



GTOG: From production to recycling: a circular economy for the European gypsum Industry with the demolition and recycling Industry



GYPSUM TO GYPSUM

Roadmap and proposal for procedures for the implementation of a sustainable value chain

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Table of Content

Executive Summary	7
1. Introduction	9
2. Level of innovation of the GtoG project.....	9
3. Transferability of the GtoG project to other construction materials	13
a. Introduction.....	13
b. Similarities and differences between the recycling value chains	13
c. The conclusions of the analysis.....	15
4. The transferability of the gypsum recycling value chain and potential for commercialisation.....	16
a) The recycling gypsum value chain is already commercialized and transferable	16
b) Why invest without precise knowledge of the real volumes of plasterboard waste (demolition, construction waste)?.....	17
c) Cooperation between gypsum manufacturers and recyclers is key for a sustainable recycling gypsum value chain	17
d) How to enhance the transferability of the Gypsum Recycling value chain to other countries?	18
1. Enhance a deconstruction mentality across Europe	18
2. Voluntary gypsum recycling targets	19
<input type="checkbox"/> Countries already recycling	19
<input type="checkbox"/> Countries where no major recycling takes place.....	19
3. Enhance the recyclability of plasterboard waste.....	20
4. Steps to follow to develop a gypsum value chain in countries where recycling is not happening or is still limited.....	20
a. General Actions	20
b. Specific tasks	22
1. Raise awareness	22
2. Mobilize the gypsum based waste deposit.....	24
3. Deploy the technology (deconstruction, recycling, re-incorporation)	26
4. Spread best practices and inform	32

5. Relevance of the project for environmentally significant issues or policy actions.	33
a. The C&D recovery target of 70% of the Waste Framework Directive (WFD)	33
b. Diverting waste from landfill	34
c. Improve the statistics for C&D waste	34
d. Design for recycling and promote waste prevention.....	34
e. Design for deconstruction	36
f. Green Public procurement.....	36
6. Summary of actions to be carried out after the project	37
7. Conclusions	40
ANNEX I: Transferability of the Gypsum value chain to other construction products	41
1. Sustainable value chain in the construction sector: the questionnaire 41	
2. Summary of the interviews	42
ANNEX II: Characteristics of the gypsum value chain	50
ANNEX III-Collection of waste by municipalities	53
ANNEX IV- Prevention of construction waste	54
Waste Flows on Construction Sites	54
(i) Direct waste	54
g(ii) Repetition Waste	54

Executive Summary

Gypsum is eternally recyclable due to its chemical composition which does not change during the transformation process: from the rock until the plaster, we have always calcium sulphate with two molecules of water.

The production of plasterboards started in Europe in 1917 and increased sharply after the Second World War. Its recycling became relevant at the end of the 1990 when buildings with plasterboard started to be demolished. Construction waste was not sorted out and recycled.

The first push came from Scandinavia early 2000 and mainly in Denmark who set up a recycling value chain and from 2005 onwards, we saw in Western Europe a push of the national authorities. First in the UK, with the implementation of the Council Decision of 19 December 2002 on the need to landfill plasterboard waste in mono-cells avoiding thereby the production of H₂S. A voluntary agreement was signed to recycle plasterboard. Today, the UK is the prominent country in term of plasterboard recycling.

In 2007, France committed to recycle and signed an industry voluntary charter for gypsum recycling. Today, France is the second best in Europe for plasterboard recycling.

In 2007, the Dutch government signed a voluntary agreement with the Netherlands and at the same year, Belgium decided to have an industry approach by having production and construction waste recycled in one of the manufacturer's plant.

In 2008, Eurogypsum drafted its waste policy and started a reflection on the recycling of plasterboard waste stemming from demolition. Up to then, the focus was to recycle production and construction waste as they were clean from any dangerous chemical substances.

In 2011, the time was mature and Eurogypsum decided to apply for a co-funded project to increase the recycling of demolition plasterboard waste. A project value chain was set up and the project co-financed for the period 1st January 2013 to 31st December 2015.

During the project, we faced the challenges of gypsum recycling in practice:

1. The need to deconstruct instead of demolishing if we want to recover plasterboard waste without contaminants;
2. The need to sort the plasterboard waste on the demolition site;
3. The need to have specifications according to high quality standards which enable to have a pure recycled gypsum with less re-incorporation issues. Paper is the main contaminant in the recycled gypsum which can mechanically impede or make difficult the re-incorporation in the plasterboard manufacturing process;
4. The re-incorporation in the manufacturing process analyzing the challenges and results to obtain innovative processes



The results are encouraging though the efforts to be made to reach over 30% recycled gypsum in the plasterboard are still huge.

To make gypsum recycling a business as usual, we need that:

- National authorities push for deconstruction and recycling of the plasterboard waste;
- Construction waste are collected separately;
- National and European statistics are better;
- Municipalities enhance the collection of plasterboard waste;
- Logistics are optimized;
- The operators of the recycling value chain cooperate;
- There is no illegal shipment of waste in other countries;
- The plasterboard waste is landfilled in mono-cells.

In other words, we need:

- An operational value chain (deconstruction instead of demolition separate collection of plasterboard waste, high quality of the recycled gypsum);
- Waste volume-constancy and storage in case the recycling gypsum cannot be absorbed at a certain moment of time because of irregular sourcing of the recycled gypsum;
- Recycled gypsum quality-constancy-the definition of the recyclable waste accepted by the recyclers and the certification of the recyclers' process is key to ensure that the recycled gypsum meet the technical requirement of the gypsum as well as ensuring that the recycled gypsum is contaminant free;
- Willingness of the manufacturers to invest in heavy process changes, which affects also the willingness to set higher recycled targets.

However, despite the difficulties mentioned above, in the project, we succeeded in achieving 30% re-incorporation for a short period of time. Still the main issues remain, volumes of plasterboard waste stemming from demolition are very low and the constancy in quality sometimes fails. During the project, we drafted guidelines for a pure gypsum (technical parameters and toxicological parameters) with the wish go for specification after the project with the community of gypsum recyclers.

From the real-life implementation of the value chain, each operator could enhance an action plan for the future which is explained in point 5 of this document. The plasterboard produced with the recycled gypsum of the project were sold. The buildings deconstructed would have been deconstructed anyway and the recyclers applied their current techniques to give a good quality recycled gypsum to the manufacturers.

1. Introduction

Based on the results of Action C1 defining best waste management options for gypsum demolition waste (use, reuse, recycle versus landfill) and in combination with the outputs of the previous actions of the project, it will be possible to determine an outline plan in order to achieve a more widespread implementation of gypsum C&D waste recycling. C1.4 the Roadmap on a sustainable value chain) will prepare an outline road map that will include the parameters that need to be optimised in order to achieve a sustainable value chain.

An awareness and dissemination road map (to be used in action E1) will be additionally prepared for dissemination of the technologies and practices demonstrated. The target group will be stakeholders in the value chain, local, regional and international industry associations, relevant institutions and public administration bodies.

The output of Action C1 defining best waste management options for gypsum demolition waste (use, reuse, recycle versus landfill) will be evaluated by the industrial partners in the frame of C1.4 a roadmap for a sustainable value chain. Evaluation criteria will include: "anonymised" production cost (to maintain the Intellectual Property Rights of each industrial producer), efficiency, process stability, percentage of waste, quality of end product, quality of raw material in the frame of the range of products concerned.

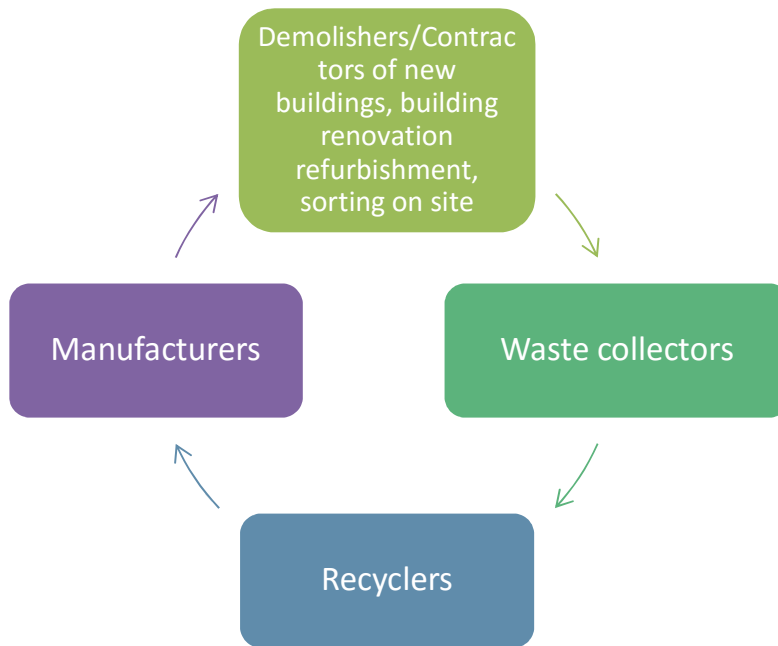
The roadmap will include strategic assessment criteria, such as:

- a. Level of innovation.
- b. Transferability and potential for commercialization.
- c. Relevance for environmentally significant issues or policy actions.
- d. Relevance for other significant issues or policy areas.

The results will appear in the "best practice" handbook (as described in B1.3) for distribution to stakeholders, associations and networks that have usual electronic dissemination methods through web pages and electronic distribution lists.

2. Level of innovation of the GtoG project

The overall aim of this project is **to transform the gypsum demolition waste market** to achieve higher recycling rates of gypsum waste, thereby helping to achieve a circular economy. The market transformation will start happening with the establishment in the project of a collaborative business model between the demolition/processing/manufacturing & recycling industries. This is indeed the main innovation of the project.



The project showed that the above-mentioned value chain is essential to increase the recyclability of gypsum-based waste. If one operator fails, the plasterboard waste is not recycled.

In practical terms, the project confirmed that the barriers for a sustainable recycling value chain are today:

- Lack of knowledge about the possibility to recycle GBW;
- Demolishing instead of deconstructing. In Europe, deconstruction is the exception and demolition is the rule. Moreover there are not sufficiently trained shifts to deconstruct in a cost effective way;
- No appropriate segregation on site of the plasterboard waste on the demolition sites and on the construction site. The percentage of job site scrap for new construction varies with the project. The gypsum construction waste currently recycled is estimated, at current market volumes – at ca. 7%;
- Lack of optimized logistics from jobsite to recycling unit;
- lack of recycling unit in some countries;
- Across the EU, there is a general non enforcement of the Council of the European Union Decision of 19 December 2002^[1] on the establishment of

^[1] 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

criteria and procedures for the acceptance of waste at landfills. Section 2.2.3 of the annex mentions: "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 Decision took effect on 16 July 2004 and Member States had to implement it by 16 July 2005.

- Low level of landfill tax in some countries contributes to impede the development of the recycling route
- The lack of reliable statistics. The construction and demolition waste market has a strong regional orientation. This regional orientation makes it difficult to obtain solid statistics, let alone to predict a solid forecast of the developments of C&D waste in Europe and moreover so for gypsum waste. There are very limited data available on plasterboard waste generation beyond anecdotal evidence and ad hoc projects. Figures from different sectors of the industry are being quoted with little evidence base;

The project, however, demonstrated some key trends:

1. When duly enforced, the council Directive of 19 December 2002, the latter enables to divert waste from landfill. Only in Belgium, France and the UK specific mono-cells for the disposal of gypsum based waste have been created. The UK is particularly a good example of law enforcement.

Indeed, in the UK, Plasterboard waste was banned from general landfill in the UK from July 2005. However, up to 10% plasterboard waste was allowed until April 2009 when the law changed and "loads of waste containing identifiable gypsum-based materials (e.g. plasterboard) were banned from general landfilling".

Loads of waste with identifiable gypsum-based materials are only permitted in non-hazardous single cell landfill, which carries a premium on landfill site gate fees (gate fees are the charges made by the landfill operator, exclusive of tax). In some countries the cost for segregated gypsum based waste in mono-cells is much higher.

In the UK, for instance, the costs for segregated gypsum based waste in monocells is around 189 €/t up to 266 €/t.

In conclusion, and taking aside other relevant factors (namely logistic costs, taxes, extra manual operations, etc.) within this specific analysis, we can say that if the recycling gate fee (average 55 Euro/tons)¹ is lower than the landfill costs, (gate fee + landfill tax), there will be more chances that:

- the demolishers will choose the recycling route,
- the recyclers will recycle more plasterboard waste, and
- the manufacturers will reincorporate more plasterboard waste in the production process.

¹ Please see report on inventory of current practices DA.1

2. In relation to mandatory dismantling, legislation is non-existing in Europe today, though best practices can be recognized in the UK, France, Belgium and the Netherlands. Indeed, in France and Flanders (Belgium), for example, mandatory audit prior to demolition of the buildings are in place for buildings over 1000 square meters. Mandatory audits could be thus enforced at EU level. DG GROW is currently carrying out a survey on pre-audits of buildings and we can hope for a change in legislation (preferably European) in the medium future;
3. Other legislative incentives to recycle are set at national level.
 - a. In the Netherlands, gypsum waste may not be landfilled.
 - b. In Germany, the recovery operations of gypsum waste to cover salt dumps were prohibited in 2012/2013. But we face the reality that German GBW is currently shipped to the Czech Republic to be recovered in mines (re-cultivation backfilling operations), thereby impeding the activities of a recently started recycling operations by a German recycler.
 - c. In the UK, the industry signed a voluntary agreement with the UK government for the recycling of plasterboard construction waste. The agreement is a success. Steps need to be taken to recycle demolition waste though high landfill costs enabling the recyclability of demolition plasterboard waste. Thanks to the GtoG project, the UK Government is pushing the Industry in that direction.
 - d. In France, the development of GBW recycling route is based on a voluntary commitment of the plasterboard manufacturer. The choice to address both demolition and construction waste was made at the early stage. By imposing to the market a stringent specification in terms of requested GBW, the manufacturers succeeded in avoiding undesirable pollution.
4. Thanks to the GtoG project, Eurogypsum started a dialogue with the recyclers to understand
 - Whether a certification scheme of their process could enhance the quality of the recycled gypsum;
 - Whether it could be possible to define "recyclable gypsum waste" and "recycled gypsum".

The dialogue has been transformed into a Eurogypsum recycler's platform which will continue to exchange best practices after the Life project and meet on an ad-hoc basis to find common solutions for increasing the recyclability of gypsum based waste.

3. Transferability of the GtoG project to other construction materials

a. Introduction

Eurogypsum wanted to assess the potential transferability of the gypsum value chain. We interviewed the following associations:

- European Insulation Manufacturers associations (Eurima)
- Metals for buildings
- PV cycle
- European Manufacturers of expanded Polystyrene (EUMEPS)
- European wood panel association
- Recovinyl

You will find in annex I the questions we asked and the answer received.

b. Similarities and differences between the recycling value chains

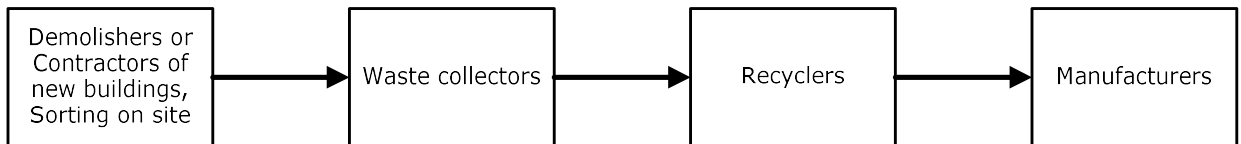
Commonalities	Differences
<p><u>Create a dismantling culture:</u> Europanels-Glass for Europe-Eurima-Eumeps-the market is not functioning or starting to function-price of the waste material insignificant</p> <p>Price of virgin wood is high but is not recovered from buildings today, but from other sources</p>	<p>For metals: the dismantling is less an issue as the material is sorted thanks to its high monetary value (there is a functioning market)</p>
<p><u>Separate collection</u> a must for Eurima-Glass for Europe-PV cycle-Europanels-Eumeps</p> <p>Not a must for PVC and metals</p>	<p>For metals: waste collectors with an unclear market functioning but</p> <p>For Glass: the obtention of the cullet must be contaminants free. After wards, re-incorporation into the manufacturing process. So clean sorting is important</p> <p>PV cycle: network of collectors points fully developed (extended producer responsibility as per the WEE Directive)</p>
Commonalities	Differences
<p><u>Waste specifications and end-of-waste</u> for Glass - End-of-waste criteria exists at EU level for glass cullet</p>	<p>Eumeps: national specifications, no end-of-waste- status</p> <p>Eurima: no specifications</p> <p>Eurogypsum: national end-of-waste status (UK) and fully developed</p>

<p>Metals-end-of waste for Iron and steel scrap metals and copper and copper alloy, aluminum and aluminum alloys</p>	<p>specifications at national level (Germany, UK) Wood: specifications between producers and collectors but no end-of-waste <u>Photovoltaic</u>: no-end-of-waste status-no clear specifications <u>PVC</u>: consider the recycled material as products once it reaches the door of the converters (image question)-PVC is REACH registered and thus a product.</p>
<p>Close-loop: metals-gypsum-EPS-Mineral wool-wood-glass Open-loop: gypsum-EPS-wood-glass PV cycle-PVC</p>	
<p>Re-incorporation rate: existing for gypsum and wood panels</p>	<p>Metals: no re-incorporation rate in the product Eurima: idem Eumeps: idem PV Cycle: idem PVC: idem</p>
<p>Processing (what we call recycling in the project): a must for gypsum. This means- a need for specifications for the recyclable gypsum waste and for the recycled gypsum result of the separation from paper and the core gypsum</p> <p>FOR ALL: the output to be re-incorporated must be contaminant free (mechanical or chemical contamination)</p>	<p>Metals: no processing Eumeps: idem PV cycle: idem Wood: idem but manual cleaning of the wood by third parties Glass: no processing but manual cleaning of the waste by third parties</p> <p>Conclusion: no intermediary between the producers and the collectors-no recyclers</p> <p>PVC: yes mechanical recycling-Yes recycling industry</p>
<p>Legislation as a driver: PV cycle: caught by the WEE directive and must implement the extended producer responsibility PVC: extreme pressure by the European Commission. A voluntary agreement was set up and duly followed; Acted as a legislation</p> <p>Gypsum: decision of the Council declaring gypsum as non-inert and to be landfilled in mono-cell as potential emission of H₂S can occur if plasterboard mixed with biodegradable waste</p>	<p>No specific legislation to our knowledge</p>

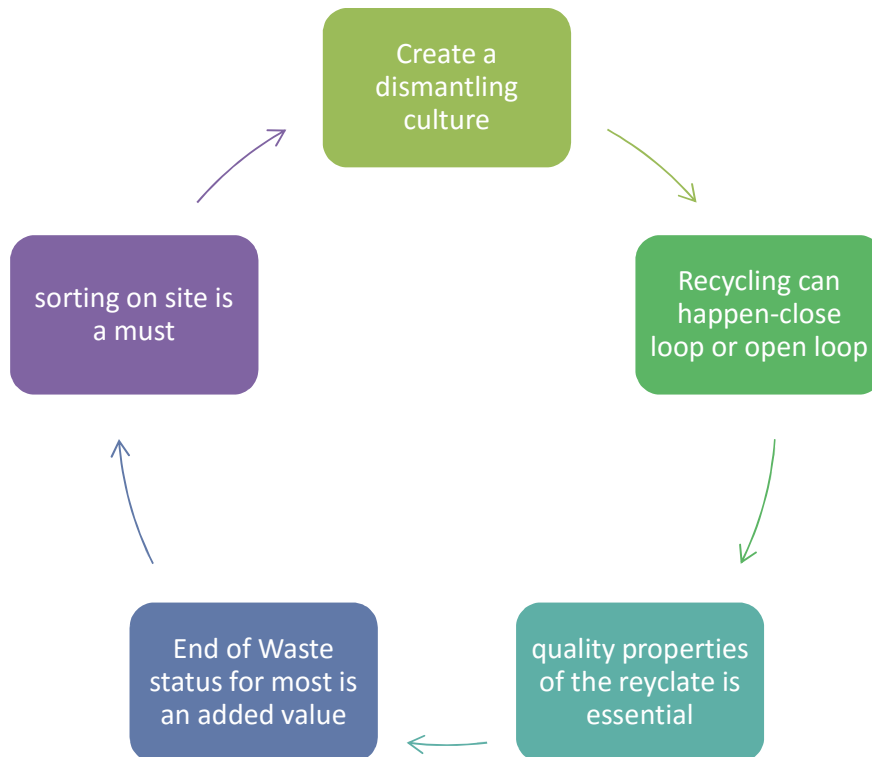
c. The conclusions of the analysis

The level of transferability is the same as for the Gypsum Value Chain:

- The same operators



- The same issues



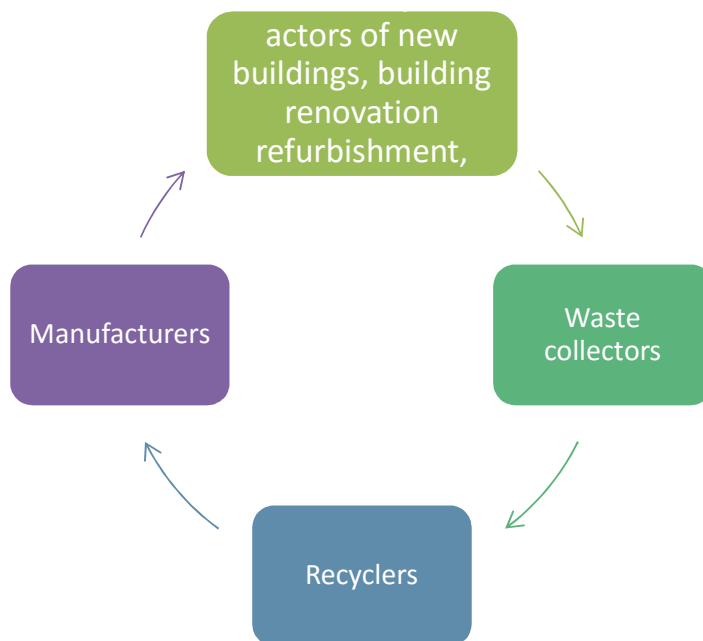
- Different motivation

1. Recoviny! Voluntary agreement with the Commission in 2003
2. PV Cycle- WEEE Directive
3. Glass in the Netherlands: an eco-fee

4. The transferability of the gypsum recycling value chain and potential for commercialisation

a) The recycling gypsum value chain is already commercialized and transferable

The recycling gypsum value chain is as follows:



For the characteristics of the Gypsum recycling chain, please refer to Annex II

This recycling gypsum value chain already operates on a commercial basis in the following countries:

- UK
- France
- Belgium
- The Netherlands
- Scandinavian countries

The GtoG project showed that it was technically feasible to reincorporate 30% of recycled gypsum in the plasterboard however not on a continuous basis but for a specific period of time.

b) Why invest without precise knowledge of the real volumes of plasterboard waste (demolition, construction waste)?

The Report on inventory of current practices identified a data gap in the generation of gypsum waste. There is, indeed, very limited data available on plasterboard waste generation beyond anecdotal evidence and ad hoc projects. Figures from different sectors of the industry are being quoted with little evidence base. The uncertainty about gypsum based waste generation in real life raises the issue:

- Waste volume-constancy and storage in case the recycling gypsum cannot be absorbed at a certain moment of time because of irregular sourcing of the recycled gypsum;
- Recycled gypsum quality-constancy-the definition of the recyclable waste accepted by the recyclers and the certification of the recyclers' process is key to ensure that the recycled gypsum meet the technical requirement of the gypsum as well as ensuring that the recycled gypsum is contaminant free;
- Willingness of the manufacturers to invest in heavy process changes, which affects also the willingness to set higher recycled targets.

c) Cooperation between gypsum manufacturers and recyclers is key for a sustainable recycling gypsum value chain

Recycled gypsum specifications exist. In the UK they are even formally approved by the government. Recycled gypsum specifications have been developed during the project. We have furthermore not reached a critical mass of recyclers (external recyclers) and internal recyclers (manufacturers playing the role of a recycler) to ensure that the values for the technical and chemical parameters are definitive and could be Europeanized. Today, we have developed in the framework of the GtoG guidelines for the quality requirements of the recycled gypsum (technical and chemical parameters)².

The quality of the recycled gypsum is also a question of enhanced partnership and trust between the recyclers and the manufacturers.

This partnership could be developed after the life project as follows:

- Striving for certification of the recycling process of the recyclers;
- Achieve high quality of recycled gypsum- via the establishment of quality criteria (technical and toxicological);
- Obtain the end-of-waste status (EOW) at national, federal or local level. This gives a real trust that the end result has the same characteristics as the natural gypsum properties;

² Action B2.2: DC2-Quality criteria for recycled gypsum, technical and toxicological parameters

- Definition of the recycled gypsum;
- Definition of the recyclable gypsum;
- Establishment of Waste acceptance criteria for countries not covered by the project.

Non -recyclable gypsum waste

The manufacturers as well as the recyclers are aware that not all plasterboards are recyclable. For example, sandwich panels and specialty boards produced using additives are today not recyclable, at least with the existing recycling techniques. Therefore, further research and development in partnership with the recyclers is needed in order to reach the full recyclability of these products.

We thus face two issues for improving gypsum recycling:

- The recyclability of the plasterboard waste at the entrance of the recycling plant.
- The recyclability of the plasterboard itself due to additives.

d) How to enhance the transferability of the Gypsum Recycling value chain to other countries?

1. Enhance a deconstruction mentality across Europe

- There is a need to know what can be dismantled efficiently and in which amount prior to the demolition work. Therefore, systematic audit of buildings prior to demolition should be encouraged and made mandatory at EU level, at least for buildings above 1.000 square meters;
- At EU level, DG GROW is also currently developing a study on audit of buildings prior to demolition. DG GROW has also finalized a C&D waste management protocol with the support of the stakeholders. The protocol will be published end of September 2016 and a high level conference on the protocol implementation will take place in Brussels end of 2016;
- At Member States level, we have the following activities:
 - The Dutch demolition association (VERAS) published a Code for responsible work in the tender and execution of demolition works.
 - The UK demolition Association, NFDC, published in January 2015 a guidance on the deconstruction of tower block.
 - In Belgium, The Confederation of Demolition and Dismantling Contractors from Belgium, CASO, together with other related industries, created TRACIMAT, a new system to handle and track all demolition and decontamination waste.
- Enhance the reference catalogue on gypsum-based systems built 20-30 years ago. Within the project framework, this catalogue covers Belgium, France, Germany, and the UK. It should be completed in 2016 with The Netherlands-Scandinavia- Austria;

- Disseminate the best practices to dismantle plasterboard systems via the national gypsum associations and the national demolition associations;
- Enhance the cooperation with the European Demolition Association to increase the uptake of plasterboard dismantling bearing in mind that high volumes coming from this source are not currently available.

Conclusions: we see that at EU and national level, the deconstruction of buildings becomes step by step, year by year each time more important. We see that maybe a mandatory audit of buildings prior to demolition work for buildings above 1000sq meter at EU level could be reached by 2020.

2. Voluntary gypsum recycling targets

➤ Countries already recycling

In France, UK, the Netherlands, Belgium and the Scandinavian countries we could reincorporate 30% of recycled gypsum as business as usual by 2020 in a gypsum plant if

- National authorities push for deconstruction and recycling of the plasterboard waste;
- Construction waste are collected separately;
- National and European statistics are better;
- Municipalities enhance the collection of plasterboard waste as it is already the case in Denmark and in France (See Annex III);
- Logistics are optimized;
- The operators of the recycling value chain cooperate;
- There is no illegal shipment of waste in other countries;
- The plasterboard waste is landfilled in mono-cells.

We could foresee an ambitious target of reincorporating 50% of recycled gypsum by 2030 with the above-mentioned conditions. From 30% to 50%, we need higher investment in the manufacturing process. Therefore, this is a difficult and challenging step.

For Germany, the target could be 30% reincorporation of recycled gypsum in 2025 and 50% in 2035.

➤ Countries where no major recycling takes place

For Italy and Spain, we should strive to implement the Gypsum value chain by 2025.

In Poland and in the Eastern countries in general, we should strive first to encourage a recycling mentality with the national authorities and consider the establishment of a recycling gypsum value chain from 2025 onwards.

3. Enhance the recyclability of plasterboard waste

Together with the gypsum recycler, consider in 2020 an EU R&D co-financed project to develop new technologies to recycle the today non-recyclable gypsum waste.

4. Steps to follow to develop a gypsum value chain in countries where recycling is not happening or is still limited

a. General Actions

Raise awareness	Raise awareness with the operators of the value chain in that country or in that regions and with general stakeholders	Contact the national/regional /local authorities to raise awareness of the potential for gypsum recycling	Keep on communicate widely about the results (GtoG's 8 countries)	Extend pilot project to new countries/regions with operators of the value chain and national/regional and local authorities
Mobilize the gypsum based waste deposit	Quantify the gypsum based waste deposit for the region/country	Mobilize the gypsum based waste on specific areas with targeted action	Set up pilot projects for the collection of the gypsum based waste and select the best logistics schemes	Adapt and spread the logistics scheme to the whole territory concerned (regional/local/national)
Deploy the technology	Deconstruct the building according to the best practices of dismantling identified during the project Apply the recycling technologies identified in the project	Adapt deconstruction schemes to national particularities pilot projects Adapt the recycling technologies to obtain higher rates of re-incorporation. Adapt the manufacturing process to increase the percentage of recycled gypsum in the	Optimize the deconstruction schemes to deploy nationally, locally or regionally in function of the experience from the pilot projects. Optimize the recycling schemes and manufacturing processes to deploy nationally, regionally in	Adapt the best methodologies in the region, countries concerned Enhance the recyclability of gypsum based products by developing R&D programs to recycle non-recyclable gypsum waste

		plasterboard	function of the experience of the pilot project	
Spread the best practices and inform			Share and spread the return of experiences from new pilot projects and duplicate	Inform all stakeholders and the operators of the value of the functioning of the value chain



b. Specific tasks

1. Raise awareness

Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Awareness raising of the stakeholders involved	Show the needs of the development of the value chain and the return on investment in that country, region, local community	Leader: TBD Stakeholders: national/regional/local authority, demolisher, recyclers, collectors, municipalities, distributors, manufacturers, installers, construction site managers	Collective and personnel meeting (phone, face to face, mail...)	Low	TBD
Mobilise the the stakeholders to participate in the pilot projects	Define the deconstruction potential, the number of construction site with potential gypsum based waste, the production waste Design the logistics route Draft waste acceptance criteria for that country,	Leader: collectors and gypsum recyclers, demolishers, manufacturers Stakeholders: national/regional/local authorities, landfills managers, installers, distributors, collectors, construction site managers	Phone conversation/leaflet/information of collectors and webpages	Low	TBD

	regions on the basis of DB 3 ³				
Mobilise the stakeholders to deploy on the pilot project zones	<p>Mobilise stakeholders to adopt the logistic scheme chosen, the quality of the recycled gypsum and the rate of re-incorporation in the manufacturing process</p> <p>Define which buildings will be deconstructed</p>	<p>Leader: gypsum recyclers, demolishers, construction site managers, manufacturers</p> <p>Stakeholders:</p> <p>national/regional/local authorities, landfills managers, installers, distributors</p>	Phone conversation/leaflet/information of collectors and webpages	Low	TBD
Mobilise the stakeholders to deploy more widely	Mobilise the stakeholders to deploy the value chain at national/regional level	<p>Leader: TBD</p> <p>Stakeholders</p> <p>national/regional/local authorities, manufacturers, demolishers, landfills managers, installers, distributors, recyclers, construction site managers</p>	Meetings, press releases, workshops	Low	TBD

³ DB3: Guidance document with criteria for acceptance of secondary gypsum for recycling



2. Mobilize the gypsum based waste deposit

Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Quantify the deposit	Estimate the annual quantities of gypsum based waste generated annually in that country, region, local community	Leader: TBD Stakeholders: manufacturers, installers, demolishers, recyclers, landfills, municipalities, collectors, distributors, national, regional, local authorities, construction site managers, professional associations	Survey by mail and extrapolation of the results base on documentary research	Medium	TBD
Mobilise the deposit in specific areas. Pilot project of collection	Put containers of the site of manufacturers, installers, demolishers, recyclers, landfills, municipalities, distributors, construction site managers Organise the logistics between the above-mentioned actors and the gypsum recyclers	Leader: TBD Stakeholders: manufacturers, installers, demolishers, recyclers, landfills, municipalities, collectors, distributors, construction site managers	Set up storage areas and logistics schemes Phone conversation/leaflet /information of collectors and webpages	Medium	TBD



Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Mobilise the manufacturers and recyclers to re-incorporate	Mobilize the recyclers to obtain a pure recycled gypsum –agree with manufacturers on technical and toxicological specifications if needed adapted to plant and in accordance to DC2 report ⁴). Manufacturers to analyze the manufacturing process to optimize re-incorporation.	Leader: TBD Stakeholders: manufacturers, gypsum recyclers	Meetings between the manufacturers and the recyclers to agree on common specifications, constancy on volume and on the recycled gypsum quality	Medium to high	TBD
Define and deploy the commercial offer and the logistics schemes chosen based on the pilot projects experiences	Define a marketing offer to deploy nationally, regionally, locally	Leaders: collectors, gypsum, recyclers, manufacturers, demolishers Stakeholders: installers, recyclers, landfills, municipalities, distributors,	Phone conversation/leaflet /information of collectors and webpages Intense cooperation between the leaders	Medium	TBD

⁴ DC2: Protocol of action B2.2: Quality criteria for recycled gypsum; technical and toxicological parameters



3. Deploy the technology (deconstruction, recycling, re-incorporation)

Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Identify the best deconstruction techniques in accordance to the results of the GtoG project. Analysis of the costs and return on investment	Make an analysis of the state of the art of deconstruction of plasterboard and plaster blocks in that country.	Leader: TBD Stakeholders: manufacturers, demolishers, collectors, municipalities points recyclers, landfills, collection	Adapt if the case may be the best available deconstruction technique in the GtoG deliverable DB1 ⁵	Medium	TBD
Test the deconstruction technique in that country, region, local community	Pilot projects	Leader: Collectors, gypsum recyclers Stakeholders: manufacturers, demolishers, recyclers,	Deconstruction tools (see GtoG project DB1)	Medium	TBD

⁵ European handbook on best practices for controlled deconstruction of drywall systems in demolition/refurbishment sites as a basis for a new European standard on deconstruction of lightweight systems



Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
<p>Define best deconstruction techniques in that country based on pilots projects experience for optimizing recycling</p>	<p>Define the most cost efficient deconstruction methods</p>	<p>collectors, municipalities, landfills, collection points</p> <p>Leader: collectors, gypsum recyclers</p> <p>Stakeholders: manufacturers, demolishers, collectors, municipalities, recyclers, landfills, collection points</p>	<p>Deconstruction workshop</p>	<p>Medium to high</p>	<p>TBD</p>
<p>Deploy the deconstruction techniques at national, regional, local level</p>	<p>Deploy the deconstruction technique chosen widely</p>	<p>Leader: collectors, gypsum recyclers</p> <p>Stakeholders: manufacturers, demolishers, collectors, municipalities, recyclers, landfills, collection points</p>	<p>Deconstruction workshop</p>	<p>Medium to high</p>	<p>TBD</p>

Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Identify the best recycling technologies and make pilot project for wider deployment thereafter	On the basis of technical and toxicological specifications (see DC2 report ⁶), manufacturers choose the recyclers matching those specifications in real life.	Leader: gypsum recyclers and gypsum manufacturers Stakeholders: Laboratories in case additional measurement is needed	Exchanges between gypsum recyclers and gypsum manufacturers	Medium to high	TBD
Test the best recycling techniques for wider deployment	On the basis of DC2 report ⁷), strive to have a certification of the recycling processes to obtain a constant quality in the recycled gypsum as well as a constant volume. Enhance the capacity of the recyclers to have	Leader: gypsum recyclers and gypsum manufacturers Stakeholders: Laboratories in case additional measurement is needed, landfill managers, municipalities, collection centers, construction managers	Exchange between the stakeholders	Medium	TBD

⁶ DC2: Protocol of action B2.2: Quality criteria for recycled gypsum; technical and toxicological parameters

⁷ DC2: Protocol of action B2.2: Quality criteria for recycled gypsum; technical and toxicological parameters



	<p>access to the resources, i.e.. the gypsum based waste.</p> <p>Gypsum manufacturers and gypsum recyclers to start R&D to recycle the today non-recyclable gypsum based waste</p>				
Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Deploy the best recycling techniques	<p>Deploy widely (in that country, nationally, regionally, locally) with the customers help (manufacturers) if volume of gypsum-based waste available on a constant basis and if quality of the recycled gypsum is constant</p>	<p>Leader: gypsum recyclers and gypsum manufacturers</p> <p>Stakeholders:</p> <p>Laboratories in case additional measurement is needed, landfill managers, municipalities, collection centers, construction managers</p>	<p>Establish contracts between recyclers, and landfill managers, construction site managers, demolishers to have access to the resource, collection centers.</p>	Medium	

Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Identify the best re-incorporation techniques	On the basis DB4 report ⁸), define the best techniques available to re-incorporate the recycled gypsum at the rate defined	Leader: gypsum manufacturer in that country Stakeholders: subsidiaries in other countries where recycling happens for advice	Analysis of DB 4 and adaptation to the national circumstances	Medium	
Test the re-incorporation techniques for wider deployment	Identify bottle necks and difficulties. Iterative process with the gypsum recyclers	Leader: gypsum manufacturer in that country and gypsum recyclers Stakeholders: subsidiaries in other countries where recycling happens for advice	Analysis of the obstacles internally. Analysis of the costs. Find solution Adaptation of the manufacturing process if volume and quality of the recycled gypsum are constant.	Medium to high	TBD

⁸ DB4: Report on Production Process Parameters



Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Deploy the best re-incorporation techniques at company level	Deploy widely at company level if volume of gypsum-based waste available on a constant basis and if quality of the recycled gypsum is constant.	<p>Leader: gypsum manufacturer in that country and gypsum recyclers</p> <p>Stakeholders: subsidiaries in other countries where recycling happens for advice</p>	R&D at company level	Medium to high	TBD



4. Spread best practices and inform

Task	Description and objectives	Stakeholders	Technical means	Financial impact	Deadline
Share and spread the experience acquired in the pilot projects zone and with the recycling technologies used	Spread and share in that country (nationally, regionally, locally) the current best practices to deconstruct, recycle and re-incorporate the recycled gypsum in the plasterboard acquired in the GtoG in addition to the experience done in the specific pilot project for that country, nationally, regionally or locally	Leader: TBD Stakeholders: national, regional and local authorities, national business associations, national recyclers association, national/regional environmental authorities	Workshops, meetings, webpages, press releases, publications ,etc Use the experience and tools developed in the GtoG project	Low	TBD

5. Relevance of the project for environmentally significant issues or policy actions.

The GtoG project helped the partners to support in practice the revision of the C&D Waste Framework Directive currently in co-decision process in the European Parliament and the Council. It also confirmed the need for better statistics for C&D waste and the necessity to design for deconstruction and design for recycling pointing out the need for applying the Waste hierarchy as foreseen in article 4 of the WFD. We also see the advantage of having proper enforcement of the Council decision of 2002 to have the plasterboard waste landfilled in mono-cells.

a. The C&D recovery target of 70% of the Waste Framework Directive (WFD)

- The Waste Framework Directive (WFD) could be an important tool for driving the recycling of C&D waste. However, the EU authorities set a target for recovery operations including recycling operations. Therefore, the current 70% recovery target (by 2020, including backfilling operations) for non-hazardous waste become an ambiguous tool and deserves a strong reorientation by the European authorities.
- Backfilling should be defined carefully as it is not per se a recovery operation but can also be a legal conversion into a landfill site at the place of a former quarry. Any target should be postponed until we rely on robust statistic and calculation method.
- We also support Support the Commission proposal on the sorting of C&D waste in the Waste Framework Directive proposal (COM (2015)595 „Member States shall take measures to promote sorting systems for construction and demolition waste and for at least the following: wood, aggregates, metal, glass and plaster“;
- Further to the publication of the Commission proposal for the revision of the Waste framework Directive, Eurogypsum proposed to the European Parliament to add the following paragraph in article 11 in the revision of the Waste Framework Directive

“By 2020, in order to harmonise re-use and recycling targets stated in the article 11, paragraph 2, point b, and in view of promoting the circular economy for construction and demolition waste, the Commission shall evaluate Members States’ implementation reports and the amount of construction and demolition waste used for backfilling operations, including reprocessing of waste into materials that are to be used for backfilling, and propose a separate re-use and recycling target for Construction and Demolition Waste which excludes backfilling operations. For recyclable waste, recycling should be the preferred option over backfilling according to article 4 of the Waste Framework Directive (Waste hierarchy).”

b. Diverting waste from landfill

It is clear from the inventory of current practice for recycling plasterboard that the council Decision 2002 to permit landfilling of plasterboard waste in non-hazardous single cell is only fully enforced in the UK and France. The Member States should fully enforce the Council decision to optimise the plasterboard recycling⁹.

c. Improve the statistics for C&D waste

Without proper statistics and a harmonised calculation method for the Member States, it is difficult to evaluate any target even if it is clearly set. We suggest proper statistical work before setting any recycling target.

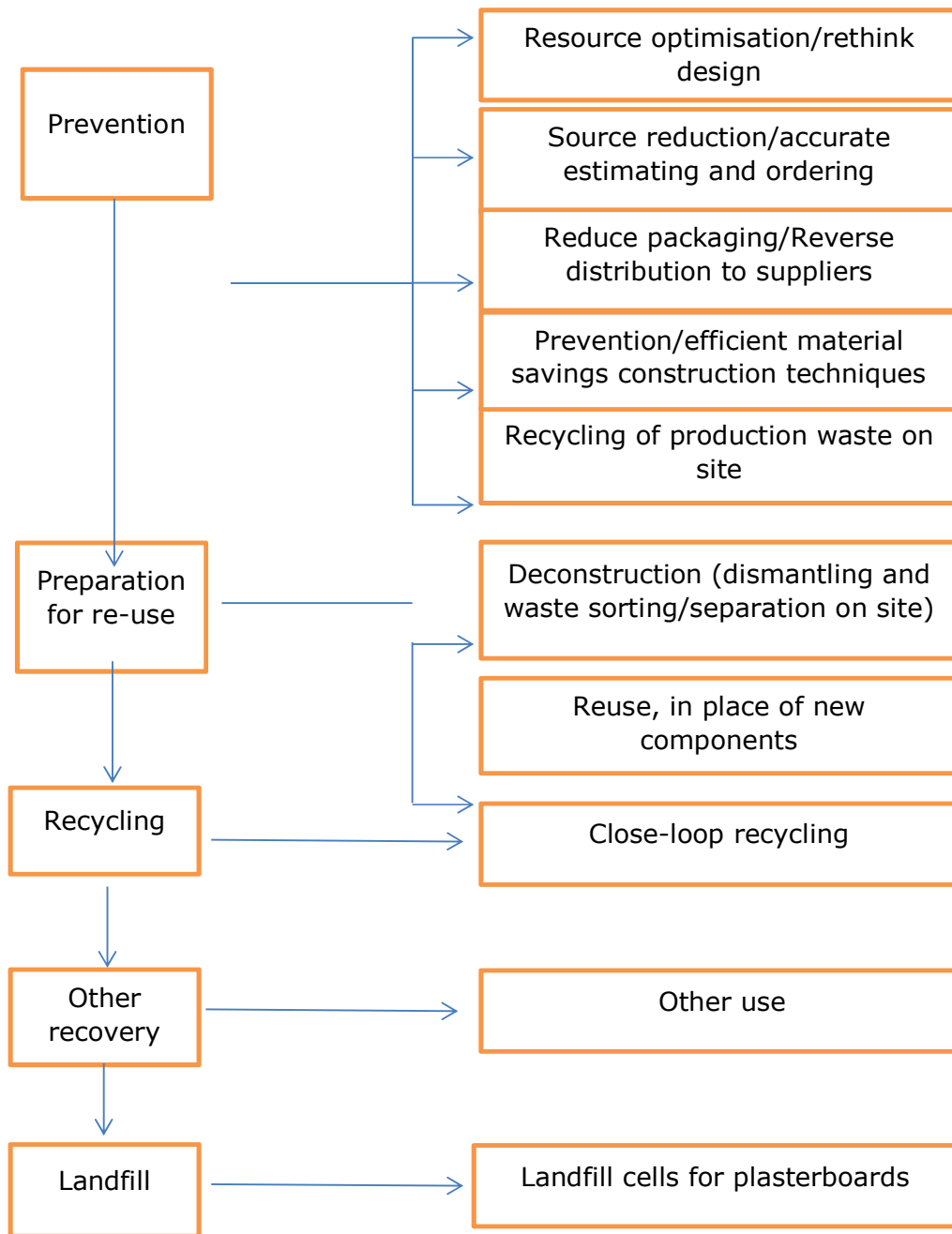
d. Design for recycling and promote waste prevention

The environmental preference is ultimately to **reduce waste at source**, i.e. at the design stage. The gypsum Industry has thus in place policies **to prevent waste e.g. by internal recycling of production waste and thus save resources** and follow the Waste Hierarchy of the Waste Framework Directive, article 4 (see annex III).

It is also important to manage properly the construction materials on the construction site to prevent the occurrence of waste (Gypsum Waste Hierarchy)

⁹ 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

Gypsum waste hierarchy model





e. Design for deconstruction

Is one of the point to be assessed as the architect and contractor do not have today the mentality of “recyclability”. Architects focus on energy efficiency although an important aspect for buildings but not the sole one.

f. Green Public procurement

The European Commission published criteria for wall panels with the following stated for plasterboard waste.

Core criteria

The gypsum content must be at least 2% recycled gypsum board (by weight, based in an annual average, not including gypsum taken from FGD sites). Where higher percentages are possible these should be selected in preference.

Comprehensive criteria

The gypsum content must be at least 5% recycled gypsum board (by weight, based on an annual average, not including gypsum taken from FGD sites). Where higher percentages are possible these should be selected in preference.

In view of the still lacking maturity of the value chain across Europe, we suggest to maintain the criteria as they are today.

6. Summary of actions to be carried out after the project

Value chain	continuous	2016	2020		
Deconstruction	disseminate best practices for plasterboard dismantling	reference catalogue for Austria, The Netherlands and Scandinavia	EU Level, legislation on a mandatory audit of buildings prior to demolition		
	Enhanced cooperation with the European demolition Association	Promotion of DG GROW waste management protocol			
	Push the collection of plasterboard waste by municipalities on the basis of the Danish and French experience	Support the following article in the proposal for the revision of the WFD			
	Prevention of waste on construction site	„Member States shall take measures to promote sorting systems for construction and demolition waste and for at least the following: wood, aggregates, metal, glass and plaster“;			
	Promote Direct logistics between demolition and construction site to recyclers				
	Promote deconstruction pilot projects				



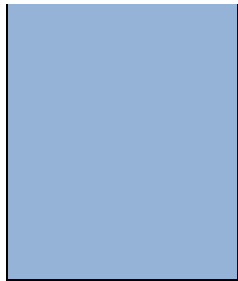
GYPSUM TO GYPSUM



Recycling	continuous	Every year			
	certification of the recyclers process	Meeting of the Eurogypsum recyclers Platform			
	Achieve high quality of recycled gypsum				
	EOW at national regional local level				
	definition of recycled gypsum				
	definition of recyclable gypsum				
	WAC for countries not part of the project				
	Better enforcement of Council decision of 2002				
Re-incorporation	continuous	2020	2025	2030	2035
	Design for recycling and deconstruction	30% recycled gypsum re-incorporated as business as usual in UK, France, Belgium, the Netherlands and Scandinavia (Sweden, Denmark, Finland, and Norway).	30% recycled gypsum re-incorporated as business as usual in Germany	50% recycled gypsum re-incorporated as business as usual in UK, France, Belgium, the Netherlands and Scandinavia	50% recycled gypsum re-incorporated as business as usual in Germany
	Adaptation of the manufacturing process to recycled gypsum		Strive to establish the value chain in Spain and Italy		



GYP SUM TO GYP SUM



		Poland and Eastern countries-push recycling mentalities and strive for establishment of value chain from 2025 onwards (see point D4 of this document)	
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7. Conclusions

The partners of the project are richer today than before the project. Indeed, working together without sometimes much empathy or with misunderstanding in the operational aspects of the value chain obliged the partners to overcome obstacles for obtaining the qualitative and quantitative results expected by the project grant.

So a step forward has been made. Going backward towards less recycling is now impossible. A learning curve with many efforts gave incentives to take over other challenges in the years to come with a concrete action plan. The cooperation between industry, universities and laboratories helped also the other partners to have a scientific approach in their daily recycling business. It also gave them methodological tools to apply now in their company.

One the biggest challenges is to transfer the recycling impetus to the Eastern and Southern countries where the recycling mentality is less present and where efforts are done more reluctantly. A good cooperation between the national authorities and the industry with concrete incentives is required to establish a successful value chain going step by step starting with production and construction waste and adding later on demolition waste.

The recycled gypsum is the third resource for the gypsum industry. Nevertheless, it is unfortunately today a small percentage of the gypsum resources we use. The change of energy policy towards the use of renewable and gas will lead to the shutting down of coal power combustion plants which produced a high quality standard synthetic gypsum used 100% in some plants in European. FGD Gypsum is indeed the perfect substitute to natural gypsum while recycled gypsum is not yet the perfect substitute.

With the sharp decrease of FGD gypsum in the years to come, we need to increase the recyclability of gypsum knowing that this will not occur overnight and that during a transition period, we will need to enhance access to natural gypsum deposits.

ANNEX I: Transferability of the Gypsum value chain to other construction products

1. Sustainable value chain in the construction sector: the questionnaire

I. Demolition versus dismantling

- Is there a similar issue in the value chain?
- Does a certification scheme or label for dismantling exist?
- What are the obstacles for dismantling in your value chain, if any?
- What are the incentives for dismantling in your value chain?
- Do you have any recommendations for making dismantling effective?
- What about construction waste recycling and sorting on site?

II. Separate collection

- Is there a similar issue in the value chain?
- Is there a take back scheme in place? If yes, who organizes it?
- What are the costs and the benefits of such a scheme?

III. Recycling (processing of the waste)

- What is the status of recycling in the value chain?
- Do the recycling technologies exist?
- Do you have specifications for the recycled material?
- Do you have a certification scheme for the recycling process (ISO or similar?)
- Did you think about a label for recycling?
- Do the recyclers have waste acceptance criteria?
- Do they have a cooperation agreement with the demolishers to receive clean waste?
- How do the recyclers deal with asbestos?

IV. Production

- Is the recycled material reused? And if yes, is closed-loop (reincorporation into the production process) or open loop (agricultural use, energy recovery, incineration, etc.) preferred?
- Is there any need for putting in place research and development processes and strategies?
- What are the costs and benefits for the producers for reincorporating recycled material into the production process?
- What is the average percentage of reincorporation of recycled material?

V. Legislation/ Incentives

- What kind of legislation has been an incentive to make the value chain cooperating for a higher use of recycled material?
- Do you rely on voluntary agreement with national government or is there a European scheme in place?



2. Summary of the interviews

Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
European Insulation Manufacturers Associations (EURIMA)	Small volumes of waste generated, with no presence of asbestos.	Not present.	Given the small volumes of waste available, there is no End-of-Waste status or any other certification scheme in place (indeed, this is even not considered an issue).	Yes. Recycling techniques not yet mature, though.	<p>No.</p> <p>There is no common discussion about recycling on short term, but rather on long term, because of the following reasons:</p> <ol style="list-style-type: none"> 1) There is no economic interest today in recycling more for the manufacturers. 2) There is no scarcity of insulation materials today. 3) It is very difficult to reach big and good volumes of recyclable material, because the insulation materials are the last ones to be sorted out.

Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
<p>European Manufacturers of Expanded Polystyrene (EUMEPS)</p>	<p>Deconstruction is essential for recovering polystyrene. However, there is a quantity issue, as volume of C&D waste are hard to estimate and, anyway, not available. There is also a contamination of waste issue as well.</p>	<p>Separate collection for packaging is working. Maybe some demolition EPS waste ends up in EPS packaging value chain. There is no separate collection for EPS construction and demolition waste.</p>	<p>The specifications are independent from producers and they are set at national level. http://epsrecycling.org End-of-waste criteria are not an issue.</p>	<p>As a general remark, it can be noted that there is nearly no difference between virgin and recycled EPSs. There is no traceability of the recycled content in the new EPS product, and it is, thus, very difficult to measure re-incorporation rates in an end application. In any case, both close and open loop are used. A recycling scheme is in place for EP packaging but not for C&D waste. Concerning recovery, EPS has a very high calorific value, (higher than coal, for example) and can be safely burnt within energy recovery units or incinerators without giving off toxic or environmentally damaging fumes.</p>	<p>Currently no legislation covering the EPS C&D waste, but rather EPS packaging waste (packaging waste directive).</p>



Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
<p>Europanel</p>	<p>Deconstruction is considered essential for recovering wood. However, nowadays only very little volume comes from deconstruction (and one of the reasons might be that wood is concentrated in family houses).</p> <p>Indeed, deconstruction has to be preferred as to preserve most of the timber present in a building.</p>	<p>Separate collection on site is also considered essential, as wood waste must be cleaned to be re-used again.</p> <p>In any case, new wood might be less expensive at the moment, as the process of selecting usable pieces of salvaged wood, pulling out nails, and refinishing for a new use can be difficult, time-consuming, and pretty expensive.</p>	<p>There are no official specifications at the moment.</p> <p>End-of-waste criteria are not an issue.</p>	<p>A very good case is that one developed in UK by the wood panel industries federation.</p> <p>The recycled content as a proportion of the total wood content is on average approximately 70%. This will be a mixture of post and pre-consumer material. When calculated according to ISO 14021, the atmospheric moisture in the wood and the resin weight will also need to be accounted for, in order to make up the total weight of the product.</p> <p>For example, if the resin content is 10% and the equilibrium moisture content is also 10%, this will leave the remaining 80% for wood. Therefore if the recycled wood content was 50% of the total wood content, the recycled</p>	<p>Legislation has not been a driver for changing the situation so far.</p> <p>The only driver might be the very high costs of virgin wood.</p>

				<p>content of the product would be 40%, according to ISO 14021 http://www.wpif.org.uk/LEED_Recycled_Content.asp</p> <p>Another recovery of wood is the energy recovery (energy producers receive subsidies to burn wood).</p>	
Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
Metal for buildings	Demolished or dismantled, the metals are always sorted out, due to its high monetary value.	Market works alone, meaning that the waste collectors sell the recycled materials directly to the producers. There is no regulation at the collection level.	<p>For this material, the producers are also recyclers, meaning that there is no intermediary between the waste collectors and the producers.</p> <p>There are international certification schemes ensuring that wastes coming from metal can be re-incorporated in the production process.</p>	<p>Yes.</p> <p>There is no recycled incorporation rate in the product, but the industry establishes an end of life recycling rate.</p>	Further and stronger legislation could increase the traceability of sorted waste metals (collections schemes).



Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
PV cycle	N/A. Recovery organized by PV cycle itself. In any case, the recycled material has not a high monetary value.	Yes. Photovoltaic are modules that are separated and collected on site.	<p>The market is formed by independent and small recyclers. The effective recycling is in place since 2010, with a volume of around 2.500 tons per annum put on the market.</p> <p>There are no EU specifications for the recycled material, as there is no traceability of the recycled material reincorporated into the production process.</p>	Yes, but there is no re-incorporation rate in the new products.	<p>The WEEE Directive regulates the appropriate treatment of end-of-life products and requires that producers (e.g. manufacturers and importers) of electronic and electrical equipment comply with national waste management obligations, including the related financing and administration. The first and original (2002/96) WEEE Directive dates from 27 January 2003 and was amended in 2003 and 2008. In 2012, PV modules fell under the scope of the WEEE Directive for the first time.</p> <p>Before 2012, industry set up a voluntary approach, by creating an association in charge of organizing the chain. The association has hired 12 persons since 2010 and has a 2 Million Euro budget. The association is basically paid by the recycling fee.</p>



Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
Glass for Europe	<p>Dismantling is essential for recycling.</p> <p>Glass for Europe wishes to introduce mandatory provisions on dismantling and sorting of glass in renovation and demolition works.</p>	Not common.	<p>Reminding that glass is 100% recyclable and can be recycled endlessly without loss in quality or purity, quality requirements are essential for the glass producers.</p> <p>Specifications for a contaminant-free recycled glass exist.</p>	<p>Yes, recycling exist.</p> <p>It is also possible to recycle in open-loop.</p> <p>End-of-Waste status for glass is a possibility.</p>	<p>No. Rather, an EPR scheme in the Netherlands has been established. It works by charging higher landfill costs (landfill gate fee and taxes).</p> <p>In Europe, a yearly amount of around 1.2 million tons of glass waste are generated by construction and demolition of buildings, and by building refurbishment both internal and external. Glass represents 0.66% of the construction and demolition waste stream-</p> <p>http://www.glassforeurope.com/images/cont/167_86498_file.pdf</p> <p>According to Glass for Europe, there is a need to complement legislative requirements with technical recommendations for Member states on collection, sorting and recycling of end-of-life building glass.</p>

Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
Recovinyl	This is not an issue for the sector. The system works with the collection of mixed waste until the transfer stations, where PVC fractions are separated.	No	<p>There is a differentiation between post-industrial and post-consumer waste, with definitions agreed together with the European Commission.</p> <p>The industry considers that the recycled materials become a product once it is available to converters.</p> <p>There is an ongoing discussion for having the End-of-Waste status for the recycled material produced by the recyclers (currently, 106 recycling companies, above all family businesses).</p> <p>The Future of post-consumer waste is uncertain, as it could be labelled as dangerous waste by CLP in the</p>	<p>Recycling techniques exist, but it is basically impossible to know how much percentage is going in each application.</p> <p>A recycling target has been established and it amounted to 240.000 tons to be recycled in 2011, 400.000 tons in 2014, and 800.000 tons by 2020.</p>	No. However, a very firm voluntary agreement (also agreed by the European Commission - DG Enterprise and DG Environment) has been signed by the industry. This shows that there is a strong commitment of the PVC industry to recycle.



			coming months. This is the reason why there is an industry's tendency to use post-industrial waste only.		
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ANNEX II: Characteristics of the gypsum value chain

1. Generation of the gypsum waste

Waste fraction	Production waste (manufacturers) Construction waste (contractors job sites) Demolition/Deconstruction waste (demolition job site) Renovation waste (home owners-citizens, civic amenities, contractors)
Technologies	On site sorting, sorting centers, landfill operations with sorting of gypsum waste, waste collectors, civic amenities
Services	Waste Collection and transport services (UK, France, Denmark, Belgium, The Netherlands)
Stakeholders	Municipalities, contractors, waste collectors, landfill operators, demolishers

2. Dismantling –renovation and demolition waste

Services	Plasterboards needs to be dismantled prior to crushing to be treated
Audit of the building prior to deconstruction	For all construction materials and currently voluntary
Technology	Manual and mechanical dismantling
Sorting on site	Space on site-loading skips
Transport of the waste to the treatment facility (recyclers)	Waste collectors
Stakeholders	Demolishers-waste collectors-recyclers

3. Production waste

Waste fraction	Plasterboards not conformed to standard and/or temporary storage of factory start-up waste
Treatment	Internal recycling on the production site
Transport of the waste to the treatment facility (recyclers)	Waste collectors or recyclers next to the plant except plant runs an own recycling unit
Stakeholders	Producers and recyclers

4. Construction waste

This characteristic of the value chain was not considered in the GTOG project but should be taken into account in the recommendations for a future sustainable roadmap.

Waste fraction	Plasterboard off cuts
Technology	Manual and mechanical
Sorting on site	Space on site-loading skips
Transport of the waste to the treatment facility (recyclers)	Waste collectors
Stakeholders	Contractors-recyclers-waste collectors

5. Waste Treatment - Recyclers

Materials	Recyclable Production, construction and demolition gypsum waste-mixed waste
Technologies	Mechanical crushing, sieving and separation of paper from core as well as separation of other impurities.
Stakeholders	Recycling companies-input phase: waste management companies, transfer stations, production waste from manufacturers, public sorting stations, demolition companies-landfill operators for non-recyclable gypsum waste
Challenges	Formulation and technology innovation Cost effectiveness and pricing Technical support and service Alliances with distributors and key end users

6. Use and reincorporation- manufacturers

Materials	Recycled gypsum
Technologies	Close-loop recycling, re-incorporation in the production process, Open-loop recycling (fertilisers in agriculture), cement production)
Stakeholders	Manufacturers, recyclers

7. Market deficiencies

Cause of Market deficiency	Explanation
Transaction costs in secondary material markets and lack of competitiveness of the secondary material	Arises from different reasons among which: <ul style="list-style-type: none"> • the diffuse and irregular nature of waste generation; • the heterogeneous nature of

	<p>secondary materials;</p> <ul style="list-style-type: none">• the lack of a recycling culture in certain countries• absence of a restrictive national regulation or non-compliance with an existing one• the unfair competition of landfill whose tax is not sufficient to divert tonnages to recycling routes
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ANNEX III-Collection of waste by municipalities

In France and in Denmark, the municipalities play an important role to collect the plasterboard waste and then transport it to the recyclers. This point should be addressed in the recommendation stemming from the project and should be embedded in a future roadmap.

Civic amenity centers enabled GRI's business in Denmark to grow. These provide disposal facilities for private individuals as well as independent builders and small building operators, who are allowed to use the sites for free or are taxed on the waste, depending on the municipality. GRI collects from all civic amenity centers under contract, and nearly all civic amenity sites in Denmark now have a GRI plasterboard container on site. Due to the nature of civic amenity centers in Denmark, up to 50% of all plasterboard waste collected by GRI originates from these centers. The remaining 50% of plasterboard waste recycled originates directly from construction companies, other associated trade companies or through the bulking up of plasterboard waste at waste transfer centers¹⁰.

In France, Siniat, Placoplatre and Knauf organised a network of around 250 collectors to collect plasterboard waste on construction and demolition sites, sort and bring them into one of the eight plasterboard plants (which are Auneuil, Saint Loubès, Carpentras and Ottmarsheim for Siniat, Chambéry, Cognac and Vaujourns for Placoplatre and Saint Souplet for Knauf). France's national gypsum association estimates at 360.000 tons the potential to recover, considering all types of projects: renovation, demolition, but also construction, because the drywall generates off-cuts. The material provided in the factory is transformed (separation of plaster, cardboard and polystyrene) and reincorporated up to 10 to 15% in the production process. Around 66.000 tons were recycled in Plasterboard factories in 2014.

¹⁰ Wrap plasterboard case study-International practice in plasterboard recycling : Denmark

ANNEX IV- Prevention of construction waste

Waste Flows on Construction Sites

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

(i) 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). 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.

g(ii) 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.

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