

Eurogypsum
Waste Policy: **Building
Value For Society**





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Foreword



Waste is an important area for the European Commission. Over the past thirty years, the European Union has laid down a number of laws that protect human health and the environment from waste, the transport of waste and major waste facilities such as landfills or incinerators. In my time as Commissioner, I have brought forward new policies to move the EU towards a recycling society, one in which waste should be prevented, reused or recycled wherever possible.

If we are to achieve these ambitious objectives all stakeholders need to play their part. European industry can make a significant difference, both in improving the way it handle or prevent its own waste, and in improving the technology that can be used to manage waste from its sources. This publication demonstrates that EuroGypsum is working towards both these aims, and I welcome this.

A handwritten signature in black ink, appearing to read 'Stavros Dimas'.

Stavros Dimas

MEMBER OF THE EUROPEAN COMMISSION





Executive Summary

Gypsum plasterboard is used to line interior walls to achieve a clean smooth finish. The environmental loads from the production, use and disposal of Gypsum plasterboard can be minimised by the recycling of Gypsum. This raw material is indeed fully and eternally recyclable.

In that respect, much has already been written and spoken about the Gypsum Industry in connection with waste generated from the construction process.

The European Directive on the Land Filling of Waste¹ is reducing the Gypsum Industry reliance on landfill and is helping to ensure that wastes destined for landfill are treated to reduce their environmental impact. The Directive was approved in 1999 and the implementation of the requirements has taken place progressively since 2001. Corresponding national legislation has resulted in a phased introduction of its requirements by the waste industry. Since 16 July 2005, high Sulphate bearing materials can only be accepted in non-hazardous landfills if they are kept separate from biodegradable waste in mono-cells.

The introduction of waste acceptance criteria (WAC) for high Sulphate content products in July 2005 has encouraged many in the general construction supply chain to review and debate future solutions.

This policy paper identifies efforts undertaken by the Gypsum Industry in improving processes to enable increased volumes of recycled products to be used in plasterboard manufacturing. This is not an easy task, even though the willingness to progress is strong within the European Gypsum Industry.

Indeed, no firm market size information is available for new construction waste, nor is collating such information permissible under competition rules, which the European Gypsum Industry strictly observes.

¹ Council Directive 1999/31/EC on the Landfill of Waste.

The application of plasterboard splits into the three traditional sectors approximately as follows:

House building: 30%

Commercial Industrial: 30%

Repair, Maintenance, Improvement: 40%

The percentage of site scrap from new construction varies with sector and project.

The demolition gypsum waste market is even more complex as no reliable statistics exist despite efforts to improve on current data. Furthermore plasterboard usage only gained widespread acceptance in Europe, at least in Continental Europe, in the 1970s-1980s. Even now in Southern Europe the more traditional ways of partitioning and interior finishing still prevail. This means that many buildings over 40 years old contain little or no plasterboard. Gypsum demolition waste is as yet seen as a secondary issue.

The environmental preference goes to reducing waste at source, i.e. at the design stage. But as some waste will inevitably be generated, construction sites need to establish the discipline of segregation. The waste industry has the expertise, independently and in collaboration with plasterboard manufacturers, to provide an appropriate service to the construction industry for the necessary collection and logistics system. Greater focus on this subject will encourage further development and opportunity within the business sector. The Gypsum Industry is currently providing routes for segregated, clean plasterboard waste to be delivered to reprocessing stations. However, we need to emphasise that, as yet, the Gypsum Industry can only offer solutions to medium to large projects in the new build residential and commercial sectors.

The focus is placed on turning Gypsum waste into a business opportunity, even though much still needs to be done to reach an economic maturity.



EU Legislation and Policy Drivers

I. Towards a European Recycling Society

Published on 21 December 2005, the Communication of the Commission on “Taking Sustainable Use of Resources forward: a Thematic Strategy on the Prevention and Recycling of Waste” is expected to have implications for current practices in the Member States and to create new opportunities for waste management options other than landfill, thereby encouraging a general move up the waste hierarchy² based on an order of environmental preference (i.e. reduce, reuse, recycle, recover and disposal).

This means less waste to landfill, more compost and energy recovery from waste and last, but not least, more and better recycling. The European Union plans to review the recycling situation in 2010 and if recycling of materials that would lead to an environmental benefit in the framework of life-cycle thinking is not taking place, further action will be carried out, e.g. landfill ban, economic instrument, collection or recycling target, etc.

The Gypsum Industry is conscious of the challenges posed by the European Union and is promoting adequate recycling solutions for Gypsum construction and demolition waste. Within the framework of life-cycle thinking, the Gypsum Industry is also striving for eco-efficient products creating wealth and economic value for society, while using fewer natural resources and producing less environmental impact. It does so via research and product development. Natural Gypsum is increasingly being substituted whenever possible by synthetic Gypsum (mainly FGD Gypsum)³.

2 Communication from the Commission «Taking Sustainable Use of Resources forward: a Thematic Strategy on the Prevention of Waste» -21 December 2005.

3 Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on Waste and By-Products, page 13.

II. The Landfill Directive and its Impact on the Gypsum Industry

On 19 December 2002⁴ the Council took a decision to establish criteria and procedures for the acceptance of waste at landfills. The following paragraph of the legislation applies to Gypsum products waste:

Paragraph 2.2.3

“Non-hazardous Gypsum-based materials should be disposed of only in landfills for non-hazardous waste in cells where no biodegradable waste is accepted. The limit values for total organic carbon and dissolved organic carbon given in sections 2.3.1 and 2.3.2 shall apply to waste land-filled together with Gypsum-based materials”. The principal reason for excluding Gypsum waste products from the list of waste acceptable at landfills for inert waste without testing is the inclusion of the parameter “Sulphate” which is inherent to all Gypsum products. The Sulphate content of Gypsum mixed with biodegradable waste in a landfill may break down, amongst other substances, into Hydrogen Sulphide (H₂S), a dangerous gas that in high concentrations is lethal and in low concentrations gives a rotten egg smell.

The Consequences of this decision are:

- Plasterboards and blocks need to be removed from demolition waste destined for disposal in inert landfills;
- The risk of Hydrogen Sulphide gas is greater unless the dedicated cell is protected from water intrusion;
- Municipal waste landfill charges are considerably higher in non-hazardous landfill than inert landfill;
- Dedicated cell costs are considerably higher than those for normal land-filling.

⁴ Council decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 and Annex II to Directive 1999/31/EC.

The Decision took effect on 16 July 2004 and Member States had to implement it by 16 July 2005.

This Commission Decision implied that the Gypsum Industry decided to improve recycling of construction waste. The costs related to landfill are definitely higher than before, depending however on the way the different EU Member States apply the decision.

In France, plaster-based products are accepted in cells in inert landfills, but you need to manage the cells as if they were in landfills for non-dangerous waste.

In the UK, there are currently only a few mono-cells in operation with gate fees ranging from 132 Euro to 198 Euro per tonne. However, if the content of the load contains small amounts of high Sulphate bearing waste, e.g. less than 10%, it may be deposited in a non-specific cell.

III. Directive of 15 March 2006 on the Management of Waste from Extractive Industries and the Gypsum Industry⁵

The plasterboard manufacturers extract the mineral "Gypsum" that they use in the production of different products. As a part of the extractive industries, the mineral Gypsum falls under the above-mentioned Directive.

Characteristics of Gypsum Mining Waste

- **Environmentally safe:** Calcium Sulphate leachate is neither toxic nor eco-toxic. There is no danger of formation of H₂S gas from Gypsum mining waste (which could only be the case for uncontrolled land-filling operations of household waste together with Gypsum).

⁵ Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the Management of Waste from Extractive Industries and amending Directive 2004/33/EC.

- **Volumes:** Unlike most other minerals, Gypsum (Calcium Sulphate) is often mined in deep open pits under important overburden cover or underground. Materials resulting from Gypsum extraction may contain a variable percentage of Calcium Sulphate. So the Gypsum rock has different degrees of purity and thus of usability. Gypsum mining waste facilities are usually located at the Gypsum deposit or very close to it. Gypsum mining waste is that part of the extracted mineral which cannot be used or recycled due to two characteristics:

- A. Very fine Gypsum particles which cannot be processed for technical reasons;
- B. The rock is too impure to be processed or used as aggregate.

- **Solubility:** Around Gypsum quarries, the Gypsum layers are often in contact with groundwater or with rain. The groundwater is in that case saturated with Sulphate. In other words, it is impossible to have a higher concentration of Sulphate in that groundwater. Therefore, the Gypsum mining waste generated by the quarry and put aside does not increase or decrease the Sulphate concentration in the deposit area. This is the reason why the solubility and resulting Sulphate concentration cannot be considered as pertinent criteria to split between inert and non-inert waste in this case. The Gypsum Industry thus consider Gypsum mining waste as inert.

The Gypsum industry is minimising Gypsum mining waste in two main ways:

- A. The Gypsum mining waste is used to backfill the voids, thus contributing to the rehabilitation of quarries;
- B. Gypsum rocks which are not usable because of insufficient purity ratios are mixed with high purity Gypsum (like FGD Gypsum), thus preventing waste.



IV. Calcium Sulphate Waste Categories in relevant European and International Waste Lists

1. European Waste Catalogue⁶

- 01 01 Wastes from mineral excavation
- 01 04 Wastes from physical and chemical processing of non-metalliferous minerals
- 06 09 Wastes from the MFSU of phosphorus chemicals and phosphorous chemical processes
- 06 11 Wastes from the manufacture of inorganic pigments and opacifiers
- 10 01 Wastes from power stations and other combustion plants (except 19)
- 10 12 Wastes from manufacture of ceramic goods, bricks, tiles and construction products
- 10 13 Wastes from manufacture of cement, lime and plaster and articles and products made of them
- 17 01 Concrete, bricks, tiles, and ceramics
- 17 08 Gypsum-based construction material
- 17 09 Other construction and demolition waste

2. OECD Waste List⁷

Green Waste List

- GG: Other wastes containing principally inorganic constituents which may contain metals and organic materials
- GG 010: Partially refined Calcium Sulphate from flue gas desulphurisation (FGD)
- GG 020: Waste Gypsum wallboard or plasterboard arising from the demolition of buildings

6 Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to article 1(4) of Council Directive 91/689/EEC on hazardous waste. Council decision of 23 July 2001 amending Commission decision 2000/532/EC as regards the list of wastes.

7 OECD Council Decision C (2001) 107 Final on transboundary movements of wastes destined for recovery operations.

Amber waste List

- AB: Waste containing principally inorganic constituents which may contain metals and organic materials
- AB 140: Gypsum arising from chemical industry processes
- AB 150: Unrefined Calcium Sulphate and Calcium Sulphate from FGD

3. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal by the United Nations Environment Programme (UNEP)

List A

Waste characterised as hazardous under article I paragraph 1(a) of the Convention. Designation of a waste on list A does not preclude the use of Annex III (hazard characteristics) to demonstrate that a waste is not hazardous.

- A2040: Waste Gypsum arising from chemical processes, when containing Annex I constituents to the extent that it exhibits Annex III hazardous characteristics (note the related entry on list B, B2080)

List B

- B2040: Other waste containing principally inorganic constituents:
- Partially refined Calcium Sulphate produced from flue-gas desulphurisation (FGD)
 - Waste Gypsum wallboard or plasterboard arising from the demolition of buildings
- B2080: Waste Gypsum arising from chemical industry processes not included on list A (note the related entry on list A, A2040)

The Basel Convention has been transposed into EU Community Law through the Regulation 1013/2006 of the European Parliament and of the Council on shipment of waste (14 June 2006).



Enhancing Value for Finished Products via a Sustainable Use of Resources

I. General Introduction

Gypsum products waste is part of the construction and demolition debris waste stream.

Construction and demolition (C&D) waste may include, but is not limited to: concrete and cement products, steel, bricks, plasterboard, glass, plastics (e.g. PVC) and second-hand materials (e.g. doors, cabinets and windows).

The benefits of recycling C&D waste are:

- Saves raw materials and energy;
- Saves landfill space;
- Decreases construction site disturbances;
- Preserves environmental integrity of construction site.

Construction & demolition waste in Europe has a strong regional orientation. This regional orientation makes it difficult to obtain reliable statistics, let alone to predict a solid forecast of the developments of C&D waste in Europe.

As of 2003, the European Union (EU) estimates its annual production of C&D waste to be approximately 180 million tons, 28% of which is recycled. Of this amount, approximately 35-40% of the C&D waste generated is concrete or concrete products.

II. Waste Prevention and Reduction of Gypsum Based Products

1. Waste Prevention: Design for Construction⁸

The following principles should be followed for a sound environmental building construction:

- The Gypsum Industry produces materials in a large range of sizes and can produce bespoke sizes to special order where the volume is large enough or to special order. All plasterboard materials can be delivered in the exact quantities required by building sites and are logistically better adapted to the demands of the building sites. These services, however, require more accurate management of ordering and logistics and for a range of reasons are only likely to be effectively applied to fairly large building sites;
- The Gypsum Industry offers substitutes that are reusable, such as modular “demountable partitions” for commercial buildings;
- The Site Manager on the construction site should plan in advance suitable storage space to ensure security, safety and protection of plaster products, Gypsum plasterboard and accessories. Those should be dry and protected from damp and extreme temperatures. Where possible, this should avoid the need to move materials to subsequent storage positions, as moving materials increases the risk of damage;
- Gypsum plasterboard should be stored on a dry level surface, stacked flat;
- The Site Manager should ensure that areas are weather tight and dry before installation begins. Other wet trades such as screeding should be completed and dried out before work begins;
- The workplace should be properly planned to avoid wastage from poor handling, fixing or spillage;



⁸ GPDA-Healthier Building with Gypsum Products : n°4 Reduction of Waste-March 1997.

- Although plasterboard systems are designed for simplicity, they require knowledge and skill to be applied efficiently. Often incorrect handling, sequencing, fixing and finishing will result in work being condemned both during and after completion of the project. Operatives and subcontracting companies should be appropriately qualified to undertake the work.

2. Waste Disposal Reduction Measures: Design for Deconstruction

The Gypsum Industry⁹ is striving for a built environment:

- That is readily deconstructable at the end of its useful life;
- Whose component (in our case, the Gypsum panels) are decoupled from the building for easy replacement and to allow full identification;
- That comprise products designed for recycling;
- Whose bulk structural materials are recyclable;
- That promotes health for its human occupants;
- That comprise an asset register for projects which contain information on the materials used and instruction on how components can be dismantled.



The above-mentioned means that the Gypsum Industry is committed to continued industry research and development in eco-design of Gypsum products to ensure that recycling is maximised, i.e. that a higher percentage of recycled content is used in the manufacturing of new products. Life-cycle analysis can also be used to improve the recyclability and reuse of Gypsum products.

⁹ Gips is het maatschappelijke geschenk voor de afbouw- brochure-NBVG-2004.

III. Prevention of Waste during Products Manufacturing

This specific waste comes from the transitional production stages: starting and stopping production and continual changes in quality. This internal flow of non-conforming product is nowadays treated in internal recycling facilities. The internal recycling facility is a part of the process of the plasterboard manufacturer. This so-called "production waste" is a source of secondary material after shredding and is therefore not considered as a waste.

The process of reintegration or reintroduction of production waste into the manufacturing process is often referred to as "feedstock recycling". In the case of plasterboard, clean scrap is either chopped into small pieces or as much paper as possible is removed before reintegration. Improved manufacturing techniques mean that production scrap levels (at around 3-5% of total production) are constantly being reduced, leaving more capacity for recycling clean scrap from new construction sites.

IV. Reuse

Construction Site Reuse

- The container systems used for plaster allow further reuse of the remaining plaster and/or refilling with additional product. The material enclosed in silos normally should not be regarded as waste, whereas reuse of material in bags is time-limited. Silos and bags should be ordered according to the amount of plaster expected and time-frame of the construction process.
- Drywall scraps can be placed in the interior wall cavities during new construction. This will eliminate the disposal and transportation costs. In recent years, the concept of recycling Gypsum drywall at the construction site has been proposed. In this approach, scrap drywall from new construction is separated and processed using a mobile grinder and then size-reduced material is land applied (prior to placement of sod) as a soil amendment or a plant nutrient (refer to VII.Reducing for other End-Uses 1 and 2). This approach may be feasible when the soils and grass species show a benefit from the application of Gypsum. This recycling technique offers a potential economic benefit when the cost to process and land application

of the ground drywall at the construction site is less than the cost to store, haul and dispose of the drywall.

- Main contractors and subcontractors could reuse plasterboard off-cuts from new building sites on other projects, if an appropriate storage is set up.

Gunite support

Gunite is concrete sprayed on at high pressure. Cut-offs (pieces of new construction drywall) can be used as forms to support gunite as it is being sprayed.

V. Recycling of Gypsum Waste Arising from the New Construction of Buildings

This concerns **sorted and clean waste only** from new construction sites. In the UK, a recent study carried out by the Federation of Plastering and Drywall Contractors estimates that plasterboard wastage within the construction industry can be anything from 10% to 20%.¹⁰ If the waste prevention measures are taken on the construction site, the Gypsum Industry estimates that plasterboard wastage can be reduced to 5%.

1. Waste Flows on Construction Sites

We distinguish between the following waste flows on the construction site¹¹:

– *Direct waste*

Site storage and handling waste – Damage to plaster and wallboard products can result from exposure to moisture and water. Wastage also occurs due to physical damage - from incorrect storage, impact from dropping, collision, accidental damage from other site activities (especially movement of plant).

¹⁰ Federation of Plastering and Drywall Contractors Diverting Plasterboard Waste from Landfill in the UK-June 2006.

¹¹ GPDA-Healthier Building with Gypsum Products : n°4 Reduction of Waste-March 1997.

Metal framing components can also suffer physical damage and corrosion if stored incorrectly.

Excess materials at the workplace –

Wastage is caused by over-mixing plaster which is then left to harden at the end of the day, and over provision of drywall products which are not returned to storage.

Fixing waste – Wallboard products can be damaged by poor handling and fixing at the workplace.

Criminal waste – Theft, pilfering from the site and vandalism.

Waste due to the wrong specification/

use – Incorrectly specified wallboard

systems which do not meet the required performance can result in work needing to

be redone during construction or as a result of later defects. This situation can also arise if the contractor uses a lower performance system, due to unclear project documentation or incorrect substitution (see also indirect waste).

Learning waste – New systems and fixing methods can lead to wastage without the proper training/trials.

Storage waste – Storage of bagged plaster products beyond their shelf life.



– *Indirect Waste*

An example of indirect waste in relation to Gypsum products would be where a lower specification would suffice. For example, if there had been an excess of acoustic boards ordered for one part of a building, which were then used in place of standard boards in another location, this would be considered as indirect waste.

– *Repetition Waste*

Probably the largest risk of wastage results from work being condemned because it has been damaged after installation. The constant pressure for faster construction can mean that the work is often installed before there is proper protection from the elements. Any significant wetting of finished wallboard can result in the loss of structural integrity. Poor sequencing and co-ordination of

trades can lead to following trades removing or damaging wallboard because there is still work to be completed behind the finished surface.

According to the Federation of Plastering and Drywall Contractors, the financial benefits of waste minimisation would lead to a reduction in waste arisings (in the UK) of around 50,000 tonnes. This figure 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 m² and an average weight of 8.35kg per m², 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.¹²

2. Collection Systems of Gypsum New Construction Waste

Current collection systems favour the large contractors: these are most likely to have corporate social responsibilities 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 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.

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. This system lends itself best to the collection of demolition waste, since it is operated by the waste industry and is the common format for handling such wastes.

¹² Federation of Plastering and Drywall Contractors Diverting Plasterboard Waste from Landfill in the UK-June 2006, page 21.



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. 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 space to accommodate the skip.¹³

The alternative collection system that could in the long run have the greatest potential is “the mosquito fleet”. This utilises small trucks, which collect the waste from sites and deliver, either to reprocessors or to waste transfer stations for onward transfer to reprocessors. The system is more adapted to SMEs and is widely used in the US where plasterboard recycling is at a more advanced stage.

In France and in Denmark, local public authorities have set up waste collection centres across the country. Only the general

public, SMEs and craftsmen can bring their waste to those centres. Today, in France, there are 150 centres already equipped to receive Gypsum plasterboard waste. The Institut Français de l'Environnement (IFEN) estimates that 55% of the Gypsum plasterboard wastes go through that waste collection system. The latter is definitively efficient and less costly for SMEs and the general public.

3. Closed-Loop Recycling of Gypsum Off-Cuts from New Construction Sites

Introduction

¹³ Federation of Plastering and Drywall Contractors Diverting Plasterboard Waste from Landfill in the UK-June 2006, page 36.

Technically, it is possible to recycle unused construction plasterboards or Gypsum blocks, if not contaminated with other products. The paper content limits the amount of recycled Gypsum allowed in new plasterboard because paper content affects its fire rating.



Construction Waste Scraps

Gypsum products can be counted amongst the very few construction materials where **“closed-loop” recycling** is possible, i.e. where the waste is used to make the same product again and not merely recovered for use in other “down-cycling” applications, e.g. waste concrete and bricks used for aggregates in road construction. Gypsum as such is 100% and eternally recyclable. You can always reuse Gypsum because the chemical composition of the raw material in plasterboards and blocks always remains the same. The reprocessed Gypsum powder recovered by the recycling companies makes up approximately 94% of the Gypsum construction and demolition waste. This reprocessed Gypsum is sent back to the plasterboard manufacturers for producing new plasterboards. The paper used in the production of plasterboard (which is already recycled paper), with related contaminants, can be reused in various ways, amongst others for composting, heat generation, building materials, etc. This material constitutes approximately 6% of Gypsum waste.

Gypsum Recycling

Therefore, the Gypsum industry estimates that once reprocessed, the Gypsum off-cuts should be classified as secondary products. In these circumstances, the construction and demolition materials have been a waste, but have ceased to be a waste once they have been reprocessed.

Reprocessed Gypsum

The costs involved in the **transport** of Gypsum scraps from construction sites to Gypsum plants or recycling companies can be high, such that some users have been reluctant to participate in recycling schemes. However, a successful scheme to recover and recycle ‘construction’ Gypsum waste has been introduced in the Netherlands and in Scandinavia. Selective collection seems to be economically viable

within a maximum radius of 200km around the recycling plants, as transport costs are likely to prove uneconomical over greater distances. One should also consider the distance from the collector site to the recycling site compared to the closest landfill. On average, the proportion of transport cost represents less than 15% of the total cost when you landfill your wastes. Today, wood travels from the area of Lyon to Milan which is over 400 km for a 4 to 6 €. This illustrates that when the price of landfill is high, and you have to sort anyway, the distance is less of an issue. In France, the latest offer of a haulier for a 500km distance is as low as 7€ per tonne per 100 km.



The key factors for success in recycling scraps from construction sites are:

- The establishment of accurate specifications for recyclable waste (which must be “clean”);
- Strong consciousness raising and training of the various people involved before the start of construction;
- Source segregation: to segregate on the building site might in some cases be difficult. However, the collectors take all the C&D wastes and separate them on their site by different means. The plasterboard waste fraction can then be sent to Gypsum recycling facilities;
- The separate storage of the waste on the building site for later sorting;
- Strict obedience to the rules on the building site.

The Economics of Gypsum Recycling

Evaluating volumes and recycling potential for Gypsum waste recycling is still quite an imperfect science. However, there are ways to estimate how much waste the industry generates and it is then possible to evaluate the potential for reduction, reuse or recycling. In any case, evaluating the Gypsum waste stream can be a challenge due to the various ways it can be measured - weight or volume. Both are acceptable methods, but the numbers could be deceiving.

Take, for example, cardboard and plasterboard. A cubic meter of cardboard will only weigh about 13 kg while a cubic meter of drywall will weigh about 180 kg. Therefore, a "full" 27 meter container filled with cardboard will only weigh about 400 kg. A 27 meter container full of shingles or drywall will weigh 5 tonnes.

In Europe, the Gypsum plasterboard waste arisings have not been monitored and hence the absolute trends in waste arising cannot be scientifically quantified. The other factors influencing the economics of recycling include:

- sorting and storage space;
- contamination;
- transportation;
- regulations (processing, air, water, disposal, storage, etc.), and
- market availability.

Gypsum waste must be processed to market specifications. Specifications vary by market type but will typically include: separation from other wastes and removal of contaminants (nails, staples, plastic, shingles, etc.). Some markets will also require processing through grinding and chipping.

New construction materials are more readily recycled than demolition or renovation wastes which are more difficult to separate, resulting in higher contamination levels. The amount of contamination is a key factor in determining market acceptance. Once it is clear that materials can be separated to maintain quality for a particular market, the transportation costs and regulations concerning storage or processing of those materials need to be weighed-up. But, partnerships built-up with designers, recyclers and others will help to overcome such obstacles and lay-out the necessary procedures for a successful recycling operation.

In the end, assuming there are available end-uses for the recovered materials, the immediate recycling of Gypsum debris makes economic sense if the total net financial cost of recovery is less than the cost of land-filling.

The implementation of the Commission decision on the waste acceptance criteria is still relatively recent, so as yet it is difficult to see if the cost of land-filling Gypsum waste has sharply increased or not as a direct result of the change in the waste acceptance criteria.

Recycling Techniques

- Recycling of plaster block waste is achieved by crushing then by batching the Gypsum. Plasterboards off-cuts can be recycled and reprocessed if they are free from contamination.
- Depending on the processes involved and the intended use, recycling waste from plasterboard involves the following:
 - Either prior separation of the carton liner from the hydrated plaster;
 - Or fine crushing before the plaster is separated from the carton liner fibres.In either case, a certain percentage of carton liner fibre will remain in the final product (which can only be used for manufacturing plasterboard).
- A third way is to crush finely without separating, thus achieving complete recycling of the plasterboard.

Who Recycles the Off-Cuts from New Construction Sites?

There are currently two recycling routes:

- Private recycling companies operators
 - The two main European recyclers operating since 2000 are:
 - **Gypsum Recycling International (GRI)**, subsidiary of NKR demolition Group, the largest demolition company in Scandinavia;
 - **New West Gypsum Recycling Inc**, a Canadian Company.
 - The recycling companies have taken four approaches to the location of their facilities:
 - Near Plasterboard mills (New West Gypsum recycling)
 - Mobile Recycling plants (Gypsum Recycling International)
 - Near Construction and Demolition waste arisings (Plasterboard Recycling UK)
 - Extension of existing facilities (Roy Hatfield Ltd)
- The Gypsum manufacturers themselves
 - Nearly all the Gypsum manufacturers have internal recycling facilities. No new factory is designed without this. The aim of these 'recycling facilities' is to prevent waste as part of the production process.

Overall the existing recycling facilities enable 5 – 15 % of Gypsum based production to be recycled depending on the recycling technique (with or without paper separation). In some factories, the capacity is not entirely used and could potentially be supplemented with off-cuts from new building sites.

VI. Recycling of Demolition and Renovation Gypsum Waste

Demolition and renovation waste is a more complex problem with additional contamination to remove (paper, paint, screws, wood, nails, etc.).

The following contaminants need to be considered:

- Nails should be removed before processing;
- Tape breaks down in compost or can be screened out;
- Paint usually covers demolition plasterboards.

Demolition Gypsum Scraps

Technically, waste plasterboards can be recycled for non-agricultural markets according to the above-mentioned techniques. Some Gypsum producers are able to perform removal of metals (nails) from the demolished plasterboards in their internal recycling facilities. In any case, the competitiveness of Gypsum recycling will depend on logistics, collection and recycling costs, compared to landfill costs.

Over the next 20-30 years the economics for demolition waste are expected to change as the quantities begin to increase substantially, due to the strong increase in the use of plasterboards in construction which began in Europe in the 1960s and 1970s. Renovation and demolition work will see increasing volumes of Gypsum waste. The increasing use of dismantling or deconstruction techniques will increasingly make possible demolition collection and recycling.

Plasterboard recovery (collection and recycling) is more frequent on large construction sites but less frequent on demolition sites for the following reasons:

- Although plasterboard was invented in the USA in the late nineteenth century and was widely used there by the 1930s, it only gained widespread acceptance in Europe – at least in Continental Europe – in the 1970s-1980s. Even now in Southern Europe, the more traditional ways of partitioning and interior finishing still prevail. This means that many buildings over 40 years old contain little or no plasterboard.
- In general, selective dismantling needs to be improved - notably in Southern European countries.

VII. Recycling for Other End-Uses (Open-Loop Recycling)

1. Land Treatment with Benefit to Agriculture and/or the Environment

Clean production and construction Gypsum waste can be used for:

Soil enrichment for potatoes

The application of crushed Gypsum drywall waste was compared to commercial Gypsum fertiliser on potatoes in 1997 and 1998 on two irrigated, sandy soils and an irrigated medium textured soil in Wisconsin (US). The application of drywall or commercial Gypsum fertilisation did not significantly affect potato yield, grade or grade-out of USA tubers, and showed increased storage life of potatoes and reduced diseases.

Soil conditioner/amendment¹⁴:

- Improves water penetration and workability of impermeable sodic 'alkali' soils
- Softens soils with a high clay content
- Helps neutralise soil acidity
- Adds plant nutrient: Calcium and Sulphur

It is used in:

- General agriculture
- Forestry and mine reclamation
- Residential lawns (sod)
- Compost additives
- Mushroom growing (additive to black earth)
- City parks
- Golf courses

Agricultural fertiliser

Successful full-scale trials were carried out in 1995 and 1996, in Sweden and Denmark respectively. Garden and park waste was composted together with clean crushed plasterboard. The composting breaks down any paper and organic materials in the

¹⁴ Gypsum Waste as Soil Amendment-Hugh Riley, *Planteforsk-2001*. Norwegian. Gypsum Waste in compost (Norwegian)-Erik Norgaard, *Norsk Jordforbedring-2002*.

waste plasterboard. Care is needed to avoid anaerobic conditions and the white-coloured end-product may reduce its marketable value.

In the US, the Clean Washington Centre established in 1997 that Gypsum wallboard can be successfully incorporated into the composting process without hindering end-product quality. As with all composting operations, aerobic conditions must be maintained (through aeration or mix porosity) in order to limit odours. Product end-use, process control and grinding optimisation efforts are important factors affecting successful incorporation of Gypsum wallboard into a compost operation¹⁵.

2. Sub-Soil Amendment on New Residential Construction Sites

In the USA, if a beneficial use can be demonstrated, e.g. of sub-soil arising during the construction process, pulverised scrap plasterboard can be spread around family home construction sites. The US Gypsum Association recommends the following procedures of job-site new construction waste plasterboard on residential building lots based on information derived from scientific studies:



- Waste Gypsum board to be disposed of on-site should be pulverised so that all pieces on the soil surface, including paper, will disintegrate in a reasonable period of time under local precipitation levels and other climatic conditions. This suggestion generally means that all pieces of waste gypsum board, including paper, placed on a residential building lot will be equal to, or smaller than, one-half-inch square or in diameter.
- Pulverised waste Gypsum board may be placed on the soil surface or mixed with the top layer of the soil.

¹⁵ Evaluation of the potential for composting Gypsum wallboard scraps (RETAP-US-1997).

- Waste Gypsum board should be spread evenly over the entire lot, where conditions of terrain and landscaping considerations permit.
- Application may be at rates up to the equivalent of 22 tonnes per acre.
- Pulverised waste Gypsum board should be disposed of only on lots or in areas that have adequate drainage and aeration (i.e. no standing water or anaerobic conditions should exist until the waste Gypsum board has completely disintegrated).
- State, local and federal regulations and statutes should be considered so as to ensure compliance with all environmental and other governing ordinances and rules that allow these types of utilisation for waste Gypsum board or, if special permission is necessary, to dispose of construction waste Gypsum in this manner.

3. Others

- Additive for cement production: however, the recycled Gypsum paper content should not be more than 1%. If it is, then it needs to be mixed with virgin Gypsum. However, possible risks to concrete performance from use of plasterboard waste have yet to be properly ascertained;
- Admixture for concrete;
- Agent for settling dirt and clay particles in turbid water;
- Additive to sludge for bulking and drying;
- For combination with wood shavings for animal bedding, as substitute for sawdust or sand to absorb moisture;
- Gypsum has moisture-absorbing characteristics and may be used for drying: e.g. sludge from municipal and industrial wastewater treatment plants;
- Gypsum can be used to absorb grease spills: e.g. grease absorbent for mechanic shop floors;
- Athletic field marker;
- Salty soil treatment: recycled Gypsum can be used to facilitate the leaching-out of sodium salt in soil along roads where salt is placed during winter;
- Manure treatment: recycled Gypsum can be mixed with animal waste to combine with Ammonia to reduce odour.

VIII. Incineration

Municipal Waste Combustion Plants

Plasterboard is rarely incinerated since Sulphate may be converted to Sulphur Dioxide gas. High Sulphur Dioxide concentrations in stack gases reduce the ability of alkaline scrubbers installed on municipal incinerators to remove other acidic gases, such as Hydrogen Chloride. This results in higher emissions of Hydrogen Chloride and other acid gases. Inclusion of Gypsum waste in municipal waste for incineration will create similar problems.

This is an excellent driver to separate the plaster from C&D waste.

IX. The Management of C&D Waste (EWC 170701) containing Gypsum

Gypsum is also used in other construction industries, mainly in the production of cement, in ceramics, in floor screeds, and thus needs to be treated at the end of life.

Around 80% of demolition waste is inert rubble (largely concrete and masonry) which can be potentially recovered for recycling into aggregates for a variety of applications, mainly in civil engineering. This inert rubble is first sorted to remove as much non-inert material (like Gypsum) as possible. It can then either be used in low-grade applications (e.g. general bulk, landscaping, ground consolidation, mine infill, embankments, road sub-base, etc.) or undergo further processing for higher-grade applications (such as road construction). Only small volumes of C&D derived aggregates are used in concrete production.

In Germany, mixed C&D Waste, which contains on average 5% Gypsum in volume, is crushed, ground and sieved to produce the following grades of fines:

- 16-32 mm, with virtually no Gypsum. Used in higher civil engineering applications, e.g. road bases;
- 8-16 mm, with very little Gypsum. Used in lower-end applications, e.g. road sub-bases;
- 0-8 mm, with max 20% Gypsum content. This is disposed to landfill.

Most countries have Gypsum content limits for the use of C&D waste derived secondary aggregates.



Permitted Gypsum content in C&D waste derived secondary aggregates.

Country	Mixed aggregates	Concrete aggregates
Germany	<1% SO ₃ content	<1% SO ₃ content
France	<1%	Virtually 0%
UK	n/a	<1%
Belgium	<1%	<1%
The Netherlands	<1%	<1%
Italy	<1%	<1%

Industry Best Practices

I. The Netherlands

Since 1999, the Dutch government has been exerting pressure on industry to reuse scrap from construction sites. Disposal costs, particularly for Gypsum scrap, have increased considerably⁶.

The Dutch Gypsum Association (NBVG) has made an opportunity of this challenge posed by the Dutch government and has developed the 4 in 1 container system. By arrangement, a 4 in 1 container is installed on the building site. This container is specially developed for the collection of the sorted:

- Gypsum scrap
- Paper
- Plastic
- Empty PUR-foam sprays/boxes

Full containers are collected from the building site by a logistics company. The Gypsum scrap is returned to the Gypsum producers to be reprocessed. Paper and plastic will go to other recycling companies and PUR foam boxes will go to landfill. When the separation of the materials is done properly, the system is cheaper than using normal open containers. Penalties are imposed when a contractor or sub-contractor uses the container in an improper way, which implies contamination of the different types of scrap.

16 Gips rest Stoffen Gooi je niet weg-Brochure-Nederlandse Branche Vereniging Gips (NBVG)-1999.

II. The Danish and Irish Recycling Programmes

The Danish programme started in Autumn of 2001 and entails collecting plasterboard scraps at collection points. Today, 500 collection points are serviced all over the country using two grabble trucks. 90% of all public waste cycling stations and civic amenity sites are now covered by the collection system and have containers. The coverage is still increasing.

This waste is recycled before being sent to the production facilities of plasterboard manufacturers.

A similar programme was set up in Dublin in Spring 2005. The system has been inspected by the Irish Minister of the Environment with great satisfaction. Most customers are from the greater Dublin area, but everyday the coverage of the system is expanding to other areas.

III. The UK Voluntary Commitment to Recycling Gypsum Construction and Demolition Waste

In March 2007, plasterboard manufacturers in Great Britain signed up to a trailblazing agreement that is set to bring a significant reduction in the amount of waste plasterboard sent to landfill.

The voluntary agreement was initiated and brokered by the Gypsum Products Development Association (GPDA) which, in Great Britain, represents Knauf Drywall, British Gypsum and Lafarge Plasterboard.

The GPDA approached the Department for Environment, Food and Rural Affairs (DEFRA) last year with an outline proposal and has since been working with WRAP (Waste & Resources Action Programme)¹⁷ and the government-funded Market Transformation Programme, to define the targets to which the industry will work.

¹⁷ Plasterboard Recycling-What is WRAP doing about Gypsum waste?
Recycling in Construction: how to segregate and recycle plasterboards-WRAP.

The targets are:

- to reduce the amount of waste being sent to landfill from UK manufacturing operations to 10,000 tonnes/year by 2010; and
- to increase the take back and recycling of plasterboard waste, for use in plasterboard manufacture, to 50% of new construction waste arisings by 2010.

In addition, all parties have agreed to work together to engage with the supply chain and develop a target to reduce the amount of wastage generated in new construction and to make further progress towards achieving the ultimate objective of zero plasterboard waste to landfill.



IV. The C&D Gypsum Waste Pilot Plant in Germany

Gypsum plasterboard and Gypsum fibreboard producers¹⁸ have signed a contract with Gesellschaft für die Aufbereitung und Verwertung von Reststoffen mbH (GFR: <http://www.gfr-mbh.com/>) to design and to run the first pilot plant that exclusively recycles Gypsum construction and demolition waste without any input of plasterboard production waste. The plant will be erected as a mobile unit with two collecting centres in the North and in the West of Germany. The system will go into operation in mid-2007 for a 2-year trial period with the intention to establish a sustainable continuous recycling option. The Gypsum Industry will fully financially support it over the trial period.

¹⁸ Merkblatt Gips Abfall Entsorgung-2005- German Gypsum Association and «Recycling of Plasterboards»-ZKG International n°5-2007-Heiner hamm, Rolf Hueller, Lörg Demmich.



Conclusions

The economics of Gypsum waste products recycling will critically change in the near future, due to scarcity of landfills able to receive non-inert waste and to much higher landfill costs and taxes. The demand for more environmentally-friendly products is also increasing, both from the government side and the customer's side, who are demanding that a waste solution for the construction off-cuts be provided and that this solution does not mean landfill.

One element of "closing the loop" on Gypsum waste is the use of **higher recycled content** in the production of new products. Thanks to its recyclability, Gypsum products will indeed be increasingly manufactured with a percentage of recycled content (100% recycled content paper backing and a minimum of 5% recycled material).

So, the pressure is on and the Gypsum Industry needs to be able to provide a response by increasing the C&D waste being recycled.

To be successful in recycling C&D Gypsum waste, we need the involvement of several players:

- Contractor and sub-contractor: for careful deconstruction and sorting;
- Collector: for effective logistics;
- Recycler: for a separation of paper-liner and gypsum-core, allowing a high recycling ratio;
- Plasterboard producer: for reintroduction of Gypsum waste into the process;
- And local authorities, to control how the law is applied!

To achieve a high rate of recycling, the Gypsum Industry needs in practice to combine its expertise in plasterboard production with third-party expertise in sorting, collecting and recycling Gypsum waste.

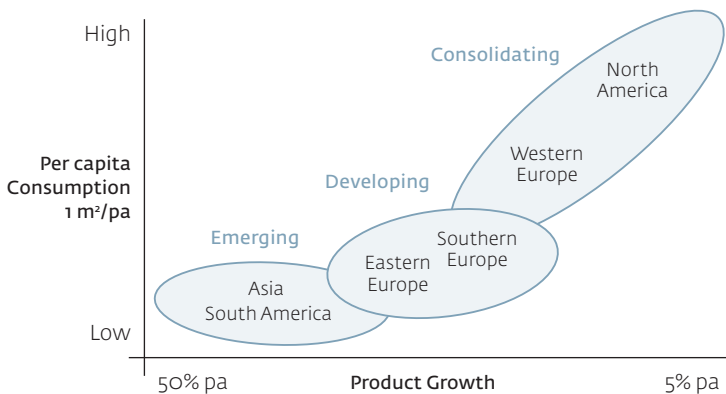


ANNEX I: Gypsum Products Markets

Emerging, Developing and Consolidating Markets

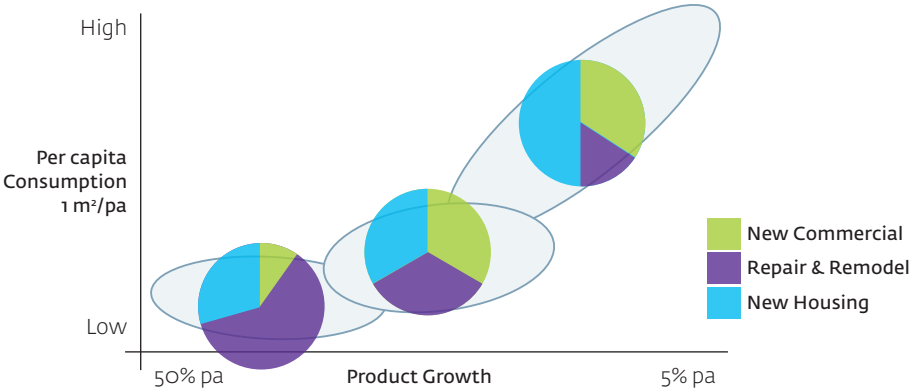
Around the world today there are three types of markets for Gypsum products. In North America, Australia, Japan, NW Europe and Scandinavia, Gypsum board systems have taken over as the dominant building product for interior lining of residential and commercial construction. In Southern and Eastern Europe, Gypsum board is gradually replacing Gypsum (or cement) plaster as the preferred interior lining system. For the remainder of the global market, Gypsum board has only recently been introduced as a new building material, in many cases replacing ancient materials, such as mud bricks. These represent an evolving global marketplace, with the three stages termed Emerging, Developing and Consolidating by one of the major suppliers. In terms of penetration rate, Figure 2 illustrates these three stages and the areas of the world that fall into each. The market use of the Gypsum board products differs in each of these types of markets as shown below in Figure 3.

FIGURE 2: **Emerging, Developing and Consolidating Markets for Gypsum Board**



As Gypsum board is introduced into new markets, the first application is primarily in new non-residential construction. New office construction and resort hotels built using western building techniques are often the first major consumers. As the market becomes more developed, both residential construction and the renovation market grow in importance. In a well-developed market such as North America, the renovation market will approach 50 percent of the overall market.

FIGURE 3: Per Capita Consumption of Gypsum Board



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