GYPSUM TO GYPSUM

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

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

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Executive Summary

The GtoG project has put in place an integrated approach to C&D waste by holistic management, starting from the major refurbishment/demolition sites to the reincorporation of the recycled gypsum in the manufacturing process via the processing of gypsum waste as a secondary raw material.
The crucial argument that the project has tried to promote for its entire duration has been that closed loop recycling involves a close collaboration among all the stakeholders throughout the entire value chain: from the dismantling and collection of plasterboard waste in buildings, via the recycling of this waste and culminating with the reincorporation of the recycled gypsum by the plasterboard manufacturing plants, in order to create a highly efficient reverse logistics.
In this sense, the GtoG project will serve to boost the closed-loop recycling route whenever possible.

- Deconstruction: dismantling of plasterboard on the demolition site. Deconstruction enables the quantity and quality optimization of valuable materials, thereby increasing the potential for their future recycling. It results in different waste fractions with minimal damage, due to the time and care taken for separating the waste, in order to achieve the minimal negative effect of its generation.

- The reprocessing of the recyclable plasterboard waste. Once plasterboard waste from construction and demolition waste is separated on site, it can be collected by a third party and transported to a gypsum recycler for processing.

- The reincorporation of the recycled gypsum in the manufacturing process. Once the plasterboard waste has been processed, the gypsum recycler provides the manufacturer with the recycled gypsum that will be reincorporated in the production process.

This document is based on the results achieved by all the project actions and is formed by the following elements:

- A general presentation of the operational environment of the GtoG project, which is characterized by different actors (European, national, local authorities, the full chain of the gypsum industry operators and the consumers) implementing different activities (belonging to legislation and business categories, above all).

- A full assessment of the gypsum value chain, including a deep analysis of the practices and needs of all the actors that are part of the gypsum industry, above all demolition, recycling and manufacturing companies.

- A series of recommendations proposed to the national authorities, to the European Commission and to the gypsum industry, in order to achieve a more widespread implementation of gypsum C&D waste recycling.

1. Introduction

Based on the results of C1.2 and C1.3 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 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 C1.2 and C1.3 will be evaluated by the industrial partners in the frame of C1.4. 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.

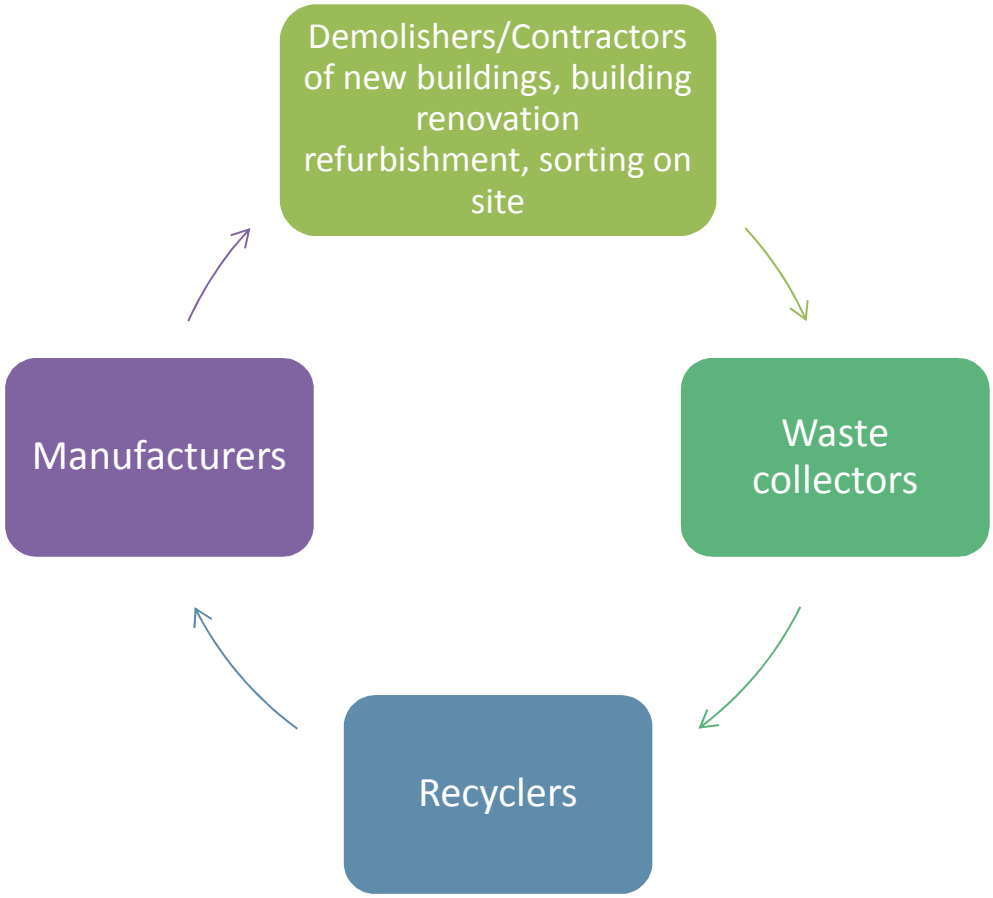
The road map will include strategic assessment criteria, such as:

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. Operational Environment

The operational environment of the GtoG project aims at achieving a circular economy for the operators of the value chain. This is presented in the figure below:



The circular economy necessarily involves a close collaboration and also a shared responsibility among all the stakeholders throughout the entire value chain: from the dismantling and collection of plasterboard waste in buildings, via the recycling of this waste and culminating with the reincorporation of the recycled gypsum by the plasterboard manufacturing plants, in order to create a highly efficient reverse logistics. It will also require the correct implementation of the EU regulation as well as its enforcement.

2.1) Policies/Legislation: opportunities and challenges

The policies and legislation impacting the management of gypsum based waste (GBW) at EU and national level have been fully described in the DA.1 report deliverable.

The legislation tends either to favor the recycling route or to be inexistent. 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. In all the other EU countries, however, buildings are currently demolished rather than dismantled. This happens because deconstruction is generally perceived as more costly.

In relation to the landfill of Gypsum Based waste, on 19 December 2002[1] , the Council took a decision to establish criteria and procedures for the acceptance of waste at landfills. The following paragraph of the legislation applies to gypsum products waste:

Paragraph 2.2.3
"Non-hazardous Gypsum-based materials should be disposed of only in landfills for non-hazardous waste in cells where no biodegradable waste is accepted. The limit values for total organic carbon and dissolved organic carbon given in sections 2.3.1 and 2.3.2 shall apply to waste land-filled together with gypsum based materials".

This decision had the following effects:

- Plasterboards and blocks should be removed from demolition waste destined for disposal in inert landfills. Nevertheless the specifications related the admission in inert landfill give the possibility to have some content of gypsum under a certain limit.
- Waste landfill charges for non-hazardous landfill are considerably higher than those ones for inert landfill. Moreover, dedicated cell rates are higher than normal landfilling cells.
- Disposal capacities may be more limited than those ones for other waste streams, as for amount of gypsum waste available.
- The economic interest of disposal site operators to provide solutions especially for gypsum waste is very limited, which may result in higher transport distances.

The decision took effect on July, 16th 2004 and Member States had to implement it by July, 16th 2005. This Commission Decision implied that the gypsum industry decided to improve recycling of construction waste. The costs related to landfill are definitely higher than before, depending however on the way the different EU Member States apply the decision. **Council Decision 2003/33/EC could be better implemented in 5 out of the 8 target countries, due to the inexistence of specific mono-cells for the disposal of gypsum waste in landfills.**

Only in Belgium, France and the UK specific mono-cells for the disposal of gypsum based waste have been created. In these cases,. only non-recyclable gypsum waste (due to contamination or non-appropriate dismantling practices) should be disposed in these mono-cells.

The decision enabled more recycling of GBW mostly in France, the UK and Belgium but uneven implementation and sometimes non enforcement make

[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

the results relatively unsuccessful though it pushed the producer to recycle construction waste and think towards cooperation with the demolishers for using demolition waste as a resource with prior dismantling of the buildings. We are however at the first steps of this cooperation. Countries such as Germany, Greece and Poland have implemented this Council Decision but no enforcement is observed.

Other legislative incentives to recycle are set at national level. In Belgium, a law requiring 6% gypsum-post-consumer waste in the plasterboard is going to be enacted soon, thereby currently requiring actions to be taken by the manufacturers.
In the Netherlands, gypsum waste may not be landfilled. Gypsum waste was however shipped to Germany for recovery in salt mines. The recovery operations cost far less than the recycling operations. Recovery of salt mines with gypsum waste in Germany was stopped at the end of 2010[2].

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.

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.

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.

The gypsum recyclers face no specific legislation and no requirement in terms of quality of the process and innovation of equipment.

Eurogypsum started a dialogue with the recyclers and hold a meeting with them on 31st October 2014 to understand:

- Whether a certification scheme of their process could enhance the quality of the recycled gypsum;

[2] Thüringer Ministerium für Landwirtschaft, Forsten, Umwelt und Naturschutz; Erlass zum Vollzug der Kali-Haldenrichtlinie (KHR) vom 18. April 2002, Nichtanwendung bzgl. Gipsabfällen; 26. November 2010

- Whether it could be possible to define "recyclable gypsum waste" and "recycled gypsum".

The first steps of an enhanced cooperation between the needs of the recyclers and the needs of the manufacturers started.

The role of landfill costs

In the DA1 deliverable, the following landfill costs were recorded for the countries studied by the partnership (p 253):

Country/Cost for non-hazardous landfilling	**Standard* cost per ton (2013)**	**Gate fee per ton (2013)**	**Landfill tax per ton**
France	80 €	40 to 95 €	17 to 30€
The UK	110 €	13-50 €	85€ (72£)
Germany	20-150 €	20-150 €	0€
Belgium	105€ (wal)	50 €	67,46€ 46,29€ (Fl)
The Netherlands	90 €	90 €	0 € as per 1/1/2013
Spain	80 €	50 - 110 €	3 € (inert)
Poland	N/A	20 to 35 €	65€
Greece	25 to 31 €	10-72 €	35 €/tons as of 1/01/2014 + 5€/year up to 60€

In some countries the cost for segregated gypsum based waste in mono-cells is much higher. **In the UK** for instance, it is around 120€/t. **In France,** the price is lower around 85 to 90 €/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 50 Euro/tons) 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.

2.2) Business options

Whereas European raw materials are becoming scarcer, access to natural resources in the EU is becoming more complex each time, and energy and fuel prices are increasing with the consequent cost production increase, there is a need in the medium term to optimize the use of secondary raw material including recycled material as well as by-product from industrial processes.

However, the recycling market is far from being perfect and inefficiencies can be described as follows:

Causes of market inefficiency	**Explanation**
Price costs in secondary material markets	Arises from the diffuse and irregular nature of waste markets. May also arise from the heterogeneous nature of secondary materials.
Information failures related to waste quality	This is the case of recycled gypsum that does not respect the quality specifications set up by a given manufacturer
Consumption externalities and risk aversion	Perceived production costs associated with the quality of the final products derived from secondary materials. Discontinuity in the volume of raw material received and discontinuity in the quality of the recycled material received.
Technological externalities related to products	Innovations costs of the recycling technologies to process currently non-recyclable gypsum waste.
Market power in primary and secondary markets	Substitution between primary and recyclable materials may be restricted due to imperfect competition and strategic behavior on the part of the firms.

When we speak about market, we refer to different business options aiming at making the value chain mentioned in point 2 more efficient, bearing in mind that the efficiency of the value chain also depends on the monetary

value of the recycled C&D gypsum waste: metal has infinite value and is thus recycled. Plasterboard is a commodity and has little monetary value for the waste collectors, the demolishers or the contractors. Therefore, at the start of the recycling activities, a producer-based approach is sometimes necessary in accordance to the specificities of each country, i.e. the producer takes the initiative of the waste collection from construction and demolition site and municipalities establish internal recycling facilities and ensure the quality of the recycled gypsum.

Before analysing the gypsum value chain more in detail, Eurogypsum met European construction products associations to have an exchange with them on how they strive to recycle their materials efficiently. For that purpose we took the below mapping as a basis of our discussion. The outcome of the qualitative discussion was recorded into minutes. No quantitative data was exchanged.

a. Study on existing/non existing 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?

b. Meetings held

Associations	People	Date
European Insulation Manufacturers Associations (EURIMA)	Jan te Bos, Marc Bosmans, Luigi Della Sala, Christine Marlet	19 September 2014
Metals for Buildings	Christian Leroy, Luigi Della Sala, Christine Marlet	30 September 2014
European Manufacturers of Expanded Polystyrene (EUMEPS)	Edmar Meeuwissen, Luigi Della Sala, Christine Marlet	2 October 2014
PV Cycle	Eleni Despotou, Luigi Della Sala, Christine Marlet	2 October 2014
PV Cycle	Jan Clyncke (MD), Eleni Despotou, Luigi Della Sala, Christine Marlet	13 November 2014
European Panel Federation	Kris Wijnendale, Silvia Melegari, Luigi Della Sala, Christine Marlet	3 November 2014
Recovinyl	Eric Criel	17 December 2014

c. Summary of the exchanges between Eurogypsum and other European materials Associations

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.	No. There is no common discussion about recycling on short term, but rather on long term, because of the following reasons: 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
European Manufacturers of Expanded Polystyrene (EUMEPS)	Deconstruction is essential for recovering polystyrene. However, there is a quantity issue, as volume of C&D waste are gard to estimate and, anyway, not available. There is also a contamination of waste issue as well.	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.	The specifications are independent from producers and they are set at national level. http://epsrecycling.org End-of-waste criteria are not an issue.	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.	Currently no legislation covering the EPS C&D waste, but rather EPS packaging waste (packaging waste directive).

Association	Demolition versus deconstruction	Separate collection on site	Processing of the waste-specifications	Recycling (close-loop-open loop)	Legislation as a driver
Europanels	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). Indeed, deconstruction has to be preferred as to preserve most of the timber present in a building.	Separate collection on site is also considered essential, as wood waste must be cleaned to be re-used again. 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.	There are no official specifications at the moment. End-of-waste criteria are not an issue.	A very good case is that one developed in UK by the wood panel industries federation. 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. 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 content of the product would be 40%, according to ISO 14021 http://www.wpif.org.uk/LEED_Recy	Legislation has not been a driver for changing the situation so far. The only driver might be the very high costs of virgin wood.

				cled_Content.asp Another recovery of wood is the energy recovery (energy producers receive subsidies to burn wood).	

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.	For this material, the producers are also recyclers, meaning that there is no intermediary between the waste collectors and the producers. There are international certification schemes ensuring that wastes coming from metal can be re-incorporated in the production process.	Yes. There is no recycled incorporation rate in the product, but the industry establishes an end of life recycling rate.	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.	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. There are no EU specifications for the recycled material, as there is no traceability of the recycled material reincorporated into the production process.	Yes, but there is no re-incorporation rate in the new products.	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. 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.

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	Dismantling is essential for recycling. Glass for Europe wishes to introduce mandatory provisions on dismantling and sorting of glass in renovation and demolition works.	Not common.	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. Specifications for a contaminant-free recycled glass exist.	Yes, recycling exist. It is also possible to recycle in open-loop. End-of-Waste status for glass is a possibility.	No. Rather, an EPR scheme in the Netherlands has been established. It works by charging higher landfill costs (landfill gate fee and taxes). 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- http://www.glassforeurope.com/images/cont/167_86498_file.pdf 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.

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	There is a differentiation between post-industrial and post-consumer waste, with definitions agreed together with the European Commission. The industry considers that the recycled materials become a product once it is available to converters. 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). The Future of post-consumer waste is uncertain, as it could be labelled as dangerous waste by CLP in the coming months. This is the reason why there is an industry's tendency to use post-industrial waste only.	Recycling techniques exist, but it is basically impossible to know how much percentage is going in each application. 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.	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.

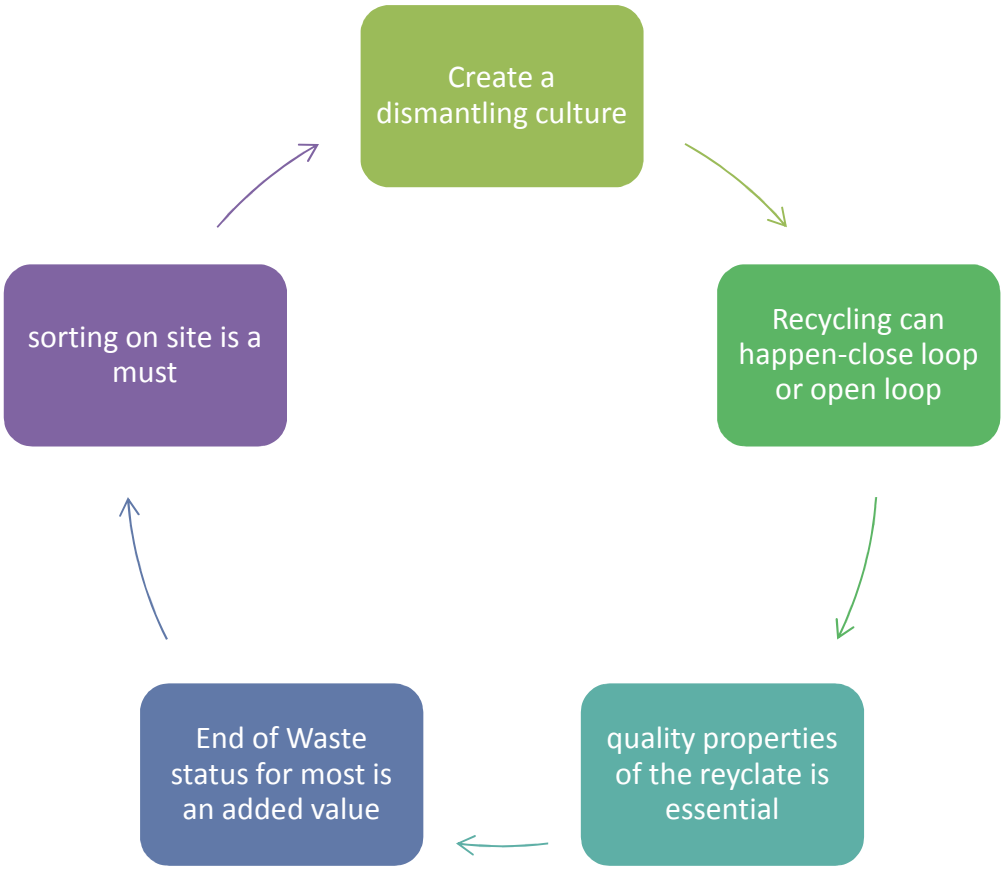
d. Similarities and differences between plasterboard waste management and the other C&D waste streams

Commonalities	Differences
Create a dismantling culture: Europanels-Glass for Europe-Eurima-Eumeps-the market is not functioning or starting to function-price of the waste material insignificant Price of virgin wood is high but is not recovered from buildings today, but from other sources	For metals: the dismantling is less an issue as the material is sorted thanks to its high monetary value (there is a functioning market)
Separate collection a must for Eurima- Glass for Europe-PV cycle-Europanels-Eumeps Not a must for PVC and metals	For metals: waste collectors with an unclear market functioning but For Glass: the obtention of the cullet must be contaminants free. After wards, re-incorporation into the manufacturing process. So clean sorting is important PV cycle: network of collectors points fully developed (extended producer responsibility as per the WEE Directive)
Waste specifications and end-of-waste for Glass - End-of-waste criteria exists at EU level for glass cullet Metals-end-of waste for Iron and steel scrap metals and copper and copper alloy, aluminum and aluminum alloys	Eurmeps: national specifications, no end-of-waste- status Eurima: no specifications Eurogypsum: national end-of-waste status (UK) and fully developed specifications at national level (Germany, UK) Wood: specifications between producers and collectors but no end-of-waste Photovoltaic: no-end-of-waste status-no clear specifications PVC: consider the recycled material as products once it reaches the door of the converters (image question)-PVC is REACH registered and thus a product.
Commonalities	**Differences**
Close-loop: metals-gypsum-EPS-	

Mineral wool-wood-glass **Open-loop**: gypsum-EPS-wood-glass PV cycle-PVC	
Re-incorporation rate: existing for gypsum and wood panels	Metals: no re-incorporation rate in the product Eurima: idem Eumeps: idem PV Cycle: idem PVC: idem
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 **FOR ALL**: the output to be re-incorporated must be contaminant free (mechanical or chemical contamination)	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 Conclusion: no intermediary between the producers and the collectors-no recyclers PVC: yes mechanical recycling-Yes recycling industry
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 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	No specific legislation to our knowledge

e. Conclusions

As far as this analysis is concerned, we can see the following main common issues:



f. EPR schemes

Among the material producers Eurogypsum met, the extended producer responsibility differs.

- **Producer responsibility and voluntary agreement**

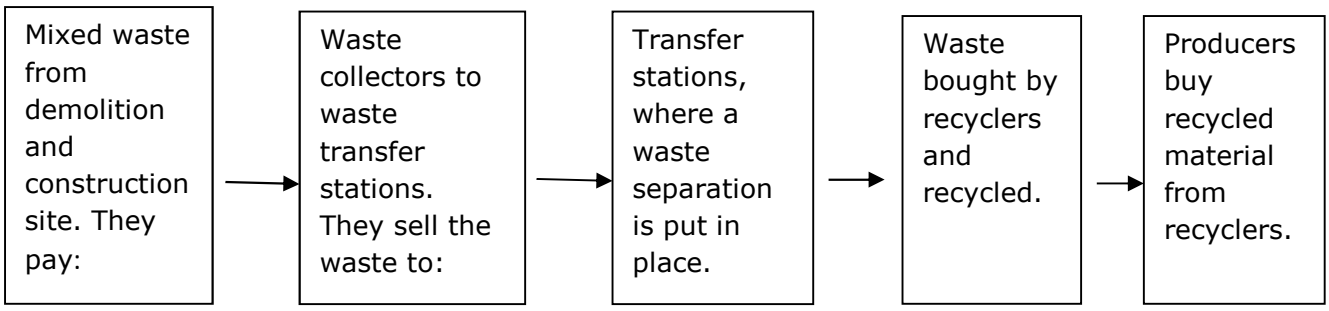
The PVC industry entered in a voluntary agreement with the European Commission in 2003. The voluntary agreement acted as a legislative leverage tool. Recovinyl was then created.

In 2014, Recovinyl reached 400.000 tons recycled PVC in Europe where PVC is produced. The have 106 certified recyclers and a firm commitment of the converters to reincorporate the recycled material from the certified recyclers in PVC applications. Quality specifications of the recycled material are set between the recyclers and the converters.

An audit of the recyclers is carried out every year and is paid by Recovinyl. The tonnage of recyled PVC is entered into the Recovinyl website database. The association budget is around two million Euro per year (paid by the PVC industry) covering:

- 1,5 person at European level
- Auditors costs
- Office cost
- Waste experts in charge of making contracts with transfer stations and municipalities

In 2003, to incentivise the market, Recovinyl paid each recycler 50/tons PVC collected at transfer stations. Today the price went down to 10 Euro per tons collected.
The business model is market based and works as follows:



The model works so that each part of the value chain has market, market output and business margins. A market win-win situation between recycler, manufacturer and waste collectors was created.

To create a recycling market, the recyclers need:

- a consistent source of waste material to process,
- a market for the recycled material,
- a margin on its business.

The Recovinyl certification system helps the recyclers to:

- Give the recyclers the opportunity of registering your recycling volumes into a centralised system;
- Locate customers who may be interested in buying material from a certified Recovinyl recycler;
- Raise the recycler profile so that they can gain new sources of quality PVC waste feedstock from collectors and the manufacturing and installing industries.

It took 10 years to reach a mature system all over Europe.

Producer Responsibility and WEEE: implementation of the extended producer responsibility

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.

In 2007, the PV industry was already recycling and had set up a no-profit organization to push for recycling. However, the mandatory legislation obliged them to organize their activity in a more professional way.
PV cycle members are:

- all manufacturers
- all importers
- companies which are reselling under their name
- companies which trademark PV modules manufactured by other supplier

Each module sold on the market includes a recycling fee. The association is basically paid by the recycling fee. In 2014, the budget was around 2 Million Euro

- 7 persons
- Organization of collection point and waste disposal services
- 5 country manager (Italy, Belgium and Netherland, France, Germany)

Since 2010, 2.500 tons of photovoltaic materials have been recycled each year. The cost of the recycling system lies on the shoulders of the buyer of photovoltaic.

- **Producer Responsibility: the case of flat glass in the Netherlands[3]**

The **Netherlands**' system, operated by a Foundation (VRN), is certainly the most mature – at least the oldest – model of all, however one must have in mind two of the country's specificities:

Glassmakers pay an eco-fee which finances part of the collection system (i.e. there is an Extended Producer Responsibility system). The scheme is mostly financed through a waste management levy (waste disposal fee) of **0.50 € per square meter of insulated double or triple glazing**

[3] Sustainable construction. Recycling of building glass waste-20 September 2013-Biointellegenc service

produced in or imported into the Netherlands (not for single glazing). Every manufacturer and importer is obliged to pay the charge. The 2012 **operating result is negative** (VRN loses 5 € per tons collected) but VRN can lose money as long as the waste management levies of previous years cover this lost.

Contrary to all other EU countries where experts have been questioned , window and glazing frames are "fixed" in building walls in the Netherlands, i.e. that walls are originally built around the frames which are part of the building structure (in other countries walls are built with "holes" left for windows and their frames). This makes particularly easy the removal of windows from their frames at the building renovation or demolition stage.

- **Conclusions**

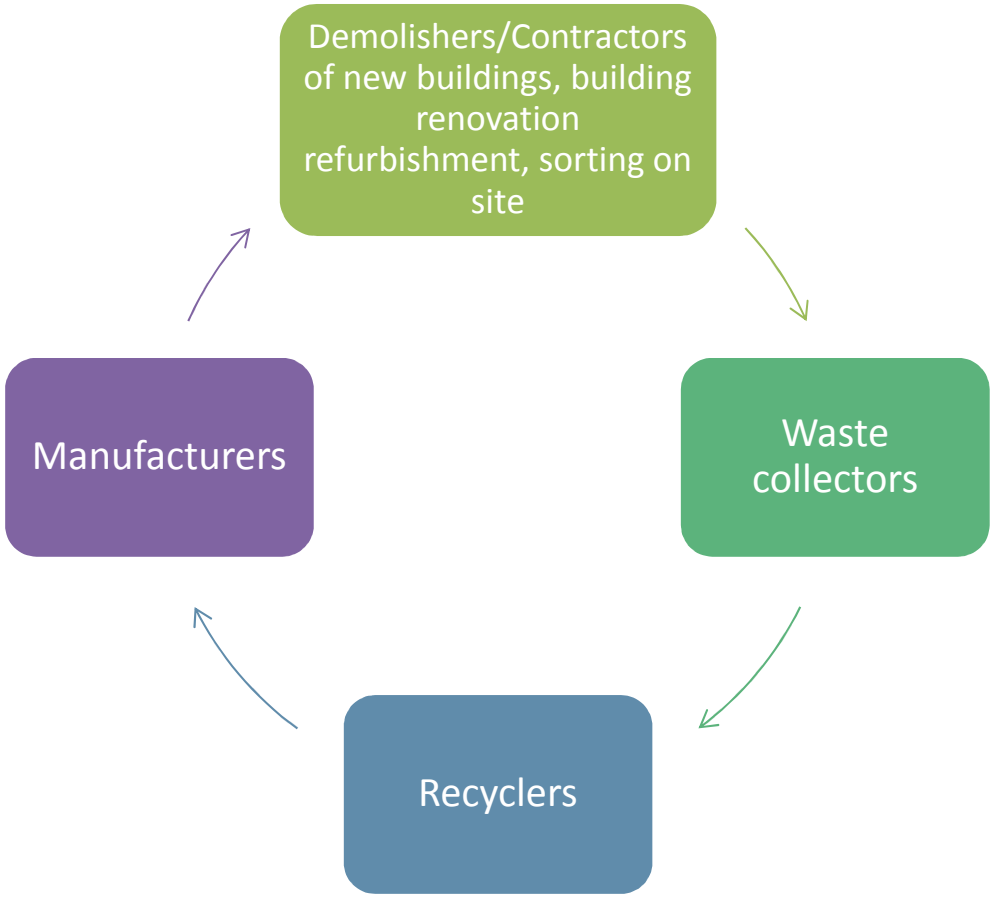
Extended producer responsibility (mandatory or voluntary) means that the costs and the organisation of the value chain fall on the shoulder of the producer who transfer the costs to the consumer via an additional tax (called recycling fee) on the product.

We can raise the following questions in relation to the producer responsibility that other manufacturers of construction materials may face:

- Is an EPR system really cost-effective?
- Does a recycling route need to be created under an EPR scheme to exist and to work efficiently?
- Would a recycling fee on the plasterboard sold in DIY or in wholesale distributors be a market based instrument to make an EPR system cost effective and also recycling effective?
- Alternatively, can private take-back schemes like we have in France and the UK (British gypsum and Placoplatre and Siniat who have in place agreement with collectors to recover the plasterboard waste) be replicated at a national scale? If yes, what investment (in terms of time, research & development, and machines) is needed from industrials?
- Can recyclers cover dismantling / sorting / recycling costs without any financial support? If not, which support can be brought to industrials? At which stage? And for how long? How to anticipate crisis period in the construction sector?
- Would an EPR system be acceptable even if the recycled tonnages are not reincorporated into the manufacturing process?

3. Gypsum value chain

The gypsum value chain is as follows:



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 centers[4].

In France, Siniat, Placoplatre and Knauf organised a network of around 250 collectors to collect plasterboard waste on construction and demolition sites,

[4] Wrap plasterboard case study-International practice in plasterboard recycling : Denmark

sort and bring them into one of the eight plasterboard plants (which are Auneuil, Saint Loubès, Carpentras and Ottmarsheim for Siniat, Chambéry, Cognac and Vaujours for Placoplatre and Saint Soupplet 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.

3.1) Characteristics of the gypsum value chain

- **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

- **Dismantling –renovation and demolition**

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

- **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

- **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

- **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

- **Use and reincorporation**

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

3.2) Identification of 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: • the diffuse and irregular nature of waste generation; • the heterogeneous nature of secondary materials; • 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

The DA1 deliverable 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. This report reached an estimation of the gypsum based waste generation (please see table below). 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.

GYPSUM TO GYPSUM

ESTIMATION OF TOTAL GYPSUM BASED WASTE GENERATED IN 2012 (IN TONNES)-A1 report								
Country	Sold volume of gypsum based products (m^2)	Population	Consumption of gypsum based products* (square meter per capita)	Consumption of gypsum based products* (square meter)	Consumption of gypsum based products (tons)	New construction waste (tons)	Demolition and renovation waste (tons)	Total gypsum based waste generated (tons)
						10% of total consumption	50% of new construction waste	
Belgium	Confidential	11,094,850	2.54	28,201,500	239,727	23,973	11,986	35,959
Germany	264,956,532	81,843,743	2.33	190,769,490	1,621,638	162,164	81,082	243,246
Greece	Confidential	11,290,067	1.08	12,182,500	103,557	10,356	5,178	15,534
Spain	100,504,000	46,196,276	1.44	66,551,649	565,723	56,572	28,286	84,858
France	292,711,321	63,409,191	4.49	284,636,700	2,419,557	241,956	120,978	362,934
The Netherlands	Confidential	16,730,348	2.14	35,871,000	304,922	30,492	15,246	45,738
Poland	105,272,000	38,538,447	1.71	66,020,816	561,211	56,121	28,061	84,182
The UK	221,100,410	63,256,141	3.46	218,639,790	1,858,550	185,855	92,927	278,782
TOTAL	**984,544,263**	**-**	**-**	**902,873,444**	**7,674,885**	**767,488**	**383,744**	**1,151,233**

Cause of market deficiency	Explanation
Consumption externalities and risk aversion	Perceived production costs associated with the quality of the final products derived from secondary materials. Discontinuity in the volume of raw material received and discontinuity in the quality of the recycled material received.

Recycled gypsum specifications exist. In the UK they are formally approved by the government. However, we face failure in implementation. Indeed, though certification schemes are foreseen in the Pas 109, recyclers do not necessarily implement them. The result is that improper recycled gypsum is placed on the market mainly in the agricultural fields as fertilizer. As a consequence, the UK government decided to prohibit the use of recycled gypsum as fertilizers. Grauki [5], the UK recycler association and the gypsum manufacturers wish thus a certification ensuring the quality process of the recycled gypsum.

Quality of the recycled gypsum is a question of enhanced partnership 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. The three recyclers within the project do currently prefer no certification scheme advocating cost reason. However, in the meeting that Eurogypsum organized with community of gypsum recyclers, 7 were in favor of a certification scheme. In the UK, the manufacturers experienced that the specifications were not implemented and led to polluted recycled gypsum. One way to avoid this is the certification of the recycling plant;
- Achieve high quality of recycled gypsum- via the establishment of quality criteria (technical and toxicological).- In the project, we prepared a guidance documents for the establishment of quality criteria for recycled gypsum. Those need to be refined after the project in cooperation with the gypsum recyclers' community.
- 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. However, the three

[5] http://www.tradebemineralsrecycling.co.uk/minerals-recycling-news/grauki-uk/

recyclers in the project do not feel that EOW will impact the quality of the recycled gypsum. In the meeting Eurogypsum held with the community of gypsum recyclers, 9 felt that a EOW status was important;
- Definition of the recycled gypsum;
- Definition of the recyclable gypsum. The community of gypsum recyclers is willing to have a definition but in contrast to a definition of recycled gypsum it is not easy to create one. This needs to be further discussed;
- Lessons learned from the development of the guidelines specifications;
- Establishment of Waste acceptance criteria for countries not covered by the project.

In the project, we discussed the way towards obtaining the end-of-waste status for the recycled gypsum. Though the manufacturers are favoring this approach, recyclers are not today inclined to strive for such a status which includes on their side to take step towards a quality management system of their process. In the framework of the project, the recycled gypsum produced stems from 2 recyclers and one manufacturer who recycles construction and demolition gypsum waste. We only cover four countries: UK Germany, France and Belgium.
It is also the first time that an external laboratory analyzed the recycled gypsum and that the results are compared to the existing specification developed so far (see report A1 and B2.2 report).

We have thus 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. We thus opted to develop guidelines for the quality requirements of the recycled gypsum (technical and chemical parameters).

The aim of those guidelines is to have a reference for all plant outside the project which can be cross-checked with the reality of that plant and with the production of that recycler which is not a partner of the project today. The guidelines are a dynamic tool and are called to evolve with time in a cooperative mode with the gypsum recyclers and with the development of the recycled gypsum market. This is a task to be carried out after the project, ideally in a cooperation frame set up by both recyclers and producers.

During the project, Eurogypsum took the initiative to organize a meeting with the gypsum recycler's partner to the project and gypsum recyclers which are not partners to the project to discuss the above-mentioned. This meeting also covered producers who are at the same time recyclers, which is the case of SINIAT France, British Gypsum (recycling construction and

production waste, not demolition waste) in the UK and Placoplatre in France (Cognac).

The recyclers participating in the meeting- which was based on a questionnaire that the recyclers received previously- were

First name	Name	Organisation	Country
Martin	Bonaimé	Siniat	France
Mark	Hatfield	Roy Hatfield Ltd	UK
Sébastien	Biehler	Ritleng Revalorisations	France
Jean-Luc	Ritleng	Ritleng Revalorisations	France
Jörg-Michael	Bunzel	MUEG	Germany
Hermann	Hahn	Strabag	Germany
Martin	Eves	EGRS	Ireland
Jan Willem	Derks	EGRS	Ireland
Gilles	Nanet	Nantet Locabennes	France
Jean	Keutchayan	Nantet Locabennes	France
Heidi	Barnard	British Gypsum	UK
Martine	Meijering	GRI	The Netherlands
Maarten	Hendricks	NWGR	Belgium
G	Kok	Gipsnet	The Netherlands

We had 13 answers from the recyclers covering end-of-waste status, certification schemes, cross-contamination, definition of recyclable gypsum waste and definition of recycled gypsum.

In relation to a definition of the output (recycled gypsum), a consensus seems to have arisen to define it as a material which is produced by recycling plants from gypsum-based waste (EWC 17 08 02) and which meets standards and quality requirements of the gypsum manufacturers. So we need to have an agreement between manufacturer and recyclers on the quality requirements of the recycled materials to be re-incorporated in the manufacturing process. Indeed, recycled gypsum is not necessarily a re-incorporable recycled gypsum.

In relation to the criteria for accepting recyclable waste as input at the recycling plant stemming from collectors or demolishers and after discussion on the replies, it was concluded that: it is not possible to define clear parameters (quantitative) for the term recyclable. It depends on recycler, on country and techniques.
It is the responsibility of each recycler to define the criteria against which the recycler will assess that the plasterboard waste load is accepted or rejected it. The

recyclers will also take into account the cross-contamination factor, i.e. When it comes to demolition and deconstruction in particular, there is a risk that gypsum waste is contaminated by other (construction building) materials in trace levels (inorganic impurities e.g. heavy metals and organic impurities).

However, a definition is seen as having an added value and still need to be worked out.
In the A1 and B1 report, UPM analysed the recyclability and waste acceptance criteria for gypsum-based waste with the following results:

ACCEPTANCE CRITERIA PER COUNTRY for recyclable gypsum waste (input)()(only valid with the recyclers participating in the GtoG project and not in the whole country)		FR	BE	UK	DE
GENERAL ISSUES	Free moisture content	Not limited			<10% in weight
	Max percentage of IMPURITIES (insulation material, wood, metal, plastic, foils, concrete, sand, wallpaper, glass tissue and other wall coverings…)	2%			2-3%
GYPSUM BASED PRODUCTS	Plaster ceilings and floors	✓	✓	✓	✓
	Ceiling plaster tiles*	✓	✓	✓	✗
	Glass reinforced gypsum (GRG) products	✓	✓	✓	✓
	Moulds / cove	✓	✓	✓	After approval
	Moulds used in foundry*	✓	✓	✓	After approval
	Plaster powder	✓	✓	✓	✓
	Plaster block	✓	✓	✓	✓
	Honeycomb plasterboard	✓	✓	✓	✓
	Plasterboard bonded to expanded polystyrene(EPS) , glass or rock wool, polyurethane (PU) **	✗	✗	✗	✗
FINISHING	Wallpaper	✓	✓	✓	✓

	Glass fibre wallpaper and vynil lining	✗	✓	✓	✓
	Lead based paint	✗	✗	✗	✗
OTHER	Autoclaved aerated concrete (AAC)	✗	✗	✗	✗
	Hazardous materials, e.g. Asbestos	✗	✗	✗	✗
	Gypsum fiberboard*		✓	✓	Limited
	Hardened boards*	✓	✓	✓	✗
	Cement bound boards*		✓	✓	✗

***In these cases gypsum waste isn´t accepted by all plasterboard producers in FR.**
****Plasterboard can be recycled when it is separated from the insulation. Recyclers involved in the GtoG project don't accept insulated plasterboards.**

General specifications permit between 2% and 3% of impurities, and generally make no reference to the limit of moisture content, but for Germany which restricts it up to 10% in weight. Nevertheless some recommendations to keep the loads dry are made by some recyclers.

Gypsum blocks, gypsum ceilings, floors, walls, molds and glass reinforced gypsum products are accepted by most of the countries under the study. For the case of molds for foundry, gypsum is highly calcined, hence not retaining its properties and in certain countries its recycling is submitted to approval.

Plasterboards with cement or high organic content (such as cement bound, gypsum fiberboards, etc.) are not accepted in some cases, as they are considered to reduce the quality of the recycled gypsum. Autoclaved aerated concrete is often perceived as gypsum waste fraction, being a different product not suitable for the recycling process. Paint is not an issue, with the exception of lead based paints and vinyl lining or glass fiber wallpapers. Hazardous waste is always forbidden in the load.

- **How to incentivise the recycler to have their recycling process certified by a quality management system**

The manufacturers will take the production costs risks of changing their process if constancy in volumes and constancy in quality are ensured. Otherwise, recycling will happen irregularly and used as a side resources, rather than as a key resource.

Partnership between recyclers and manufacturers should be further enhanced as well as trust. Trust is the key to build a long-term business relationship (delivery and taking delivery contract).

In France, the French association of construction and demolition waste recyclers developed a certification scheme of C&D waste for all the operators involved.

This certification scheme goes beyond a pure conformity to regulatory requirements:

- It aims to identify and formalize the good practice of the profession with objectives in terms of performance for recognition of the profession and enhance the expertise of its members,
- It also aims to gradually bring them to industrialize their sorting and recycling of construction waste and thus gain a competitive advantage.

This approach will enable:

- The Union of Construction Recyclers to engage all members in an improvement process for the recognition of their professionalism and associate them to the 2020 goals to enhance 70% of non-hazardous waste BTP;
- Companies to assess their strategic positioning towards customers displaying their ambition to become major player in waste management and guaranteeing their mission of service in the state of the art.

The label will be issued after an audit by an external service provider. This quality management system developed in partnership with the consultant RECOVERING studies and support of ADEME is recognized as part of the waste management exit procedure..

Technological externalities related to products	Innovations costs of the recycling technologies to process currently 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.

Market power in primary and secondary markets	Substitution between primary and recyclable materials may be restricted due to imperfect competition and strategic behavior on the part of the firms.

The gypsum industry uses FGD gypsum in high volume. There is no power market between primary and secondary raw materials as long as the quality of the secondary raw material is proven and as long as the constancy in volumes is ensured. The business risk perceived by the industrial partners are still high as partnership and trust should be further developed between recyclers and manufacturers for an industrial use of recycled gypsum.

3.3) Current market functioning and pricing structure

There is no real mature market for recycled gypsum yet. Actors are acting to respond to urgent market incentives.

In the UK, the voluntary agreement between government, industry, recyclers and contractors – in place since 2006 - enhanced the recyclability of plasterboard construction waste though much still must be carried out in the field of demolition waste. It also enabled to fix the end-of-waste status of the recycled gypsum and qualification criteria for recyclers.

Siniat UK recycle C&D stemming from various recyclers among them NWGR but not solely, while British gypsum has set up collection take-back schemes for construction waste as well as internal recycling facilities.

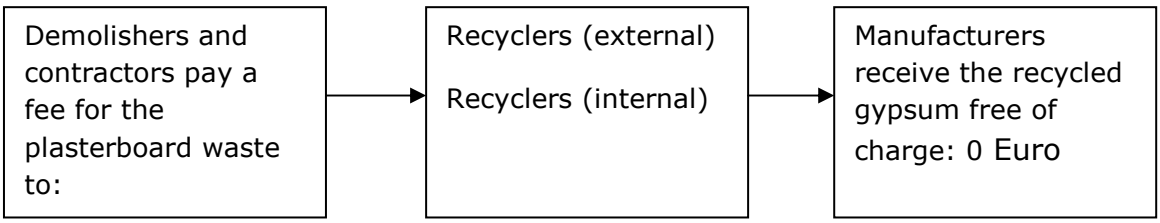
In France, the industry committed to recycle with a declaration of intention. The French government supported this declaration, as natural gypsum is a non-renewable source and one of the main resources in France, and the optimization of recycling meant, thus, the optimization in the use of gypsum. Placoplatre organised a network of collection point for mainly construction plasterboard waste. For the recycling, they rely on internal recycling facilities, with two recyclers (NWGR and Nantet Locabennes). In this specific case, NWGR and Nantet Locabennes do not collect plasterboard waste. Waste and recycled gypsum logistics are organised by the manufacturers.
Always in France, Siniat has internal recycling facilities in Auneuil, Saint Loubès and Carpentras, where construction & demolition waste are accepted by the manufacturers gate according to waste acceptance criteria. Collection is done through a network of 150 collection points throughout France. A dedicated team constantly develops the network. In Alsace, at Ottmarsheim, Siniat relies on the services of an independent recycler Ritleng Revalorisations.

In Belgium, a forthcoming mandatory recycled content in the plasterboard may lead the actors to organise the value chain in a more professional way. Today, production, construction and demolition waste in the Flanders region arrive at Saint-Gobain Gyproc in Kallo and are re-incorporated in the manufacturing process of Saint-Gobain Gyproc. The green procurement requirement of 6% post-consumer waste in the plasterboard will lead to a more competitive market where each manufacturer will need to organise a recycling value chain.

In Scandinavia, and mostly in Denmark, a network of collection of C&D waste both from construction and demolition sites as from households, has been put in place by GRI who send the recycled gypsum to the plasterboard manufacturers. There is thus a market functioning with one recycler being the collectors of C&D waste and the manufacturer. For the time being, there is neither end-of-waste status nor a qualification scheme for recyclers.

In Germany, the recycling value chain is starting since the closure of the Kalihalden for recovery operation of untreated plasterboard waste. The German association has delivered quality criteria for the recycled gypsum to reach a product status in December 2013. Two recyclers have started activities in 2014. However, the German association now faces the issue of plasterboard waste being shipped from some Federal States, e.g. Leipzig/Saxonia (where one recycler recently started recycling operation) to the Czech Republic for low price recultivation and backfilling operations not observing the waste hierarchy according WFD (recycling higher priority than other recovery). Now, recycling in Leipzig is working at reduced capacity and may be stopped.

The market pricing structure is as follows:



The recycling gate fee is around 55 euro (A1 report). The Recycling route is feasible if landfill costs are higher than 55 Euro
However, all the figures presented above are based on a case study and variations can be found in different EU countries. .

4. Towards an efficient gypsum recycling value chain

4.1) Recycling versus landfill route costs based on a case study

Based on the below logistic chain, on the estimated amount of gypsum based waste, on an average cost of 336 Euro/tons dismantling and on an average transport cost of 43 Euro/tons (example of the case study in France A1 report), we can assess that the recycling route for the countries studied in the project could become an economic value if we reached 100 Euro/tons landfill costs.

However, the economic value also depends on:

- The durability of the plasterboard in the buildings.
- The actual and real dismantling of all buildings small and big.
- The real recyclability of the plasterboard waste. Which percentage of the waste received today is not acceptable and goes to landfill?
- The quality of the recycled gypsum to be re-incorporated in the manufacturing process.
- The technological improvement in the recycling and manufacturing process.

Estimation of benefits of the recycling route versus landfill costs based on a pilot study developed within the GtoG project											
Country	Total GBW generated in 2012 (tons)	Estimated 35% uncertainty about total GBW generated	Estimated total GBW	Dismantling costs of plasterboard 336 Euro/ton-case study A1 report	Transport cost from jobsite to delivery site-43 Euro/ton-case study A1 report	Recycling gate fee 55 Euro/ton	**Total costs for recycling**	Landfill costs 30 euro/ton	Landfill costs 100 euro/ton	**Total costs landfill 30 euro**	**Total costs landfill 100 euro**
Belgium	35,959	12.585,65	23.373,35	7.853.445,6	1.005.054,05	1.285.534,25	10.144.033,90	701.200,50	2.337.335	9.559.700,15	11.195.834,65
Germany	243,246	85.136,10	158.110	53.124.960	6.798.730	8.696.050	68.619.740	4.743.300	15.811.000	57.868.260	75.734.690
Spain	84,858	29.700,30	55.158	18.533.088	2.371.794	3.033.690	23.938.572	1.654.740	5.515.800	22.559.622	26.420.682
France	362,934	127.026,9	235.908	79.265.08	10.144.044	12.974.940	102.384.072	7.077.240	23.590.800	96.486.372	112.999.932
The Netherlands	45,738	16.008,3	29.730	9.989.280	1.278.390	1.635.150	12.902.820	891.900	2.973.000	12.159.570	14.240.670
Poland	84,182	29.463,7	54.719	18.385.584	2.352.917	3.009.545	23.748.046	1.641.570	5.471.900	22.380.071	26.210.401
The UK	278,782	97.573,7	181.209	60.886.224	7.791.987	9.966.495	78.644.706	5.436.270	18.120.900	74.114.481	86.799.111
TOTAL	**1.135.699**	**397.494,65**	**738.207,35**	**248.037.669,60**	**31.742.916,05**	**40.601.404,25**	**320.381.989,90**	**22.146.220,50**	**73.820.735**	**295.128.076,15**	**353.601.320,65**

4.2) Creating a dismantling culture in the value chain

The application of plasterboard splits into three traditional sectors

- House building: 30%
- Commercial/Industrial: 30%
- Repair-maintenance-improvement: 40%

As stated in the A1 report we have three types of gypsum waste:

- Production waste
- Construction waste
- Demolition waste

The three sources are currently mixed and re-incorporated in the production process as none of those sources alone can make a business case for recycling due to low volumes.

However to recover plasterboard waste from demolition site, the demolishers must dismantle/deconstruct the building. If not, the crushed buildings produce mixed C&D waste which is sent to landfill for non-hazardous, and the GBW cannot be recycled in this case. The inert waste is contaminated by the GBW.

In the UK, Belgium and France, dismantling practices are present but they need to be strengthened and harmonized all over Europe to increase recycling rates.

In addition to the economic feasibility of dismantling/deconstruction versus demolishing, 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, at least for buildings above 1.000 square meters.

The word demolition covers what is called selective demolition. The word demolition is used indifferently for both selective and conventional demolition. There is thus maybe a need to clarify the words and have a clear definition to cover the selective demolition, usually called deconstruction.

The sector is aware of its responsibility to be sustainable and to strive for increased recyclability of demolished materials even though they are commodities.

Recently 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.

In the summer of 2014 the Flemish Building Confederation (VCB), the Confederation of demolition and dismantling contractors (CASO), the Federation of producers of recycled aggregates (FPRG) and the Organization of consulting engineers – and consultancies (ORI), created a new system to handle and track all demolition and decontamination waste.

Prior to the demolition and/or decontamination of a building (or infrastructure), an expert will do an inventory about all the waste and hazardous substances found. Following this initial inventory, demolition and/or decontamination works will carry on, with the obligation of contractors to handle properly each waste stream and provide the documents to justify all the recycling or disposal operations.

Conclusion of report B1

The way the gypsum-based systems can be deconstructed is key in the recyclability of the gypsum-based materials. The techniques must allow to gather as much gypsum-based materials as possible and to separate it easily from the other materials which are not allowed in the criteria acceptance of the plaster-based products recyclers. The economic impact is predominant in the choice of deconstruction techniques compared to demolition but it is not the only parameter to take into account.

Although the demolishers have an important role to play on the recyclability of the gypsum-based materials, they are not the only ones who will impact the recyclability. At the end-of-life of a building and of a system, the options that the demolishers have mainly depend on the choice of the system and of the implementation that had been made during the design and the construction of the building. Thus several other players have a key role to play much before the end-of-life of the building: the plasterboard manufacturers that manufacture and launch on the market their products (design for recycling), the project owners and project managers that give instructions regarding the choice of a system instead of another and regarding the coating for instance, and the construction companies that implement the system.

To close the loop, at each step, these players have to keep in mind that the building or at least some parts of the buildings and systems will be deconstructed one day and make their choices consequently. As far as gypsum-based systems are concerned, to make choices as relevant as possible, the project owners, the project managers and the construction companies have to take note of the existence of recycling routes locally and of the specifications of the recyclers (that could evolve) as well as the demolition companies.

4.3) Results of the indicators

DC1 report on best practices indicators for deconstruction, recycling and reincorporation practices provides insight on the development of Key Performance Indicators (KPIs) and presents a set of Best Practice Indicators (BPIs) aiming to increase the amount of gypsum waste capable of being recycled, as well as to maximize the quality and percentage of recycled gypsum that can be reincorporated in the manufacturing process.

Practices implemented through the whole End-of-Life (EoL) of gypsum plasterboard have been assessed. That is to say, from the building deconstruction, through the gypsum recycling (processing), to the reincorporation into the manufacturing process. Key Performance Indicators (KPIs) are formulated and used to monitor and compare practices implemented in the five GtoG pilot projects.

The report presents a set of 37 Key Performance Indicators (KPIs) and the selected 29 Best Practice Indicators (BPIs), presented in the figure below. These BPIs address the entire gypsum value chain (deconstruction, recycling and reincorporation), being classified per category: technical, social, economic and environmental; and per stage: pre-deconstruction audit, gypsum-based systems deconstruction, gypsum waste traceability, end route, reception by the gypsum recycler, storage, processing and transport of the recycled gypsum, reception by the plasterboard manufacturer, storage, reincorporation, pre-processing and plasterboard manufacturing.

The defined analytical framework can be used as a decision-making tool helping to increase the effectiveness of the gypsum EoL recycling route, measuring the performance and progress of gypsum waste management, detecting the possibilities of improvement as well as monitoring changes over time.

CATEGORY	STAGE	DECONSTRUCTION BPIs
TECH	Audit	TECH1. Existence and deviation of the audit for gypsum systems
	Deconstruction	TECH2. Effectiveness of the deconstruction process
	Traceability	TECH3. Effectiveness of the traceability
ENV	End route	ENV1. Gypsum waste sent to landfill
		ENV2. Transport emissions comparison between recyclnig and landfilling
SOC	Deconstruction	SOC4. Training of the deconstruction team
		SOC5. Follow-up of the waste management
ECO	Traceability	ECO4. Cost difference between recycling GW and landfilling route
		RECYCLING BPIs
TECH	Reception	TECH1. Quality of the gypsum waste received
		TECH2. Gypsum waste rejected
	Storage	TECH3. Warehouse storage capacity for gypsum waste
	Processing	TECH4. Output materials of the recycling process
ENV	Processing and transport	ENV1. CO_2 Emissions from the recycling process ENV2. Natural gypsum saved
SOC	Reception	SOC1. Recycler's satisfaction
		REINCORPORATIOIN BPIs
TECH	Reception	TECH1. Recycled gypsum rejected by the manufacturer
		TECH2. Recycled gypsum quality criteria
	Storage	TECH3. Recycled gypsum required space for storage
	Reincorporation	TECH4. Recycled gypsum content
		TECH5. Recycled content increase
	Production	TECH6. Production waste
ENV	Preprocessing	ENV1. CO_2 emissions: business-as-usual compared to maximized recycled content in the pre-processing
	Manufacturing	ENV2. CO_2 emissions: business-as-usual compared to maximized recycled content in the production
SOC	Manufacturing	SOC1. Manufacturer's satisfaction
ECO	Reception	ECO1. Cost difference between business-as-usual and maximized recycled content quality check
		ECO2. Cost difference between natural gypsum and recycled gypsum
		ECO3. Cost difference between FGD gypsum and recycled gypsum
	Preprocessing	ECO4. Energy cost difference between business-as-usual and maximized recycled content in the pre-processing
	Manufacturing	ECO5. Energy cost difference between business-as-usual and maximized recycled content in the production process

a. Evaluation of the results for demolition (indicators of C1.1 sub-action)

Best practices are implemented during the deconstruction process if:

- A pre-deconstruction audit for gypsum systems exists, and a minimum deviation compared with the real amount and type of gypsum waste generated results.
- There is no presence of impurities in the gypsum waste, and as a result there is no recyclable gypsum waste refused by the waste outlet.
- All gypsum waste generated is tracked.
- There is no recyclable gypsum waste sent to landfill.
- Transport emissions are kept as low as possible.
- Trained workers are in charge of the dismantling, sorting and storing processes.
- At least one person is appointed to follow-up the waste management including the tracking records.

- When comparing the cost of recycling and landfilling, which include the rental of skips, unloading and loading operations, recyclers' gate fee and tax, the cost of recycling is favourable.

b. Evaluation of the results for recycling (indicators of C1.1 sub-action)

Best practices are implemented during the recycling process if:

- Gypsum waste at the recycling plant complies with the recyclers' waste acceptance criteria thus no gypsum waste is rejected nor sent to landfill.
- A properly dimensioned storage place is set up in order to guarantee a constant feedstock, avoiding further presence of impurities and moisture content at the same time, once received.
- Paper is generated as an output material of the recycling process, when plasterboard is present at the waste load.
- CO_2 emissions resulting from the recycling process are lower than those generated from the extraction of natural gypsum.
- The use of recycled gypsum in the manufacturing of new plasterboard saves natural gypsum from extraction.

c. Evaluation of the results for re-incorporation in the manufacturing process (Indicators of sub-action C1.1)

Best practices are implemented during the reincorporation process if:

- Recycled gypsum at the plasterboard manufacturing plant complies with the agreed quality criteria thus no recycled gypsum is rejected.
- A properly dimensioned storage place is set up in order to guarantee a constant recycled gypsum feedstock, avoiding further presence of impurities and moisture content at the same time, once received.
- The recycled gypsum reincorporated is kept as high as feasible.
- The nonconforming plasterboard during the production process is below the European average.
- Energy consumption, costs and CO2 emissions have no significant negative impact when maximizing the recycled gypsum feedstock.
- Plasterboard with maximized recycled content fulfil with the implementing European standards.

d. Conclusions

The results of the measurement of the indicators applied to the GtoG pilot projects are presented in the table below.

GYPSUM TO GYPSUM

	DECONSTRUCTION															REINCORPORATION													
	Audit	Deconstruct.		Traceability			End route		Reception		Stor.	Recep	Process. & transp.			Reception					Stor.	Preprocess.		Reincorp.		Manufacturing			
	TECH1	TECH2	SOC3	SOC4	TECH3	ECO4	ENV1	ENV2	TECH1	TECH2	TECH3	SOC1	TECH4	ENV1	ENV2	TECH1	TECH2	ECO1	ECO2	ECO3	TECH3	ENV1	ECO4	TECH4	TECH5	TECH6	ENV2	SOC1	ECO5
R1														-					n/a			-	-						
R2														-				-	-	-		-	-						-
R3														-				-		n/a		-	-						
R4														-						n/a		-	-						
R5								-						-					n/a	n/a		-	-						

The results of the deconstruction processes implemented show best practices in the majority of cases. Main challenges observed are related to the pre-deconstruction audit of materials (TECH1). Due to the different construction systems that finally appeared which weren't those expected or because the audit is not mandatory.

The results of the recycling processes implemented show best practices in all cases. Main challengues observed are related to data collection for the calculation of CO_2 emissions from the recycling process (ENV1) regarding processing and transport stages.

The results of the reincorporation processes implemented show:

- Non-compliance with at least one of the technical or toxicological parameters, according to the "Guideline for the establishment of Quality criteria for recycled gypsum at European level" (TECH2).
- A reincorporation rate of recycled gypsum between 17 and 28% (TECH4 and TECH5).
- A lack of data regarding the pre-processing stage (ENV1 and ECO4) and quality check costs (ECO1) during the reception stage.
- No remarkable impact on energy, cost (ECO5) and CO_2 emissions (ENV2) when comparing business-as-usual and maximized recycled content.

Non available data / not aplicable

Best practices applied

Need corrective actions

5. Recommendations on

5.1) Setting up national value chains for the recycling of gypsum based waste

A fit for all solutions may not be the most adequate. Indeed, across Europe, the plasterboard maturity differs, i.e.; the plaster consumption rate and thus the recyclability of the material differ.

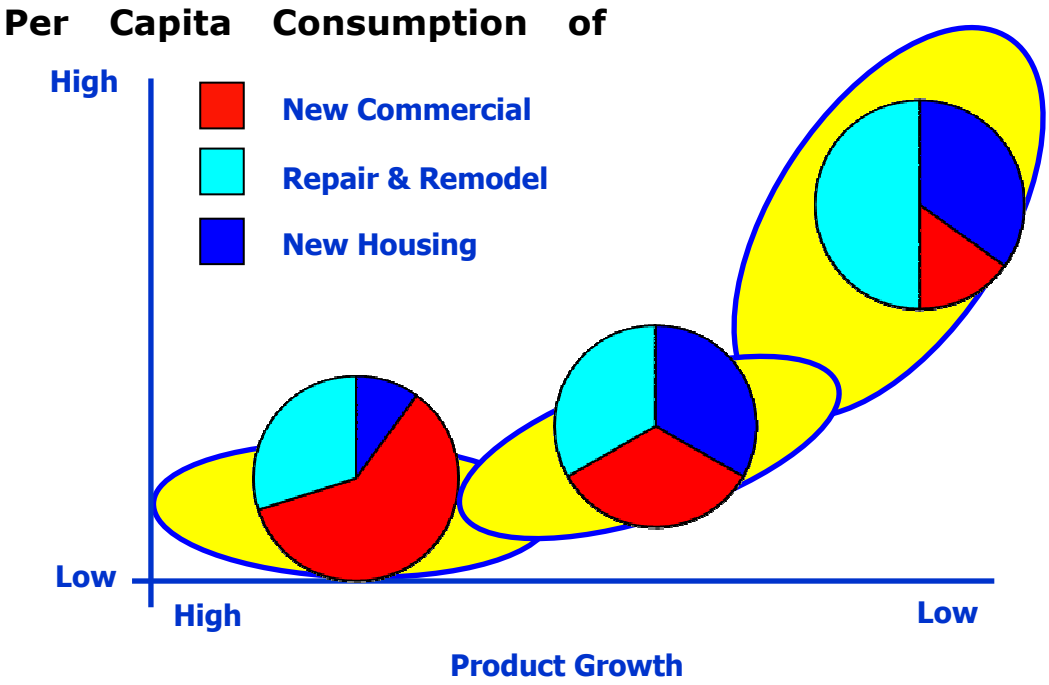
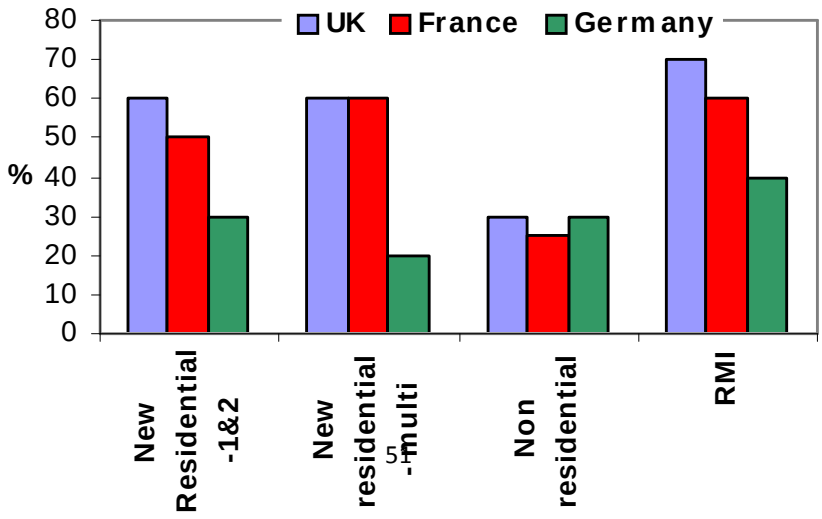
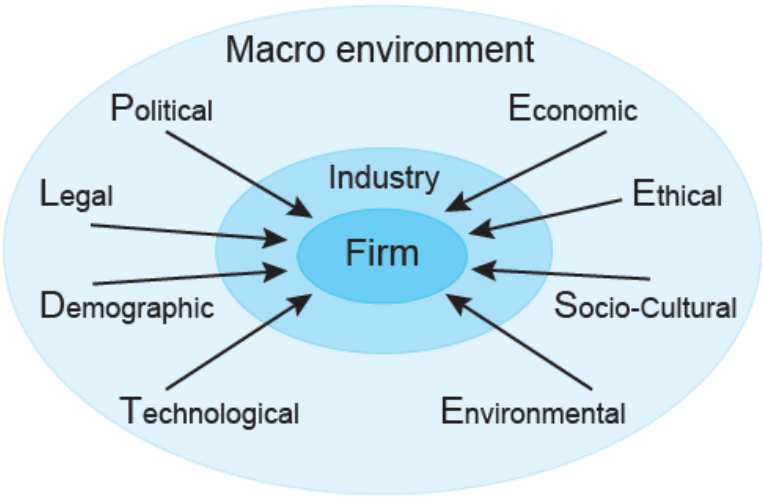


Figure 6
Usage Patterns for Gypsum Board



The recycling of production, construction and demolition waste highly depends on the macro-environment dominating in each country.

Recyclable solutions should be thus taken at country level on the basis of the below diagram:



The questions that each operator should ask themselves and **in partnership** are the following:

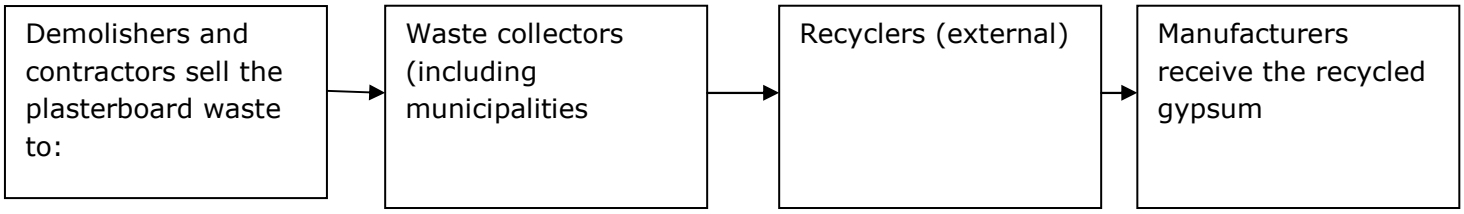
- What is the political situation of the country and how can it affect the gypsum waste value chain development in that country?
- What are the EU legislation affecting gypsum waste management in the gypsum waste value chain?
- Is the national policy favoring dismantling? How to create a dismantling culture? How to promote standardisation for dismantling? How to define dismantling?
- What are the prevalent economic factors to recycle more?
- How much importance does culture have in the gypsum recycling market and what are its determinants?
- What technological innovations are likely to pop up and affect the gypsum recycling market structure?

- Which technological progress is necessary in the gypsum waste value chain to make recycling an effective business?
- What are the environmental concerns for the gypsum value chain to recycle more?

The main aim is to achieve constant volume, constant quality of the recycled gypsum and an economic gain for each operator in the value chain.

The level of maturity of this macro environment is different from country to country. Regulation is based on different building codes and practices with different cultures and political priorities.

Therefore we suggest the establishment of the value chain in each country with exchange of best practices from the most experienced ones to the less experience one. The general frame of this value chain that can serve as basis for further discussion and developments, is presented below:



5.2) The European push

- **The C&D Recovery target of 70% (Waste Framework Directive)**

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.

In accordance to the recently published communication on resource efficiency opportunities (COM (2014) 445 final), we support the Commission proposal to promote the exchange of best practice with Member States on

measures that divert CDW from landfilling and backfilling, either through increased charges or regulatory measures.

- **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.

- **Design for recycling and promote waste prevention (important aspect of the waste hierarchy in the WFD)**

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 I).

- **Design for disassembly**

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.

1	Minimise the number of different types of components - this will simplify the process of sorting on site and make the potential for reprocess more attractive due to the larger quantities of same or similar items
2	Use an open building system where parts of the building are more freely interchangeable and less unique to one application - this will allow alterations in the building layout through relocation of component without significant modification
3	Use modular design - use components and pre-assembled subassemblies that are compatible with other systems both dimensionally and functionally
4	Use assembly technologies that are compatible with standard building practice - specialist technologies will make disassembly difficult to perform and may require specialist labor and equipment that makes the option of reuse more difficult
5	Provide access to all parts of the building and all components – ease of access will allow ease of disassembly, if possible allow for components to be recovered from within the building without the use of specialist plant equipment
6	Use components that are sized to suit the intended means of handling – allow for various possible handling options at all stages of assembly, disassembly, transport, reprocessing, and re-assembly
7	Provide a means of handling components during disassembly –

	handling during disassembly may require points of connection for lifting equipment or temporary supporting devices
8	Provide realistic tolerances to allow for movement during disassembly – the disassembly process may require greater tolerances than the manufacture process or the initial assembly process
9	Design joints and connectors to withstand repeated use – to minimise damage and deformation of components and materials during repeated assembly and disassembly procedures
10	Allow for parallel disassembly rather than sequential disassembly - so that components or materials can be removed without disrupting other components or materials, where this is not possible make the most reusable or 'valuable' parts of the building most accessible, to allow for maximum recovery of those components and materials that are most likely to be reused
11	Use prefabricated subassemblies and a system of mass production - to reduce site work and allow greater control over component quality and conformity
12	Provide spare parts and on-site storage for them - particularly for custom designed parts, both to replace broken or damaged components and to facilitate minor alterations to the building design
13	Sustain all information on the building manufacture and assembly process – measures should be taken to ensure the preservation of information such as 'as built drawing', information about disassembly process, material and component life expectancy, and maintenance requirements

- **Mandatory audit of building prior to demolition**

Deconstruction (Dismantling and sorting/separating on site) is essential for recycling and should become the focus of European regulatory and non-regulatory measures in the future. In that sense, the assessment of the materials in the buildings prior to deconstruction is a step towards a dismantling culture, at least for building above 1000 square meters. Separation on site of off-cuts from construction sites should also become a norm. The materials are clean and thus directly re-usable by the manufacturers. Construction waste was not a focus of this project but as the gypsum manufacturers recover construction waste, separation on site is an optimal way forward to recycle construction gypsum based waste.

- **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.

- **Financial support for technology deployment and development**

The funding of collaborative value chain to recycle specific waste streams via the financial tools of the European Commission is essential for the uptake of a recycling mentality of C&D waste.

In the case of gypsum products, the recycling technologies should be further enhanced in a collaborative manner to recycle the today non-recyclable plasterboard systems and to improve the current quality requirements (technical and chemical) of the recycled gypsum via a voluntary quality certification of the recycling process. This would facilitate the uptake of a product status for the recycled gypsum at national level or if the conditions are there, at European level. In that case, we support the Commission proposal in the communication on resource efficiency opportunities (COM (2014) 445 final to explore options for measures to ensure that recycled materials meet necessary quality and safety requirements, through standardization and certification.

5.3) The European gypsum industry forthcoming steps

- **Design for recycling**

This is a point on the agenda of the gypsum manufacturers that will be developed via their R&D centers.

- **Selective demolition of plasterboard systems**

1. Enhancement of 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;

2. Dissemination of the best practices to dismantle plasterboard systems via the national gypsum associations and the national demolition associations.
3. 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.

- **Recycling (processing of the plasterboard waste) and re-incorporation in the manufacturing process**

Set up a collaborative platform between the gypsum recyclers (independent or producers assuming the role and activities of the recyclers) spread in Europe (mainly the UK-France-Belgium-Germany-The Netherlands-Ireland) to exchange best practices and to decide on common actions on:

- The technical and chemical parameters for the recycled gypsum- Is there a European opportunity- how can the parameters evolves;
- Recyclable plasterboard waste definition and waste acceptance criteria for countries not covered by the project;
- Certification of the recycling process;
- Development of innovation to recycle currently non-recyclable plasterboard systems and other gypsum waste;
- The definition of the product status of the recycled gypsum. How to progress on this issue
- Monitoring of the waste legislation et EU and national level-bi-annual newsletter

- **Construction waste- recycling and waste minimisation on the job site**

Thought the focus of the project was not on construction waste, the European gypsum industry re-incorporates construction waste in the countries where the project took place. In this case, cooperation with the contactors is important as they are the ones who can save material or make recycling happen.

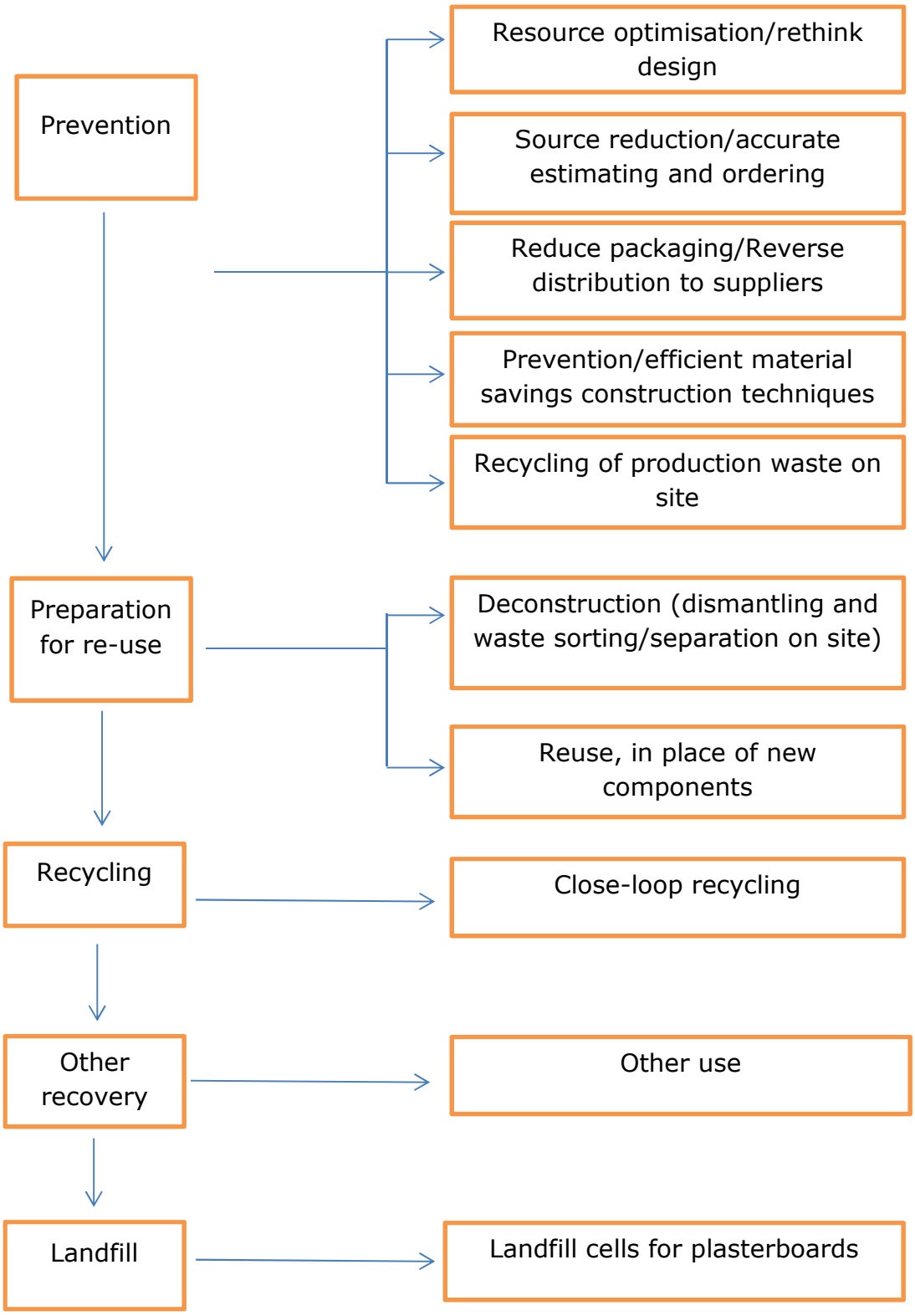
According to the Federation of Plastering and Drywall Contractors, the financial benefits of waste minimisation would lead to a reduction in waste arising (in the UK) of around 50,000 tons. This figure is considered realistic through increased designing out of waste, greater utilisation of the bespoke service offered by plasterboard manufacturers, improved on-site storage, and a reduction in over-ordering. Based on an average purchase price of £1.20 per square meter and an average weight of 8.35kg per square meter, it is estimated that saving 50,000 tons of board represents a saving of £7.2 million on purchasing. In addition, based on a disposal cost of £50 per tons,

a further £2.5 million would be saved on direct disposal costs. Additional savings would arise from the reduction in material handling, storage etc.[6]

You will find in Annex II the way to prevent waste arising on the job site.

[6] Federation of Plastering and Drywall Contractors "Diverting Plasterboard Waste from Landfill in the UK-June 2006. page 21.

ANNEX I-gypsum waste hierarchy model



GYPSUM TO GYPSUM

ANNEX II- Recycling of gypsum waste arising from the new construction of buildings

This concerns ***sorted and clean waste only*** from new construction sites. In the UK, a study carried out by the Federation of Plastering and Drywall Contractors estimates that plasterboard wastage within the construction industry can be anything from 10% to 20%.[7] If the waste prevention measures are taken on the construction site, the gypsum industry estimates that plasterboard wastage can be reduced to 5%.

Waste Flows on Construction Sites

We distinguish between the following waste flows on the construction site[8]:

(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

[7] Federation of Plastering and Drywall Contractors "Diverting Plasterboard Waste from Landfill in the UK-June 2006.
[8] GPDA-Healthier Building with Gypsum Products : n°4 Reduction of Waste-March 1997

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.