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Experience in gypsum recycling on three continents

Everywhere in the world the pressure to decrease disposal of waste at landfills and increase recycling activities is becoming stronger and stronger. Although recycling activities covering construction and demolition (C&D) waste have grown significantly in the past decade, gypsum plasterboard waste was until recently in virtually all countries one of the most important fractions from C&D, if not the most important fraction, that was not recycled. As a consequence, approximately 10Mt of plasterboard waste was landfilled in 2006 around the globe. If this waste was recycled instead, the plasterboard industry would get access to 10Mt of high quality raw materials at prices much better than that of virgin materials.

Plasterboard recycling has been established on three continents of the world: Europe, North America and Asia. The conditions for establishing plasterboard recycling systems are not the same on the three continents, and not even within the countries of each continent, as described in detail in this paper. Consequently, plasterboard recycling has only been established in some countries, but alone the extraordinary success and growth of the plasterboard recycling system from Gypsum Recycling International, offering a win-win partnering model to the plasterboard industry, has assured that plasterboard recycling is now occurring in 10 countries. The continued pressure and support for recycling from the authorities, the public and the plasterboard users combined with the win-win model from GRI will assure the continued growth and spreading of plasterboard recycling to new areas and countries. But, in fact the most important driver for the growth of plasterboard recycling might be the climate change which will dictate to governments all over the world to avoid landfilling of waste due to the creation of the greenhouse gas methane, which is 20 times more damaging to the climate than $C0_2$. As a consequence, more and more recycled gypsum made from plasterboard waste will be available in the years to come. If the plasterboard industry does not seize this opportunity other users of gypsum raw materials and the plasterboard industry will end up as the minor beneficiary of such materials, exactly as it is already on the way to happening in the UK today.

Below: Gypsum Recycling International's XL recycling unit model: the biggest plasterboard recycling unit in the world, but still mobile on two trailers. It can be transported everywhere in Europe and North America. Capacity: 200,000t p.a.

Introduction – plasterboard recycling on three continents

When Gypsum Recycling International (GRI) first had the pleasure of presenting the possibilities of recycling plasterboard waste at the Global Gypsum Conference 2003 in Barcelona, plasterboard recycling as well as GRI had a relatively short life story. In Barcelona, GRI launched its win-win business model to the plasterboard industry internationally. Since then there has been a rapid development.

The win-win business model combined with GRI's ability to produce a recycled gypsum powder 99% as good as virgin gypsum raw materials and continued pressure on the industry to become engaged in recycling of plasterboard waste has led to an unprecedented growth of GRI and the plasterboard recycling activities: Thus, today GRI is active on three continents and it is the experience from plasterboard recycling activities on these continents that is the topic for this article.

However, before that, just a few words on what made this extraordinary expansion possible.

Expanding plasterboard recycling activities to three continents

Three factors have laid the foundation for this extraordinary growth: The complete high quality system GRI has developed, including an own specialised collection system, the win-win business model offered to the industry and the mobility of the recycling technology used by GRI.

Win-win business model: GRI's offer to the industry is that GRI will take care of all aspects of establishing the recycling system. The only thing the industry will do, is to use the recycled gypsum powder which GRI

The expansion of GRI's plasterboard recycling activities	
• Denmark, 2001	• UK, 2005
• Sweden, 2003	• USA, 2005
• Norway, 2003	• Belgium, 2006
• Holland, 2004	• Switzerland, 2007
• Ireland, 2005	• Japan, 2007

will sell at a price well below that of virgin gypsum raw materials. The industry does not have to make any investments to become involved and furthermore get the benefit of an improved environmental image by becoming involved. With such clear advantages to the industry, it is of little surprise that GRI since 2003 have been able to sign long term cooperation agreements with all the five leading plasterboard groups in the world.

Complete high quality system with its own specialised collection system: GRI's complete system for plasterboard recycling consists of the mobile recycling units together with its own specialised collection and connected logistic system. The mobile recycling units can recycle gypsum based waste into a reusable gypsum powder which is 99% as good as virgin gypsum raw materials, and the recycling units can recycle any type of gypsum waste:

• new construction waste as well as reconstruction and demolition waste,
• dry waste as well as wet waste.

The specialised collection and logistic system developed by GRI assures that GRI - very cost efficiently - can take care of the waste from the site where the waste was created until it has been recycled into a reusable gypsum powder. The system consists of dedicated plasterboard recycling containers and specially developed grab trucks which can pick up the waste from the dedicated containers.

Mobile recycling equipment: As the recycling units from GRI are mobile, expanding the system to cover new areas is relatively straightforward once a mobile recycling unit has been located on a continent. Thus, as the recycling units can be dismantled in a few hours and transported anywhere within a couple of days within the continent where the unit is active, GRI have been able to - and can continue to - start up recycling of plasterboard easily in any part of Europe, North America and/or Japan. Using Europe as an example, having established the system in Holland in 2004, it was easy for GRI to start the recycling system in Belgium in 2006, just by opening up another warehouse located there. Similarly, having established the system in Massachusetts, it is easy to expand the system to cover New York, Washington or Miami, simply by opening up a new warehouse and relocate the recycling unit to that warehouse once it is full of plasterboard waste ready to be recycled.

Plasterboard recycling in Europe

The general attitude of the authorities in Europe, mainly expressed through the European Union (EU), is that recycling should be supported and that it should be avoided that gypsum waste is landfilled. This is due to the potential for creating hydrogen sulphide gases in the landfills if mixed with organic waste. Therefore the EU decided that plasterboard waste should only be disposed of in landfills in special cells, where no organic waste must be present, at the 'non inert – non hazardous' landfills. This principle was decided back in 2002 in the EU Directive 33, which the EU member countries had until the summer of 2005 to implement.

However, most countries have been delayed in implementing this directive and due to this and the fact that Europe is a big continent, the conditions for establishing profitable plasterboard recycling systems varies from country to country. So does the attitude of the plasterboard industry.

Roughly speaking, Europe can be subdivided into 5 larger areas where the conditions are more or less are same:

• Scandinavia
• Holland, Belgium, Switzerland and Austria
• UK and Ireland
• Germany, France, Spain, Portugal, Italy and Greece
• Eastern Europe

Below: The special developed gypsum waste recycling container. The front lids allow the users to load the waste more easily.

Scandinavia

Scandinavia has always been known for its focus on recycling and thus it is of little surprise, that plasterboard recycling has become very successful in Scandinavia after GRI introduced it there. A vast amount of waste is now diverted away from landfills and reused instead, and recycling rates ranging from 30-70% is achieved.

Above: Special grab trucks collect the plasterboard waste from the containers thereby saving transport costs.

The recycling activities are assisted by general taxes on landfill and there is a positive attitude of the population towards recycling, despite the fact that most countries in this region have not yet implemented EU Directive 33. Also the general consumption of plasterboard is quite high. Public recycling centres (at no cost to the general population, but charge for smaller amounts of commercial waste) therefore play an important role as a supplier of materials and so do building sites, as segregation at source (on the building site) is quite common.

The plasterboard industry has been very supportive in getting the recycling system established. The companies have cooperated together to increase the likelihood of success for the recycling efforts. They now benefit from this support and receive all the materials that are made from recycling of plasterboard waste. Up to 20-25% of the plasterboard manufacturers' needs for raw materials are now covered by recycled materials. As a consequence of this, GRI has moved from being a marginal supplier, that was 'nice to have' mainly due to the improved environmental image this gave the industry,

Right: GRI's first mobile recycling unit: the SM Model, on one trailer (24*3*4m).

Below: Dedicated plasterboard recycling container on a buidling site in Scandinavia, where the plasterer makes the segregation.

into being a strategic or 'need to have' supplier.

Holland, Belgium, Switzerland and Austria

Although the recycling culture is not as developed as in the Scandinavian countries, the general attitude of these countries is very pro-recycling and the governments are very supportive of establishing recycling programmes. Despite this, none of the EU member countries among these has implemented EU Directive 33 in time.

Public recycling centres exist and are generally at a quite high level, but in these countries the general population typically have to pay to use them. Also most often commercial waste is not accepted at such facilities. Consequently although they do play a role as suppliers of plasterboard waste for recycling, they do not play the same important role as in Scandinavia.

The consumption of plasterboard is somewhat lower than in Scandinavia and the segregation at source on the building sites is not so frequently occurring.

Taxes are levied on landfilling in all of these countries, with Holland having the highest tax of all the European countries. However, to a certain extent, with Holland as the most influenced, they are all negatively influenced by the so-called 'escape-route' where waste is exported into Germany, and put into old salt mines with virtually no disposal cost. The governments of these countries are generally against this behaviour which seriously jeopardises the ability for recyclers to compete, but have so far not been able to do much about it due to the EU rules of free movement of goods (including waste).

Consequently, recycling of plasterboard waste has not yet reached the level in Scandinavia, and in Austria it has not happened at all. The industry, and there is typically 1 or 2 plants in every country, is generally positive towards recycling, among others due to the pressure from the customers and the government, and in most countries they have tried to cooperate about the recycling.

The limited amount of plasterboard waste that is recycled ends up at the plasterboard plants due to their positive and cooperative attitude.

UK and Ireland

UK and Ireland are perhaps the countries in Europe undergoing the greatest changes with respect to recycling in these years. From having been far behind continental Europe both countries are catching up very fast. The governments are supporting recycling strongly with grants, aids, stronger enforcement of rules, increased taxes on landfilling etc. The general attitude towards recycling is improving significantly each year.

However, both countries are coming from a modest level so it will take some more years before they reach the level of Scandinavia and continental Europe. The consumption of plasterboard is very significant and therefore there is a large volume of waste available for recycling. Plasterboard recycling is occurring in both countries, but as a percentage of the plasterboard industry's raw material need the supply of recycled materials is still of limited importance.

Some factors are limiting the ability of the recyclers to succeed:

- Limited segregation at the site where the waste was created,
- use of builders' skips instead of waste containers,
- transfer stations/sorting facilities with limited segregation,
- wrong implementation of EU directive 33,
- and the plasterboard manufacturers have expanded their competitive playing field to include the waste area.

As limited segregation is happening on the building sites, most plasterboard waste comes into transfer stations/sorting facilities in mixed waste containers, and typically a 'builder's skip' only containing $10m^3$ or so is used instead of a waste container with $30m^3$. This fact alone makes recycling difficult as transport costs using such small skips are very high.

As plasterboard waste easily breaks up and disintegrates and as the transfer stations do not have that advanced technology, it is virtually impossible to segregate out the plasterboard waste at the facilities if it comes in mixed waste skips. Consequently, most – if not all – plasterboard waste coming into such facilities ends up in landfills just as before. This is occurring despite the fact that both countries have implemented EU Directive 33, but they have not done it correctly and the UK has even generated its own invented 'escape clause' allowing plasterboard waste to go into general landfill as long as it makes up less than 10% of a load. This is not in line with the directive.

On top of this, the plasterboard manufacturers have

Above: Dedicated plasterboard recycling container at a public recycling centre, where the public makes the segregation.

Below: Recycling culture in Ireland. Builders' skips are used... or the waste is just dumped on the ground!

seen waste as a chance to improve their offering and beat the competitors, so instead of working together on improving recycling in total, they have primarily focused on how they could offer their customers certain waste recycling services, that the other manufacturers can not. And 'obviously' such a service is only made available for waste arising out of use of their own products.

This is not in line with the government's intentions to increase recycling, and especially the UK government is set on making this happen. The landfill tax in the UK is destined to go up from US$47.76 (Euro35.13) per ton in 2007 to US$111.44 (Euro91.95) per tons in 2011, which will make UK have the highest tax of any country in the world. Recycling rates are therefore bound to increase significantly in the UK in the years to come.

The attitude of the manufacturers, which makes it difficult for recyclers to depend on cooperating with them, have led to a 'new' development, where the plasterboard manufacturers are not the only receivers of the recycled market waste. If not already, then due to the significant growth expected for recycling in the UK, the plasterboard industry is likely to receive less than 50% of the recycled materials in the future!

Germany, France and Southern Europe

Although the recycling attitude of Germany is well known and at a high level, Germany has - due to the use of salt mines to dispose of plasterboard waste - been located in this group of countries where the conditions for establishing plasterboard recycling is getting better but is not at a level yet, where really profitable recycling of market waste can be established.

For the other countries in this group the recycling culture is not that developed and the general waste infrastructure is far less developed than in other areas of Europe. Consequently the use of waste sorting facilities, waste segregation at site etc. is well below the level found in the other regions. Likewise the tax levied on waste going to landfill is limited and so is the implementation of EU Directive 33.

The attitude of the plasterboard manufacturers are positive at least in Germany and France where they would like to get recycling started, but due to the conditions for recycling they are struggling to find a way to get it done. The manufacturers see recycling as a new source of materials, as they are concerned about the lack of sufficient low cost FGD/DSG in the future.

Eastern Europe

The former East European countries are all characterised by having a relatively low cost for waste disposal and a limited recycling culture. As a consequence, no plasterboard recycling activities have been established.

Plasterboard recycling in North America

Similarly to what was found in Europe with the EU Directive 33, there is one common trend influencing all states in North America with respect to plasterboard recycling, which is the LEED Programme. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ is a nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED promotes a whole-building approach to sustainability by recognising performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

The building projects are rated according to how many points they have achieved in the 5 areas, and points are given for recycling of the building waste, including plasterboard waste. The LEED Rating System was created to transform the built environment to sustainability by providing the building industry with consistent, credible standards for what constitutes a green building. The rating system is developed and continuously refined via an open, consensus-based process that has made LEED the green building standard of choice for federal agencies and state and local governments nationwide.

Other than that, the conditions for plasterboard waste recycling varies significantly from region to region. North America can be broken down into the following regions according to the conditions present:

- The North West (including Western part of Canada),
- New England and the North East of the US and Canada,
- California,
- Florida,
- Other states.

Left: Recycling culture in the North East of the US. There is still room for improvement!

The North West (including Western part of Canada)

This region is the most mature region for plasterboard recycling in North America. It originally started as a result of the ban that the Canadian province British Columbia implemented back in 1984. Recycling then spread down the coast to the US, primarily to the states of Washington and Oregon. These states did not adopt a ban, but the support for recycling is probably not higher in any other states in the US. As landfill charges are high in these states, it makes economic sense to send the waste to recycling.

In the Canadian part the ban is still in place which forces the market to supply the waste to recyclers. As a consequence, the recyclers have to worry less about how to get it in from the market.

In the US part there is no ban, and consequently the recyclers cannot depend on the market delivering the waste to them. Instead they have to go out in the market and get the waste, and especially the so-called scrubber services are generating a significant amount of waste for recycling. A scrubber service is a 'clean-up and waste removal' service offered by independent companies specialising in sending in crews of primarily young low cost workers, that go through the building (typically domestic housings), clean up where necessary and take the waste with them out of the building into their small vans.

Different from the plasterboard recycling activities in Europe, in the US only waste from new constructions are recycled, as the manufacturers are afraid of the demolition waste due to possible contamination with asbestos, that was used in the joint fillers until 1973. As a consequence, no demolition waste is recycled.

The manufacturers' attitude towards recycling is generally positive, except for the demolition waste part. In the Canadian part the manufacturers are more or less forced to be so due to the ban, while the US manufacturers have become involved to obtain low cost raw materials, which is generally more attractive as most of them rely on relatively expensive imports from Mexico. Typically the recycled external waste makes up 10-15% of the raw material supply for the manufacturers.

New England and the North East of the US and Canada

In this area the attitude of the general public to recycle is generally positive and the disposal costs at landfills are significant. The construction industry is generally positive towards segregating out the waste at site, due to the lower cost offered by the recyclers and the LEED points they can make on sending the materials for recycling. However, the recycling culture is not yet as well established as in Europe, which means that the quality of the segregation puts high demands on the recyclers ability to remove contaminants from the waste, such that a high quality of recycled material can still be made.

Furthermore as the states in this area have had severe problems with hydrogen sulphide gases allegedly created by plasterboard waste at the landfills, the authorities have been pushing for establishing recycling systems, even threatening to ban the plasterboard waste from landfills in certain states.

Plasterboard recycling systems have so far been established in Toronto, and Boston/Massachusetts and to a lesser extent in Pennsylvania. In Toronto and Boston the recycled materials all end up with the plasterboard manufacturers, whereas the materials in Pennsylvania - having a lower quality - are used for agricultural applications.

Only new construction waste is accepted for recycling due to the fear of asbestos in demolition waste. The manufacturers are generally very positive towards recycling and see this as an opportunity to get lower priced raw materials at the same time as they are improving their environmental image.

California

The attitude of the general population to recycling is quite positive and in some parts of California the landfill charges are also at such a level that some plasterboard recycling can exist profitably, although the extent is still limited. Due to the size of California, no state wide programmes exist.

The manufacturers have not been that interested in getting recycling systems up and running, as they generally are benefitting from already relatively low cost of their raw materials due to the proximity to Mexico. This combined with the lower quality of the recycled materials have made the recyclers find alternative markets for their recycled materials, primarily in agricultural applications.

Below: Delivery of new construction waste plasterboard by container truck at GRI's Boston facility.

Right: Recycling in Japan - limited space makes source segregation more difficult.

Florida

Due to severe problems with hydrogen sulphide gases at the landfills in Florida allegedly caused by plasterboard waste and the climate conditions there, the interest from the authorities to get plasterboard recycling started in Florida is very high. However, as landfill charges are still modest, except for a few trials no real plasterboard recycling is occurring.

Other states

All other states in North America are characterised by having a relatively low cost for waste disposal and a limited recycling culture. As a consequence, no plasterboard recycling activities have been established there.

Plasterboard recycling in Asia

The conditions for establishing plasterboard recycling systems in Asia varies a lot from country to country that one can hardly speak about general conditions which are influencing the possibilities in all countries in this region.

However, one country stands out, where the conditions for establishing plasterboard recycling systems are present: Japan.

Japan

The attitude towards recycling is generally very positive in Japan and the disposal costs at the landfills are high. Disposal costs are driven up by relatively few landfills available compared to the population and the governments policy of only landfilling plasterboard waste at the most advanced and expensive landfills.

The construction industry is generally positive towards recycling as a method to drive down their otherwise high disposal costs. However, due to limited space at building sites in the major cities, source segregation is not always happening. When source segregation occurs, primarily small containers are used again due to the limited space available. As a consequence transport costs make up a large part of the waste disposal costs. The plasterboard manufacturers in Japan, and there are only two of them, have been positive towards recycling in the sense that they have become (minority) share holders of the first Japanese plasterboard recycler, that was established in 2003, mainly by one of the leading construction companies.

Below: Typical Japanese waste container for source segregated waste, only 4m^3.

However, despite the fact that the waste market is very significant in Japan, the first Japanese plasterboard recycler has not expanded its business or started up in other cities than Tokyo.

The main reason seems to be the unusual high cost involved in the Japanese solution. An investment of several million US$ seemed to have been necessary for the first Japanese plasterboard recycler, and the technology requires a lot of space and up to 10 operators to produce a volume similar to what GRI can do with just 1 operator.

Obviously such high investment costs and space requirements are not beneficial for the expansion of the system and as the plasterboard manufacturers on top of that seem to have demanded payment for accepting the recycled waste, the business model of the first Japanese recycler is not that attractive.

This is likely the main reason why the second Japanese plasterboard recycler will be based on technology supplied by GRI!

Other countries in Asia

Although the fast growing economies of Hong Kong, South Korea, Taiwan, Singapore, China etc. make these countries resemble Japan in a lot of other respects, when it comes to plasterboard recycling they are far behind Japan and the very low disposal rates at the landfills alone make it impossible so far to get recycling up and running. If Hong Kong is used as an example, the disposal rate of waste at landfills in Hong Kong is less than US$20/ton, despite the fact that space is very scarce and that there is an over-production of waste. The government is very interested in increasing the recycling rates, but as long as the disposal costs are so low, it will probably not happen.

As can be seen from the overview, several factors have to work in the same direction to assure that high recycling rates are obtained.

First of all source segregation at the building sites is a major contributor to securing the success of plasterboard recycling systems, and this requires the cooperation of the construction industry. Such cooperation is likely

only to happen – due to the many other concerns when a building project is ongoing – if the construction industry can save costs by participating in recycling or is 'pressured' by the regulations (LEED or EU directives)/ the owners/the general population/or the government to participate. The UK is a good example of the difficulties in getting plasterboard recycling systems up and running, when there is only limited source segregation occurring.

Secondly and linked to the first, plasterboard recycling is much more likely to have a chance of being implemented if there already is an established recycling culture in the area, as this will increase the pressure mentioned above. This is evident from the Scandinavian experience, where very high recycling rates have been achieved fast.

Thirdly, as even an already existing strong recycling culture generally is not enough to motivate the industry participants to really become involved with recycling, the alternative cost for disposal at landfills needs to be high, whereby all involved with the recycling can obtain economic savings by participating. Germany is a very good example of this, as it is virtually impossible to get plasterboard recycling up and running in Germany, despite good support from the culture and the general population, simply because the waste can be disposed of cheaper in the salt mines. The rule seems to be that no matter how environmentally friendly the industry participants want to be, only monetary concerns can really move the volume. However, if savings can be obtained then recycling of plasterboard waste will occur, also without a well established recycling culture, as can be seen for instance in the North West of the US. And likewise it can be seen that no recycling is occurring in the areas where the cost of the alternative disposal at landfills is low.

Fourthly, the plasterboard manufacturers need to have a cooperative spirit towards recycling to assure high recycling rates and that the manufacturers will end up as the receivers of the recycled materials. The UK case is illustrative of what can happen when the manufacturers try to expand their competitive playing field to waste also. This has a direct negative impact on the amount of waste being recycled and will most likely also lead to the manufacturers ending up only as a marginal receiver of the recycled materials, as the recyclers will find other and more supportive users of the materials. The same has happened in California due to limited support from the manufacturers.

In Japan where some manufacturers have tried demanding a gate fee for receiving the materials, obviously such attitude has had a negative effect on the ability to establish plasterboard recycling systems.

Fifthly, despite the current difficulties in achieving high recycling rates in some areas of the three continents it can safely be concluded that plasterboard recycling rates will grow significantly in the years to come. The governments on all the three continents seem set on increasing recycling and they will use their powers in the form of laws and regulations to see this materialising. The recent decision by the UK government to implement the highest tax on landfilling in the world is an example of this, the EU directives where gypsum waste is particularly targeted and the state of Massachusetts' wish to start banning landfilling of plasterboard waste in 2008 are other good examples.

Above: Handing over a GRI recycling unit to the Japanese partners.

Closing remarks – climate change

The win-win model offered to the plasterboard manufacturers by GRI together with GRI's complete and mobile system for plasterboard recycling has secured an unprecedented growth for GRI and in the expansion of plasterboard recycling activities to three continents.

This together with the political intentions (based on the publics' general support for recycling) evident on all three continents to increase recycling in the time to come will lead to significant increases in the amount of plasterboard waste being recycled in the future on all the three continents.

However, there might actually be a new 'driver' much stronger than the desire to recycle that will determine the developments in the years to come: global warming and climate change.

Global warming and climate change is perhaps the single most important issue that is occupying the authorities all over the world today. Whereas it is widely spread recognised that global warming is caused by greenhouse gases (among other CO_2) trapping the heat from the sun inside the earth's atmosphere, it has just begun to come to the attention of the authorities that CO_2 is not the only greenhouse gas worth paying attention to. Methane gas is another, especially as 1t of methane gas makes the same damage as 20t of CO_2, and consequently methane is responsible for 10% of the global warming and climate changes that occur.

As landfills are the main producer of methane it is evident that we will see authorities implementing strong measures to avoid landfilling of any kind in future, not just because they want the waste recycled, but simply because they want to see as little waste as possible going to landfill, due to the methane that is otherwise created.

In such a scenario it is only of marginal interest whether plasterboard waste in itself is actually producing a greenhouse gas or not, as plasterboard waste will be hit by the same initiatives, regulations and laws aimed at preventing any waste going to landfill at all.