Towards an Inventory of Best Practices for an Efficient Gypsum Recycling Value Chain

Ana Jiménez Rivero, Universidad Politécnica de Madrid, Spain
Ana de Guzmán Báez, Universidad Politécnica de Madrid, Spain
Marta Rodríguez Quijano, Universidad Politécnica de Madrid, Spain
Justo García Navarro, Universidad Politécnica de Madrid, Spain

The European Conference on Sustainability, Energy & the Environment 2015
Official Conference Proceedings

Abstract
In Europe, an increasing use of gypsum plasterboard began in the 1960s – 1970s, especially growing popularity from the mid-1980s. Ever since a large proportion of gypsum waste is being landfilled and backfilled worldwide, including building plaster, gypsum blocks and plasterboard, being the later the most common recyclable gypsum waste generated in Europe.

Considering a reference service life of 50 years, most of the buildings being currently renovated or demolished contain very few or inexistent plasterboard. However, in the coming years, the quantities of plasterboard waste are expected to substantially increase, and becoming a forthcoming issue.

This investigation presents the work conducted to develop an inventory of best practices towards an efficient gypsum recycling value chain, within the framework of the Life+ GtoG project. The study is based on three pillars: the crucial indicators for the effectiveness of the recycling route, relevant results from the monitoring of a set of European pilot projects, and conclusions regarding the life cycle effects on carbon emissions of different levels of plasterboard recycling. These best practices would not only help to minimize the construction and demolition (C&D) waste sent to landfills, but also to mitigate primary mineral resource depletion.

Keywords: Plasterboard, gypsum recycling, value chain, best practices, GtoG project

Introduction

Gypsum products are used for partitions, ceilings and lining of walls in building construction and renovation, being plasterboard the most common recyclable gypsum product generated in Europe. Around 10.73 million tonnes of plasterboard were consumed in the EU-27 in 2013 (ELCD database 2.0, 2007; Eurostat, 2013; Williams, 2008), while an estimated amount of 1.9 million tonnes of post-consumer plasterboard waste was generated, of which 87% might have been landfilled (Eurostat, 2012; Gypsum to Gypsum project LIFE11 ENV/BE/001039, 2013). In the coming years, this amount is expected to substantially increase, as plasterboard grew in popularity in the mid 1980s (Eurogypsum, n.d.). Although gypsum is fully recyclable, recycling systems are only operating in 7 out of the 27 Member States (Belgium, Denmark, Finland, France, the Netherlands, the United Kingdom and Sweden).

The End-of-Life (EoL) of gypsum plasterboard comprises demolition or deconstruction of the building, transport of the plasterboard waste to recycling facility (either direct or via transfer station), waste processing operations and final disposal (European Committee for Standardisation (CEN), 2012). These processes can be grouped into two main routes: the gypsum recycling and the gypsum landfilling route, as shown in Figure 1.

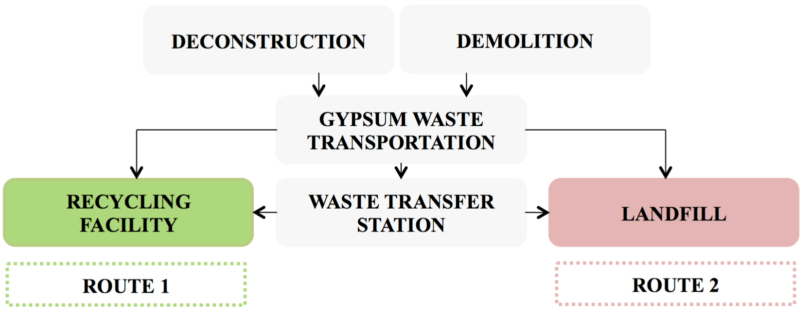

Figure 1: End-of-Life (EoL) of gypsum plasterboard main processes and routes.

If gypsum waste is landfilled, the combination of sulphate content of gypsum and biodegradable waste may break down, amongst other substances, into Hydrogen Sulphide (H_2S), a hazardous flammable gas with environmental and health effects when inhaled. This H_2S emission rate is variable and depends on different factors such as soil moisture, H_2S concentration and temperature (Xu & Townsend, 2014).

In a circular economy post-consumer gypsum waste is effectively collected, recycled and used to make new plasterboard (Figure 2), whereas natural gypsum is only used when secondary raw materials are not available. From January 2013 the European Life+ Gypsum to Gypsum (GtoG) project ENV/BE/001039 “From Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry” is working for fostering the recycled gypsum market, by promoting deconstruction practices, standardized quality criteria and quantifying the environmental impact of the recycling and the landfilling route. The consortium is composed by 17 European partners, including gypsum recyclers, plasterboard manufacturers, deconstruction, consultancy companies and research institutions, being the coordinator of the project Eurogypsum, the European federation of national associations of gypsum products manufacturers[1].

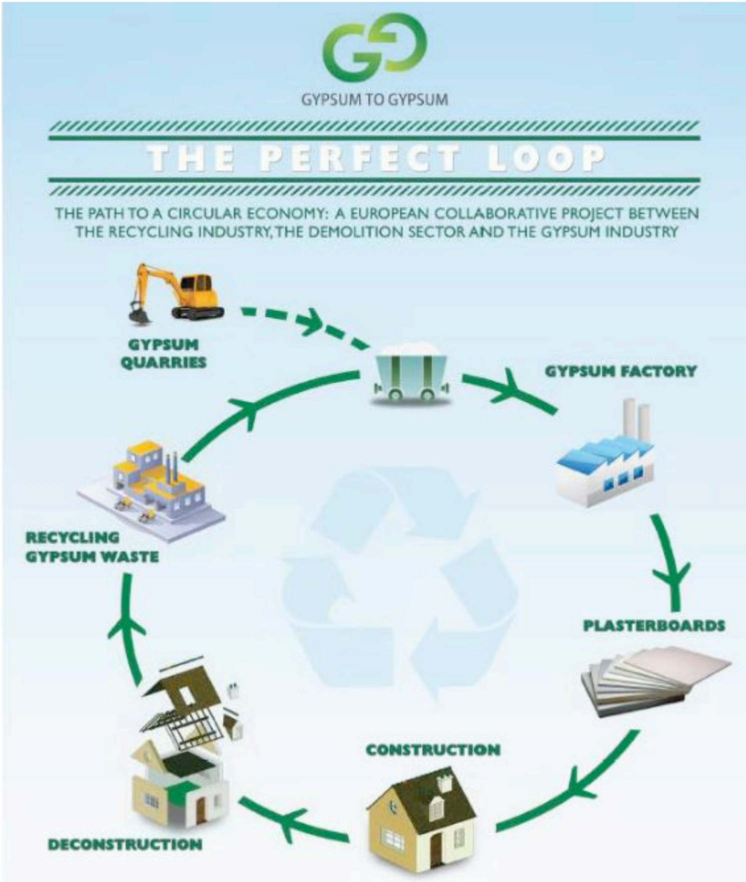

Figure 2: GtoG project poster.

If best practices during building deconstruction, gypsum recycling (processing) and recycled gypsum reincorporation are not implemented; recyclable gypsum waste can turn into non-recyclable waste. This study presents three main pillars for formulating best practices associated to the EoL of gypsum plasterboard, towards an efficient gypsum recycling value chain.

Basis of the Inventory of Best Practices

Three pillars, further detailed in subsequent sections, are the basis of the Inventory of Best Practices:

- A number of indicators for assessing the success of closed-loop gypsum recycling in the European Union;
- Results from the monitoring of a set of European pilot projects on deconstruction, processing of gypsum waste and reincorporation of the recycled gypsum into the manufacturing process: Key Performance Indicators (KPIs) and Best Practice Indicators (BPIs);
- Conclusions regarding the life cycle effects on carbon emissions of different levels of plasterboard recycling.

In addition, previous and ongoing GtoG deliverables complement the study:

[1] Further information can be found in http://gypsumtogypsum.org/

- European Handbook on best practices for plasterboard deconstruction and Manual for best practices in audit prior deconstruction[2];
- Report on Production Process Parameters (on going);
- Guidance criteria recycled gypsum and recycled gypsum End-of-Waste (EoW) (on going).

Indicators for assessing the success of closed-loop gypsum recycling in the EU

Major indicators impacting the success of closed-loop gypsum recycling systems have been identified and tested in the 8 EU selected countries target of the GtoG project: Belgium, France, Germany, Greece, Poland, Spain, the Netherlands and the United Kingdom.

i. *"*Reach of the gypsum recycling system*"* assesses the distance from the gypsum waste source to the gypsum recycling facility.
ii. "Segregation of gypsum waste from other C&D waste" represents the amount of gypsum waste that is segregated from other C&D waste.
iii. "Competitiveness of the recycling solution compared to local landfills" shows the competitiveness of the gypsum recycling solution compared to landfill disposal.
iv. "Compliance with the existing regulation impacting gypsum waste" describes the amount of gypsum waste that complies with the existing regulation.
v. "Legal alternative destinations" estimates the amount of gypsum waste or recycled gypsum that does not follow other alternative routes.
vi. "Environmental focus" describes the share of gypsum waste market for which environmental factors determine the final destination.

Results from the monitoring of a set of European pilot projects: KPIs and BPIs

A total of 36 KPIs are applied in a set of European pilot projects (Table 1). After data collection and analysis, 29 Best Practice Indicators (BPIs), aiming to recognize and encourage best practices in the deconstruction, recycling and reincorporation processes are selected.

Figure 3: Plasterboard dismantling and segregation in different GtoG pilot projects. From left to right: strip-out activities in London (the UK), manual plasterboard dismantling in Graben (Germany), waste storage in Levallois Perret (France) and mechanical plasterboard dismantling in Brussels (Belgium).

Whilst for deconstruction and recycling there are several socio-economic BPIs that have not been selected, mainly due to their variability depending on the different

[2] Downloadable from http://ec.europa.eu/environment/life/project

market context, policies and competitive environments from the country under study, in the case of reincorporation all of them are considered.

Deconstruction - Performance Indicators		
Criteria	**Stage**	**Indicator**
TECH	Audit Deconstruction Traceability	TECH1. Existence and deviation of the audit for gypsum-based systems TECH2. Effectiveness of the deconstruction process TECH3. Effectiveness of the traceability
ENV	End route	ENV1. Gypsum waste sent to landfill ENV2. Transport emissions comparison between recycling and landfilling
SOC	Decon - Demol Deconstruction	SOC1. Labour time difference between dismantling and demolishing plasterboard SOC2. Productivity SOC3. Training of the deconstruction team SOC4. Follow-up of the waste management
ECO	Audit Deconstruction Traceability	ECO1. Audit cost ECO2. Plasterboard dismantling and loading cost ECO3. Gypsum block dismantling and loading cost ECO4. Cost difference between recycling GW and landfilling route

Recycling - Performance Indicators		
Criteria	**Stage**	**Indicator**
TECH	Reception Storage Processing	TECH1. Quality of the gypsum waste received TECH2. Gypsum waste rejected TECH3. Warehouse storage capacity for gypsum waste 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
ECO	Processing Transport	ECO1. Energy cost of the gypsum waste processing ECO2. Transport cost of the recycled gypsum

Reincorporation - Performance indicators		
Criteria	**Stage**	**Indicator**
TECH	Reception Storage Reincorporation Manufacturing	TECH1. Recycled gypsum rejected by the manufacturer TECH2. Recycled gypsum quality criteria TECH3. Warehouse storage capacity for recycled gypsum TECH4. Recycled gypsum content TECH5. Recycled content increase TECH6. Production waste
ENV	Preprocessing Manufacturing	ENV1. CO_2 emissions: business-as-usual compared to maximized recycled content in the preprocessing ENV2. CO_2 emissions: business-as-usual compared to maximized recycled content in the production process
SOC	Manufacturing	SOC1. Manufacturer's satisfaction
ECO	Reception Preprocessing Manufacturing	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 ECO4. Energy cost difference between business-as-usual and maximized recycled content in the preprocessing ECO5. Energy cost difference between business-as-usual and maximized recycled content in the production process

Table 1: Developed KPIs. Most of them are selected as BPIs, with the exception of Deconstruction SOC1, SOC2, ECO1, ECO2, ECO3 and Recycling ECO1 and ECO2, which are variable depending on the country under study, skills of the workers and/or equipment performance.

Conclusions regarding the life cycle effects on carbon emissions of different levels of plasterboard recycling

A life cycle model is the basis of the assessment, from which the known mass flows are quantified using principles of mass balance. Three scenarios are defined: 2013 base case (5% recycled content) and two alternatives: low recycling case (0% recycled content) and high recycling case (nearly no gypsum waste sent to landfill, corresponding to 18.5% recycled gypsum in new plasterboard).

- When moving from the 2013 base case towards the high recycling case, greater impacts occur in the processes of transport of recycled gypsum, pre-processing stage, transport of plasterboard waste to recycling and waste processing, while lower impacts are observed in gypsum mining, transport of natural gypsum and final disposal.
- When plasterboard is landfilled, plasterboard's lining paper is degraded by anaerobic bacteria, producing GHG emissions.
- The total GHG emissions are smaller in the high recycling case, mainly due to the avoided methane released from facing paper degradation.

Conclusion

Best practices for an efficient gypsum recycling value chain would not only help to minimize gypsum waste sent to landfills, but also to mitigate H_2S and CH_4 emissions from landfill, landscape degradation and natural resources depletion.

The general GtoG action plan foresees the submission of the DA.2 deliverable, *Report: Inventory of Best Practices*, planned for December 2015.

Acknowledgement

This study has been performed under the framework of the GtoG project, supported by the European Commission – DG Environment through the Life + programme; under contract number LIFE11 ENV/BE/001039.

References

ELCD database 2.0. (2007). Process information. Retrieved from http://eplca.jrc.ec.europa.eu/ELCD3/showProcess.xhtml;jsessionid=2703835E85D137D1E5882A56E8BBD0C6?uuid=cc39e70e-4a40-42b6-89e3-7305f0b95dc4&version=03.00.000

Eurogypsum. (n.d.). *Living with Gypsum : From Raw Material to Finished Products*.

European Committee for Standardisation (CEN). (2012). EN 15804:2012. Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products.

Eurostat. (2012). Generation of waste, NACE_R2: Construction.

Eurostat. (2013). PRODCOM ANNUAL SOLD (NACE Rev. 2.) Eurostat PRCCODE : 23522000, 23621050 and 23621090. Retrieved from http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database

Gypsum to Gypsum project LIFE11 ENV/BE/001039. (2013). *DA.1: Inventory of current practices. GtoG : From production to recycling : a circular economy for the European Gypsum Industry with the Demolition and Recycling Industry.*

Williams, B. (2008). Europroms PRODCOM Data, User Guide, 1–18.

Xu, Q., & Townsend, T. (2014). Factors affecting temporal H2S emission at construction and demolition (C&D) debris landfills. *Chemosphere*, *96*, 105–11. doi:10.1016/j.chemosphere.2013.07.052

Contact email: ana.jimenez@upm.es