including mill waste then alternative disposal or recovery solutions would need to be found.

WRAP has set up a programme focussed on plasterboard recovery, and the development of alternative end markets is a core objective. This would potentially reduce the reliance on the closed loop market and could increase the number of plasterboard reprocessors. This would have a profound effect on both transportation infrastructure and recovery costs.

5.4 Section conclusion and discussion

The analysis undertaken in this section has identified a number of key points:

- There are currently two prominent collection systems. They differ significantly in that the bag system utilises methods adapted from conventional delivery systems, i.e. flatbed vehicles with lifts, and the skip system utilises the waste collection infrastructure.
- The skip type system most lends itself to the collection of demolition waste since it is operated by the waste industry and is the common format for handling such wastes.
- The availability of on-site storage space for plasterboard waste is currently a key determinant on the viability of recovery due to the nature of the two collection systems in operation, i.e. the space is critical for the bag system to ensure sufficient bags can be stored to guarantee viable collection route densities, and the skip system needs the space to accommodate the skip.
- Although the cost of disposal to landfill mono-cells is high, the forecast increase in disposal cost to the waste generators has not arisen due to:
    - The '10% rule' on gypsum waste sent to landfill, which is being exploited by small developers, waste transfer stations and landfill operators.
    - The competitive nature of the waste management industry which is keeping prices down, especially within the skip hire business. Table 5 shows that plasterboard waste can be recovered for as little as £51 per tonne.
- The "medium-sized" companies represent the gap in the current market for alternative recovery systems. It is estimated that such companies account for circa 70,000 tonnes of plasterboard waste. A "me too" attitude can both be nurtured and exploited to encourage such companies to follow the lead set by the larger companies. The next section will examine alternative recovery options that are suited to the medium sized companies.
- Regions such as the South East, London and the North West are most in need of additional reprocessing capacity if local solutions are considered the best means of managing waste. However, systems developed in Canada can viably transport wastes 350km from the waste transfer station to the reprocessors.

6 Analysis of alternative collection systems

This section focuses on two potential alternative approaches to plasterboard collection, namely:

- *Utilisation of the existing delivery infrastructure. This is an alternative method of recovering construction waste. This could potentially reduce the overall vehicle movements required which could have both an environmental and economic benefit. In addition, this represents an opportunity to provide a standardised collection system since there is commonality in the methods of delivering the plasterboard.*
- *Breaking the link between on-site space and segregation / mixed systems.*

6.1 Utilisation of existing delivery infrastructure

Although BG is involved in the collection infrastructure, their system cannot be regarded as a "reverse haul" system since it uses third party operators to collect and deliver the bags to the reprocessing plant. It is a general observation that there are few existing examples of the delivery infrastructure being used to recover waste plasterboard. Essex Drywall Ltd, a regional specialist merchant, is one example. The system used is a bag system whereby waste bags are collected at the point of delivery and taken direct to PBR UK for recovery. This system is operated on a relatively low scale at present.

There are two potential means of utilising the existing delivery infrastructure to collect new waste plasterboard from the construction industry: either plasterboard manufacturers or merchants operating a reverse haul scheme.

6.1.1 Reverse haul by plasterboard manufacturers

In theory this represents the simplest and most cost-effective means of collecting plasterboard waste (Figure 25). The waste plasterboard is collected at the point of delivery and returned to the manufacturers for reprocessing. The potential benefits include:

- Utilisation of backhaul vehicle capacity
- Short and integrated supply chain
- Closed-loop recovery.

Figure 25: Reverse haul collection of waste by the plasterboard manufacturers.

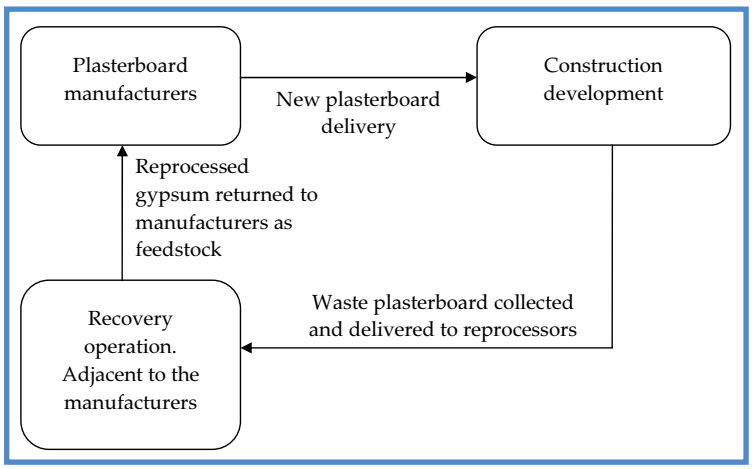
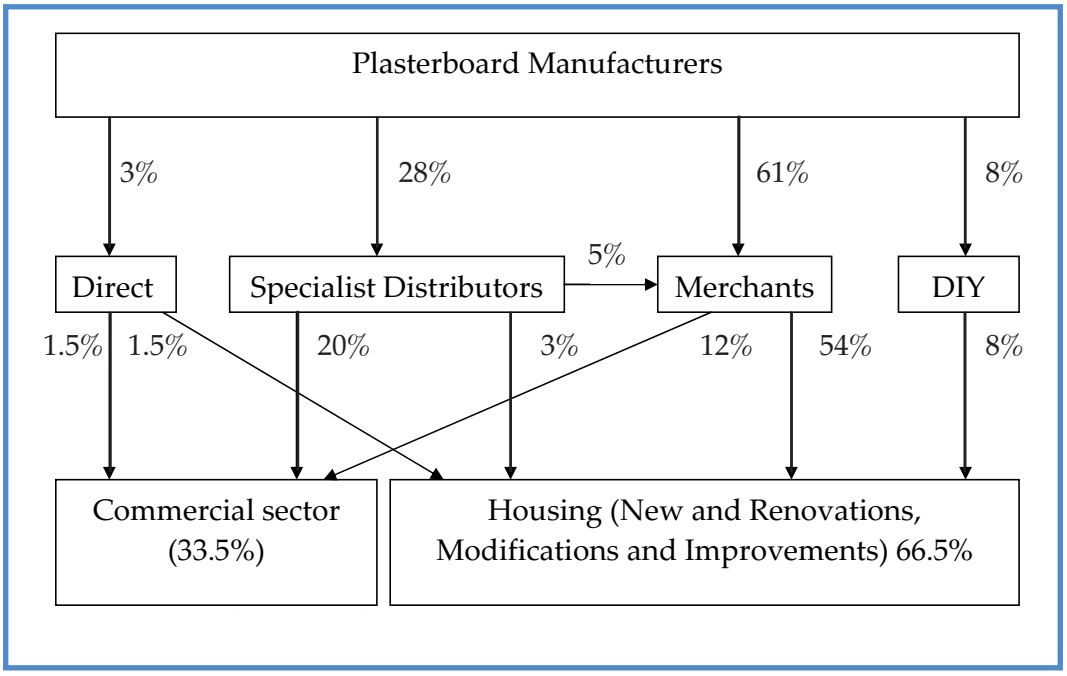


Figure 26: Plasterboard material transaction flow chart in 2000.



Source: Duncan Barker. Jewson Ltd.

Figure 26 shows the flow of plasterboard transactions. This shows that only 3% of plasterboard transactions involve the simplest route of manufacturers dealing directly with the consumers. In terms of physical material flows Lafarge report that they deliver 30% of board direct to consumers. Although the direct material flows are much higher at 30% it still limits the opportunity in this option since this would involve the large clients who are most likely to be engaged in one of the existing recovery systems. In addition, manufacturers such as Lafarge do not operate their own fleet of vehicles and hence vehicles are unlikely to return to the manufacturers. Journeys back to the manufacturing plant would therefore represent an additional cost rather than a utilisation of backhaul capacity.

6.1.2 Reverse haul by merchants

Figure 26 shows that 66% of plasterboard (customer deliveries) is managed by general merchants and 23% by specialist merchants, hence they are better positioned to take back plasterboard waste than are the manufacturers. The client base of the two types of merchants differs significantly with the client base of the specialist merchants being predominantly heavy users and the general merchants having a broader range of clients from heavy to light users. For the purpose of this study it is the lighter users that are the target, since the heavier users are generally covered by existing recovery systems.

Jewson is one of the main general merchants with plasterboard sales of 30 million m^2 or 250

tonnes per annum. Jewson examined the business benefits of operating a take-back scheme and concluded that the benefits were currently outweighed by the additional complexities of operating a waste carrier license, cost of operator training, additional staffing at each depot and managing contamination.

It is concluded that this system would be more attractive if the '10% rule' were abolished and a zero-tolerance approach were adopted. If this were to happen then it would be advantageous for such companies to observe the performance of the BG scheme to establish the level of additional sales gained from offering the collection service. In addition, the viability of becoming a third party haulier for the plasterboard manufacturers should also be explored. For example, the take-back scheme may complement the BG scheme by minimising the number of additional vehicle movements on sites.

6.2 Breaking the link between space and segregation

An alternative system which overcomes the issue of availability of on-site space was highlighted by NWGR. In North America 54% of gypsum collected for reprocessing by NWGR is done so in loads of less than 1.5 tonnes, with 46% being delivered direct to reprocessors and 8% sent through waste transfer stations. The most popular means of recovering such loads involves "mosquito fleets" of small trucks, which collect the waste from sites and deliver them either direct to reprocessors or to waste transfer stations for onward transfer to reprocessors. Figure 27 shows the trucks delivering the board to a reprocessing facility.

In the "mosquito fleet" system the waste board is heaped up by the waste generators in an area that is readily accessible to the truck driver.

Figure 27: The mosquito fleet system.

Figure 28 shows the board waste in the centre of the room. This approach outsources the management of the waste to the collector, i.e. only a minimal level of waste handling is undertaken by the developer. Figure 29 shows the waste on a pallet at the side of the road.

Figure 28: Waste stored in the centre of the room awaiting collection.

Figure 29: Waste stored at the side of the road awaiting collection.

The driver then manually loads the board onto the truck and delivers it to the waste transfer station or reprocessor where a dedicated skip or area is provided to store the waste (Figure 30).

The truck driver is paid either by the tonne, by the build unit / house, by the load or by the square footage of the building, for example 10p per square foot, depending on the agreement with the building contractor. Most collectors have one or two building or plasterboard contractors that they work for on a steady basis. The contractor is invoiced by the tonne, which includes the tipping fee plus the collectors fee or by the load. For loads that are from more than one job, the collectors try to keep the loads separated by using larger pieces of drywall. Part of the load is then off-loaded by hand and the load is re-weighed creating two invoices.

The key points of the Canadian system include:

- The "Scrappers" receive between £58 to £88 per tonne for the collection and pay a gate fee of between £22 and £40 per tonne to either a waste transfer station operator or to NWGR.
- NWGR feed plasterboard mills as in the UK.
- Building contractors, plasterboard applicators, demolition/renovation contractors and homeowners are served by this system.
- There is a zero-tolerance of gypsum to landfill in some Canadian provinces.

Figure 30: An example of a waste transfer station in Canada.

Key points of the "mosquito fleet" system are:

For	Against
The waste is segregated and hence requires minimal onward sorting.	A new concept to the UK with no networks or infrastructure currently in place.
No on-site space required for containers. This is particularly beneficial on small developments or on sites where the footprint of the building is equivalent to the footprint of the site, e.g. urban renovations.	The smaller potential clients who currently use the mixed skip system will currently fall under the EA '10% rule' undermining the benefits of the system to them.
Minimal handling of waste required by drylining contractors and main contractors.	
Waste can be removed from site on a daily basis minimising build-up.	
Contamination levels can be vetted by collectors at the point of collection.	
The system can be used for both construction and demolition waste.	

RC Interiors in London is one company that provides a similar service in the UK using 1.3 tonne and 2.8 tonne vehicles (Figure 31). The scheme overcomes a number of the constraints associated with servicing developments in areas with restricted access for skips, which are commonplace in large urban areas such as London. Figure 32 shows the plasterboard removed from partitioning in an Overbury refitting development. The waste board has been placed in two heaps awaiting collection. The site in question had no room to accommodate a skip and was a live building, i.e. was still being used while the refit was undertaken. Unfortunately, although the plasterboard is segregated at source the waste transfer station receiving the board does not currently have a dedicated area for gypsum and hence it is landfilled. The system therefore demonstrates that it is practically viable to recover segregated strip-out plasterboard in the UK, but does not prove the economic viability of plasterboard recovery using this system.

It is concluded that the "mosquito fleet" system can potentially address a constraint of current recovery systems, namely space availability on site to accommodate containers (bags or skips). In addition, the system is most suited to small and medium sized waste generators and hence is complementary to the existing systems.

Figure 31: The collection vehicle used by RC Interiors.

Figure 32: An example of waste plasterboard awaiting collection by RC Interiors.

7 Conclusion and discussion

The study has shown that there is significant scope for waste minimisation with up to 20% yield losses being cited by the construction industry. Reducing waste arisings by 50,000 tonnes is considered a realistic initial target with focus placed on designers and architects designing out waste and the promotion of the bespoke service offered by plasterboard manufacturers.

The focus on designing out waste fits into the Government's strategy on waste prevention. The "consultation document on the review of England's waste strategy" (Defra Feb 2006) stresses:

"There is a need to design products which generate less waste in use, result in less process and end of life waste and use fewer hazardous materials in their manufacture. Poor design and / or purchase specifications results in avoidable waste production during use, service delivery or at end of life, or result in the provision of disposable / low durability goods".

Four recommendations have been made by stakeholders with regard to legislation or its implementation:

- Fast tracking waste licensing to aid the build of reprocessing capacity.
- Clarity over the '10% rule' with particular emphasis on the legality of dilution at waste transfer stations and landfills.
- Provision of practical guidance on how to assess loads with respect to the 10% sulphate content.
- A review of the success of the legislation in terms of reducing sulphate levels in landfills.

The study has shown that the waste generators have, in the main, not incurred the anticipated rise in disposal costs due to:

- The competitive nature of the waste management industry. This is especially true of the skip hire market and is due to the bargaining power of the large construction companies
- The Environment Agency '10% rule'.

A large majority of small and medium sized companies contacted in the study have not had to modify practices due to the '10% rule' permitting the mixed landfilling of waste. Although this can be regarded as beneficial from a business and industry perspective the impact this has had on the Waste Acceptance Criteria (WAC) meeting its objectives is questioned.

The WAC has had a greater impact on large construction companies in terms of causing a behavioural change and such companies have readily integrated recycling schemes set up by the plasterboard manufacturers. Due to the size of developments these companies are more able to segregate or part-segregate waste at source and the large quantities of waste generated help support the value chain in terms of economies of scale and bargaining power with the waste management industry.

The large construction companies have begun marketing their recovery practices through Corporate Social Responsibility and Environmental Management Systems policies and clients are beginning to specify material recovery in contracts. This is considered to be a significant driver in incentivising medium sized businesses, who account for circa 70,000tpa of plasterboard waste, to introduce recovery systems.

The delivery infrastructure is currently under-utilised in the collection of waste plasterboard due primarily to:

- A lack of incentives to participate
- The need for waste carrier licenses
- Staff training
- Contamination rates.

From a practical standpoint the builders' merchants and specialist distributors are best positioned to offer such a service since they handle 89% of the plasterboard transactions with end users. The general builders' merchants would be of particular interest since their client base is made up of a high percentage of the smaller end users and those who are difficult to reach using other collection methods due to the lack of economy of scale and site restrictions. However, the application of the '10% rule' acts as a disincentive to such businesses to switch from current cheaper disposal methods.

The alternative recovery system that is considered to have the greatest potential is the "mosquito fleet" system. This is easy to set up and is complementary to the existing collection systems in terms of the material that is targeted. This system is well proven in North America where plasterboard recovery is in an advanced stage.

8 Recommendations

The recommendations have been developed with focus on the key delivery body:

8.1 The construction industry: Waste minimisation

The study has identified a number of factors influencing the quantities of waste arising. The primary recommendation is to focus on reducing the quantities of trimming waste being generated; currently accounting for circa 70% of waste arisings. Priority should be placed on designers and architects designing out the waste through the reduction of unnecessary variability and the standardisation of room dimensions. Further, the bespoke service offered by the plasterboard manufacturers should be more extensively and rigorously promoted.

In addition, weather damage is one factor that appears to have been overlooked and it is recommended that focus be placed on the development of solutions to overcome this problem. For example, minimising the storage of board outside through a more "just in time" approach or, if board must be stored outside, improving the covers used on plasterboard and better housekeeping. The introduction of pallet sheets would reduce the ingress of moisture through the pallet and more robust reusable covers would also be beneficial. The demand for such equipment should be taken up by the construction industry since it is in their best interest, rather than in the interest of the plasterboard manufacturers, to reduce the quantities of waste arisings.

It is estimated that a £9.7 million saving could be made through the reduction of waste arisings by 50,000 tonnes.

8.2 The Environment Agency: Improved guidance and procedures

The '10% rule' is holding back the full scale adoption of gypsum recycling. However it is the lack of clarity on such issues as the modification of loads that has caused much contention. It is therefore recommended that the Environment Agency consult with the stakeholders to identify the points that need clarification and to draw up clear guidance on these issues. If the modification of loads at landfill and waste transfer stations is deemed illegal then this would cause a significant reduction in the quantities of waste generated, especially from the medium and large companies, that is sent to mixed landfill. This would encourage such companies to seek alternative diversion options. A conservative estimate is that this would reduce the material that is legitimately sent to mixed landfill by 100,000 tonnes.

In addition, it is recommended that the Environment Agency undertakes a review of the WAC to ensure it has had the desired impact in terms of the quantities of gypsum waste diverted from non-hazardous landfills accepting biodegradable material.

The Greater Vancouver Borough Council may be a useful contact in terms of knowledge pooling, i.e. on what scientific grounds was the zero tolerance approach adopted and what impact has it had on the competitiveness of the stakeholders in the construction and demolition sectors?

A review of the application and the guidance for waste licensing is recommended to determine whether the system can be improved to speed up the processing of applications and the consistency of the guidance provided.

8.3 The waste industry: Focus recovery on the low hanging fruit

Taking into consideration the barriers and enablers to plasterboard recovery the following are recommended in rank order:

- Maximise the recovery from large construction companies using existing collection systems.
- Maximise the recovery from large and medium sized construction companies using alternative collection systems, see Section 8.4.
- Maximise the recovery of selected demolition waste, i.e. partitioning.

It is estimated that circa 126,000tpa of construction waste can be recovered using existing collection systems and a further 70,000tpa using alternative systems. Due to the lack of base data on demolition waste it is not possible to make an accurate estimate on the level of demolition waste that can be recovered.

8.4 The waste industry: "Mosquito fleet" trial

This study has identified the "mosquito fleet" system as a complementary alternative means of recovering plasterboard waste from the construction and demolition sectors. It is estimated that this system could increase the collection coverage within the construction sector by 70,000 tonnes and at least a similar quantity of demolition waste.

The waste industry is encouraged to assess the viability of this method especially, as in the case of the systems in operation in Canada, the small entrepreneurs.

On the strength of this study a demonstration trial funded through WRAP commenced in January 2006 to determine the viability of this system in the UK. The study is focussed on strip-out waste from Overbury sites in London and the findings will be disseminated to encourage the take-up of this system by the waste industry.

8.5 WRAP and the waste industry: Develop alternative end markets in regions with inadequate reprocessing provision

Although NWGR have proved in Canada that gypsum waste can be recovered from a radius of 350km, this recommendation focuses on the development of regional reprocessing capacity. The increased number and geographic penetration of gypsum reprocessors is considered important since from an economic perspective centralised reprocessors have a difficult task competing against local landfill disposal due to the additional transportation and bulking up costs.

The provision of funding from WRAP for the development of alternative end markets will create a pull type market mechanism incentivising new entrants and existing operators to set up in the geographic areas currently with inadequate reprocessing provision, i.e. the South East, London and the North West (Table 8). Agriculture and Portland cement are two end markets that have received much attention in North America and that warrant greater assessment in the UK.

9 Further work

Although the conclusions and recommendations are considered robust the study has found the raw data on waste arisings to be poor. Historically, neither the construction or demolition industries has gathered data on waste arisings and the study confirms data gathering and process monitoring to be in its infancy. Demolition waste arisings is the area of most concern. It would therefore be beneficial to undertake a detailed analysis of demolition waste arisings to establish:

- A better estimate of total waste arisings
- A detailed analysis of the type and quantities of waste that can be recovered and the barriers to recovery.

In addition, this study highlighted waste minimisation in the construction industry as the top opportunity. The yield loss data was again wide ranging and this also warrants a detailed assessment.

Glossary

'10% rule'	The Environment Agency's ruling that mixed waste loads containing less than 10% gypsum waste can continue to be sent to conventional landfill
C&D	Construction and demolition
CPA	Construction Products Association
CSR	Corporate social responsibility
FPDC	Federation of Plastering and Drywall Contractors
tpa	tonnes per annum
Ktpa	thousand tonnes per annum
Mtpa	million tonnes per annum
NWGR	New West Gypsum Recycling
RM&I	Refurbishment, modifications and improvements
PWC	Price Waterhouse Cooper
WAC	Waste Acceptance Criteria
WRAP	Waste & Resources Action Programme