Development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure

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Industrial Transformation and Advanced Value Chains

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Cover photo: Kretz, D. 2017.

This photo depicts the Europa Building in Brussels, Belgium. The Europa Building exemplifies sustainable design, especially through the use of recycled materials in its construction. 28 Member States make up the EU at present and thus restored wooden window frames from 28 countries that have been retrieved from renovation or demolition sites are found in its façade. The building was designed by Samyn and Partners (Belgium), Studio Valle Progettazioni (Italy) and Buro Happold (United Kingdom).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

Based on volume, Construction and Demolition Waste (CDW) is the largest waste stream by volume in the EU – it represents about one third of all waste produced. Proper management of CDW and recycled materials – including the correct handling of hazardous waste – can have major benefits in terms of sustainability and the quality of life and can also provide major benefits for the EU construction and recycling industry, as it boosts demand for CD recycled materials.

The key legislation in the context of CDW recycling is the Waste Framework Directive[1], which sets the basic concepts and definitions related to waste management and prescribes Member States to achieve the target of 70% of CDW being recovered by 2020. The recent and ambitious Circular Economy Package[2], which includes revised legislative proposals on waste as well as an ambitious Circular Economy Action Plan (CEAP)[3] to stimulate Europe's transition towards a circular economy. The CEAP targets "closing the loop", moving from a linear to a circular economy, and highlights the importance secondary raw materials and maintaining the value of waste at the end of life through reuse and recycling as a central part of a successful circular economy. Previous studies completed including the CDW Management Protocol[4] and the CDW Pre-demolition Audit[5] have enabled the need for analysing and identifying business models in CDW recycling, which culminates in this study.

This study on fostering investments in Construction and Demolition Waste recycling infrastructure is set within the policy context of both the Waste Framework Directive and the Circular Economy Package and has two major objectives: (i) to identify, list and analyse existing business models in the field of CDW recycling within a selection of EU countries and select non-EU countries and (ii) building on these analyses, to develop and elaborate a set of five business cases that are exemplary in their nature for the planning and design of new CDW recycling facilities. This is targeted especially in countries where recovery rates are currently below the Waste Framework Directive target of 70% and where recycling of CDW waste requires fostering over other, less ambitious forms of recovery in line with the Circular Economy Package, which aims to maintain the value of products at the end of life.

Through the five business cases resulting from this study, the outcome of this study will be a direct contribution to the improvement of the CDW recycling facility development, especially in countries that are lagging behind in CDW recycling. The study aims bridging the so-called 'valley of death' between entrepreneurs and financial institutions. It is instrumental in facilitating the use of funding from the European Fund for Strategic Investments (EFSI) as well as of other EU funding instruments for the encouragement of individual CDW recycling projects inspired on the business cases proposed and as such ultimately invigorates the drive towards the improved recycling of CDW.

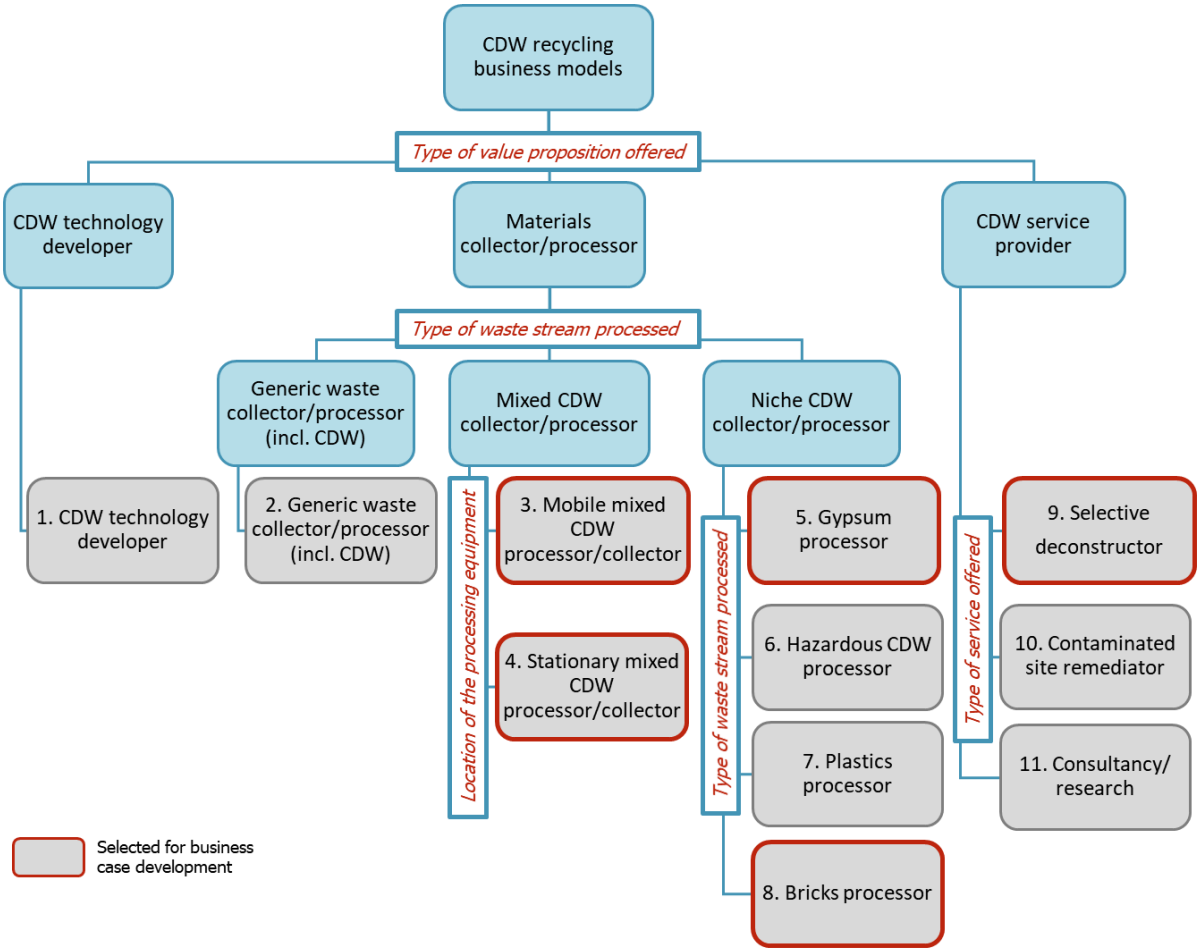
The study includes consultations with stakeholders in an iterative and inclusive interactive process to ensure the viability of the results. This is through the inclusion of stakeholder inputs from the onset through information gathering and interviews, the development of business cases in collaboration with key stakeholders as well as a validation exercise completed through the validation workshop (November 16th 2017) on the resulting elaborated business cases, whereby participants were also asked to provide feedback via a questionnaire.

Through targeted country selection and information gathering based on interviews, expert knowledge and literature, a representative view of significant business models were able to be distilled in a typology. The typology, which is strongly oriented towards high volume waste streams, is depicted in Figure 1, whereby business models could be differentiated using distinguishing features.

[1] Directive 2008/98/EC, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098
[2] Adopted 2nd December 2015, http://ec.europa.eu/environment/circular-economy/index_en.htm
[3] See http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52015DC0614&from=EN
[4] European Commission (2017) 'EU Construction & Demolition Waste Management Protocol', completed by Ecorys for DG Grow, obtained via https://ec.europa.eu/docsroom/documents/24761/attachments/10/translations/en/renditions/native
[5] European Commission (2017) 'Technical and Economic Study with regard to the Development of Specific Tools and/or Guidelines for Assessment of Construction and Demolition Waste Streams prior to Demolition or Renovation of Buildings and Infrastructures', completed by VTT, technalia and RPA for DG Grow, obtained via https://ec.europa.eu/docsroom/documents/24562/attachments/1/translations/en/renditions/pdf

In Europe we find distinctive differences between advanced CDW recycling countries and lagging CDW recycling countries which both help and hamper further CDW recycling activities, respectively. The market, regulatory framework, available technologies as well as the social conditions make up the business context in which CDW recycling takes place.

Figure 1: Overview of the business model typology for CDW recycling distilled from the information gathered in the context of this study.[6]



Source: IDEA Consult

Business cases were developed with the aim of being readily used by potential financers and entrepreneurs as an instrument to improve the CDW recycling infrastructure in the EU. The business cases are developed based on the result of an expert multi-criteria analysis which assessed the profitability, sustainability, stability of the demand and supply and the legal compliance of all business models.

[6] Please note that the representative significant business models depicted reflect those that were captured as a part of the information gathering phase of this study and it is fully acknowledged that the figure does not reflect all available business models especially niche CDW collector/processors including glass, metal, wood, among others. Business models for recycling particular high value materials such as metals, wood, glass have not been focussed on because they are already well established and incorporated in sustainable production methods across the EU-industry and do not represent the bulk volume of CDW.

The placement of the five business cases along the CDW recycling value chain is depicted in Figure 2 and they include:

- Gypsum processor
- Brick processor
- Stationary Mixed CDW Processor
- Mobile Mixed CDW Processor
- Selective Deconstruction

The business cases present spreadsheet templates in which ranges of values coming from the project-specific business environment such as landfill costs, prices of alternative uses, prices of recycled materials, input volumes, quality of incoming material, gate fees and assess the financial viability of the project can be entered. 2- How to use them? How future readers of this report could use the business cases presented and the related spreadsheets?

Stakeholders indicated that the five business cases developed are important and unique tools for bridging the information gap between entrepreneurs, investors and the financial community. The role of the public partner is in creating the appropriate market conditions in which CDW recycling businesses can flourish, in particular legislation and enforcement, quality assurance systems, traceability and certification as well as green public procurement. Indeed, one of the major barriers for the uptake of CDW recycling products is still the lack of trust in the quality of secondary materials. Additionally, the price of substitute virgin raw materials remains an important condition to be taken into account. Nevertheless, the business cases presented as well as the testimonials showed that CDW recycling can be a viable business activity that not only contribute to the EU circular economy but also to growth and job creation.

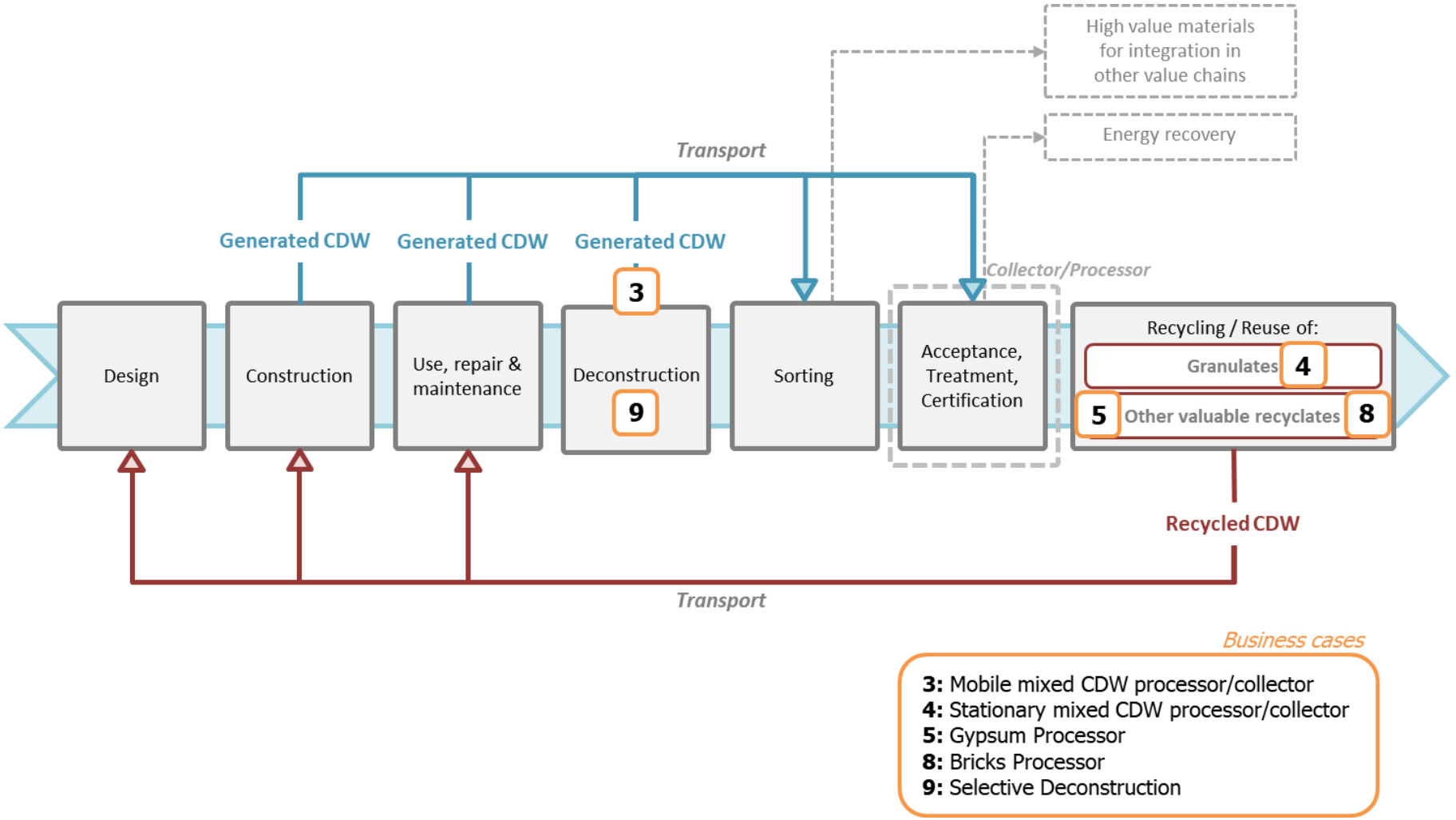
Through EFSI and InnovFin, the EIB presents clear opportunities to address the finance gap faced by CDW recycling infrastructure to realise the remaining, yet necessary, CDW recycling potential in the EU. While the relatively small size of CDW recycling investments and the relatively modest rate of return of CDW recycling investment continue to be a hurdle, promoters are encouraged to explore specific examples of finance opportunities together with EIB advisors on a case by case basis. For EFSI the aim is to leverage and de-risk private capital, targeting so-called mid-cap companies as well as SMEs with typical lending amounts between EUR 7.5 and 25 million. InnovFin targets very specifically projects that are oriented towards innovation and research with clear criteria to be met. Indirect financing available via the EIB typically takes form through third party banks in support of the EIB. This means that dedicated financing lines are initiated towards bank, which is used for on-lending at reduced interest rate to 'eligible' SMEs and Mid-Caps with reduced EIB scrutiny at the project level and rather at the on-lending level. Possibilities for clustering of activities, blending of financial instruments and intermediated finance present possible and viable solutions. Both investor and entrepreneur alike may benefit from the practical applicable business cases that have been elaborated in this study. As such the work of this project may contribute to the further uptake of CDW recycling activities in Europe and helps to attain more ambitious levels of CDW recycling, especially in MS that are currently lagging in this area.

Reaching higher levels of CDW recycling is in line with the Waste Framework Directive target as well as the Circular Economy Action Plan and requires additional investments in infrastructure, which can be best achieved by concentrating investments on volumes of CDW through mobile and stationary mixed CDW recycling treatment facilities. The Waste Framework Directive emphasises a recovery target, which involves recycling as well as backfilling as forms of CDW recovery. The Circular Economy Action Plan (CEAP) puts forward ambition for improved recycling of CDW that draws upon improved waste management that supports the recycling and reuse of CDW, maintaining and giving value to materials that would otherwise be landfilled or backfilled.

To achieve high CDW recycling in line with the CEAP, increased and improved CDW recycling infrastructure is needed. Based on the information gathered in this study, we estimate 73 million tonnes of CDW remain to be recycled to reach the 70% recovery target at EU level Three scenarios of development delineate the costs associated with this transition, these include (i) mobile CDW facility only investments, (ii) stationary mixed CDW facility investments and (iii) both mobile and stationary mixed investments can be applied in order to assess the possible range of costs to reach the target. This results in an estimated cost of CDW recycling infrastructure (for 73 million tonnes of CDW) to reach the WFD 70% recovery target by 2020:

- Scenario 1: mobile mixed CDW recycling facilities only: **EUR 742,700,000**
- Scenario 2: stationary mixed CDW recycling facilities only: **EUR 1,095,000,000**
- Scenario 3: both mobile and stationary mixed CDW recycling facilities: **EUR 918,900,000**

Figure 2: Placement of five selected business cases in the CDW value chain



Source: IDEA Consult

1/ Introduction

Based on volume, Construction and Demolition Waste (CDW) is the largest waste stream in the EU – it represents about one third of all waste produced. Proper management of CDW and recycled materials – including the correct handling of hazardous waste – can have major benefits in terms of sustainability and the quality of life. CDW recycling can also provide major benefits for the EU construction and recycling industry, as it boosts demand for CDW recycled materials.

This final report details the findings and analysis involved in the identification of business models and the development of business cases to support fostering Construction and Demolition Waste (CDW) recycling infrastructure in Europe. The purpose of these business cases is to bridge the gap between entrepreneurs and finance in CDW recycling by reducing the information asymmetry that exists between investors and entrepreneurs by simulate and assessing specific investment opportunities while considering the specific business parameters and the business context.

The report includes the business model typology and a factsheet on the business context. In order to select which business models to develop into business cases, a multi-criteria analysis, which assesses which business models are best fit for purpose was undergone and resulted in a set of five business cases including:

- Gypsum Processor
- Bricks Processor
- Mobile Mixed CDW Processor/Collector
- Stationary Mixed CDW Processor/Collector
- Selective Deconstruction

Stakeholder consultation was a vital component of the development of the business model typology, as well as the development and validation of the business cases. In total 39 interviews have been completed, of which 21 focus on business models and 18 are geared towards the business context. The final version of the questionnaire can be found in Annex 1.Business cases were put to developed and assessed by individual entrepreneurs and financers in order to make sure that the parameters used are realistic and that no crucial information would be lacking, which culminated in a stakeholder workshop and validation meeting on November 16th 2017.

Key findings from the stakeholder interaction and stakeholder workshop are considered for the business cases and in the overall revision of this report. As a conclusion, the estimated cost of investment to reach both the Waste Framework Directive target of 70% CDW recovery by 2020, as well as the cost of investment needed to reach a more ambitious 70% recycling, excluding backfilling by 2020 is also calculated to underline the cost of the transition towards a circular economy.

In the remaining sub-chapters of this introduction, the policy context and the objectives of the study are presented. Chapter 2/ illustrates the conceptual framework that is used to capture and analyse the evidence on CDW recycling business models and contexts. Chapter 3/ presents the selection of countries which were targeted for evidence gathering. Chapter 4/ presents shortly the questionnaire development. As such the first four chapters provide background material on concepts and information gathering which are needed to interpret the results in the subsequent chapters. The results from the first task which is the identification of the most common types of CDW recycling models with an emphasis on volumes, are presented in Chapter 5/. A typology with 11 CDW recycling models was developed together with a comprehensive factsheet for each of these models. The subsequent part of the report, Chapter 6/, presents the key characteristics for different types of business environments that could be identified in Member States with advanced and lagging CDW recycling practices, which are based on evidence from the interviews and the literature review. Chapter 7/ presents the selection of the five business models using an expert multi-criteria analysis (MCA). All the results from previous chapters culminate in the elaboration of the five selected business models into detailed generic business models.

These are documented in Chapter 8/. Separately, for each model a separate spreadsheet template has been provided in which project-specific parameters can be filled in to provide estimates for key investment decision indicators. Chapter 9/ presents the rationale, set-up, agenda and main results from the validation workshop with the stakeholders. Chapter 10/ provides the conclusions among which the estimated investment cost to reach the 70% CDW recovery target, as well as a more ambitious 70% recycling (excluding backfilling) ambition.

1.1 Policy background

The key legislation in the context of CDW recycling is the Waste Framework Directive[7], which sets the basic concepts and definitions related to waste management and prescribes Member States to achieve the target of 70% of CDW being recovered by 2020.

The recent and ambitious Circular Economy Package[8], which includes revised legislative proposals on waste as well as an ambitious Circular Economy Action Plan (CEAP)[9] to stimulate Europe's transition towards a circular economy. The CEAP targets "closing the loop", moving from a linear to a circular economy, and highlights the importance secondary raw materials and maintaining the value of waste at the end of life through reuse and recycling as a central part of a successful circular economy..

Previous studies completed including the CDW Management Protocol[10] and the CDW Pre-demolition Audit[11] have enabled the need for analysing and identifying business models in CDW recycling, which culminates in this study. Worth mentioning are also the Construction 2020 strategy[12], the Communication on Resource Efficiency Opportunities in the Building Sector[13], as well as the EMAS Sectoral Reference Documents on Best Environmental Management Practices for the Waste Management Sector (addressing among others Construction and Demolition Waste) and for the Construction Sector.[14]

1.2 Objectives of the study

This study on fostering investments in CDW recycling infrastructure is set within the policy context of both the Waste Framework Directive and the Circular Economy Action Plan has two major objectives:

i. to identify, list and analyse existing business models in the field of CDW recycling within a selection of EU countries and select non-EU countries and, building on these analyses,
ii. to develop and elaborate a set of five business cases that are exemplary in their nature for the planning and design of new CDW recycling facilities.

[7] Directive 2008/98/EC, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098
[8] Adopted 2nd December 2015, http://ec.europa.eu/environment/circular-economy/index_en.htm
[9] See http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52015DC0614&from=EN
[10] European Commission (2017) 'EU Construction & Demolition Waste Management Protocol', completed by Ecorys for DG Grow, obtained via https://ec.europa.eu/docsroom/documents/24761/attachments/10/translations/en/renditions/native
[11] European Commission (2017) 'Technical and Economic Study with regard to the Development of Specific Tools and/or Guidelines for Assessment of Construction and Demolition Waste Streams prior to Demolition or Renovation of Buildings and Infrastructures', completed by VTT, technalia and RPA for DG Grow, obtained via https://ec.europa.eu/docsroom/documents/24562/attachments/1/translations/en/renditions/pdf
[12] Strategy for the Sustainable competitiveness of the construction sector and its enterprises, COM (2012) 433, http://eur-lex.europa.eu/procedure/EN/201859
[13] COM (2014) 445 final, http://ec.europa.eu/environment/eussd/pdf/SustainableBuildingsCommunication.pdf
[14] For example, the development of the EMAS Sectoral Reference Documents on Best Environmental Management Practices for the Waste Management Sector (addressing among others Construction and Demolition Waste) and for the Construction Sector. http://susproc.jrc.ec.europa.eu/activities/emas/index.html

This is targeted especially in countries where recovery rates are currently below the Waste Framework Directive target of 70% and where recycling of CDW waste management in line with the Circular Economy Action Plan, which aims to maintain the value of products at the end of life, is needed.

The study includes consultations with stakeholders in an iterative and inclusive interactive process to ensure the viability of the results. This is through the inclusion of stakeholder inputs from the onset and constitutes a validation workshop on the resulting elaborated business cases.

Through the five business cases resulting from this study, the outcome of this study will be a direct contribution to the improvement of the CDW recycling facility development, especially in countries that are lagging behind on their Waste Framework Directive targets. The study aims bridging the so-called 'valley of death' between entrepreneurs and financial institutions. It is instrumental in facilitating the use of funding from the European Fund for Strategic Investments (EFSI) as well as of other EU funding instruments. Inspired by the business cases proposed, the uptake of individual CDW recycling projects is encouraged and as such ultimately invigorates the drive towards the circular economy in which the value of waste is maintained, also at end of life.

2/ Business model building blocks in a wider perspective: the CDW value chain and business context

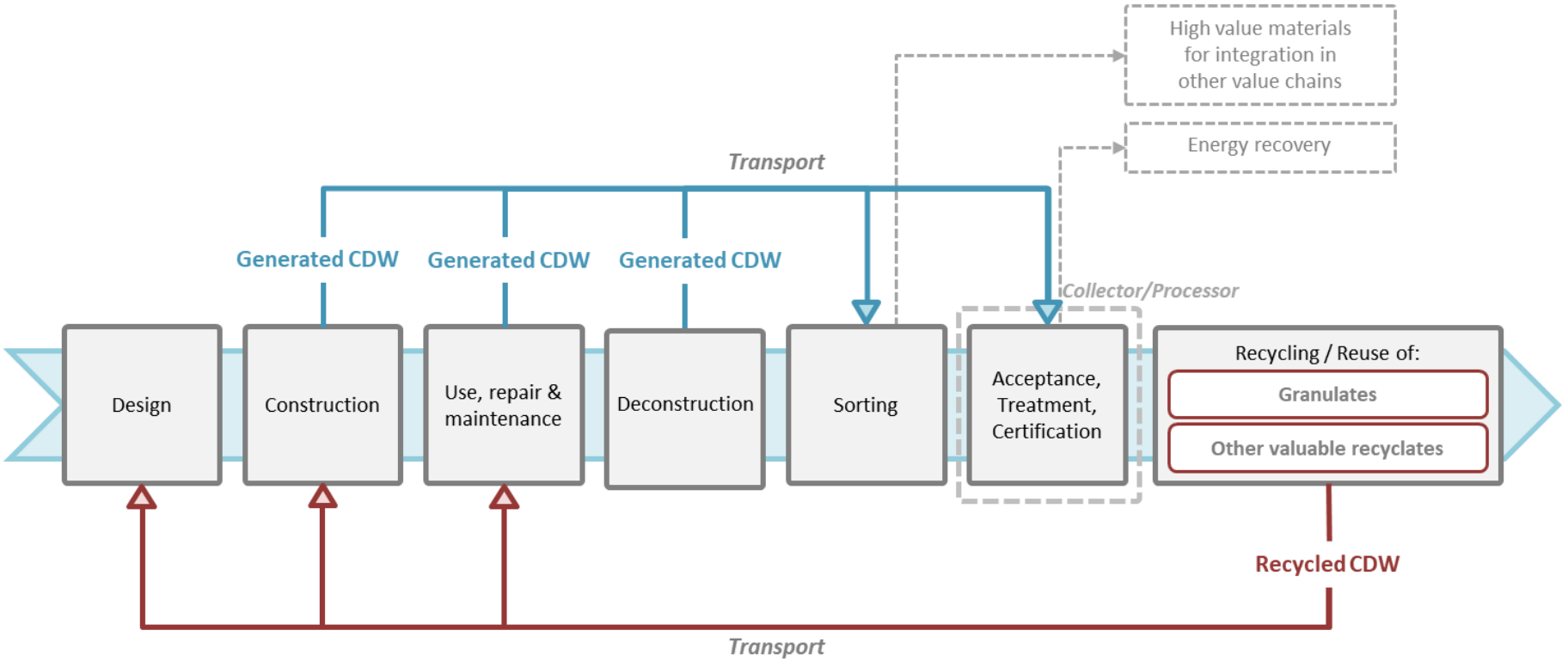
The purpose of this chapter is to introduce the necessary concepts and terms that are needed for (i) capturing and subsequently understanding the variety and main types CDW recycling business models and (ii) assessing the relation between the models used and their wider business environment. We start with a general perspective on the CDW value chain. After that we zoom into the concept of a business model and business context.

2.1 The CDW value chain

The CDW value chain is an essential feature in understanding the recycling of CDW. Value chains in general are defined as the full range of activities that firms undertake to bring a product or a service from its conception to its end use by final consumers, including even end of life and recycling.[15] The value chain depicted in Figure 3 depicts the multitude of steps in the value chain, the material stream and the flows (transport) of generated CDW (blue lines) as well as CDW recycled materials (red lines).

[15] OECD (2012) Mapping Global Value Chains (Working Party Trade Committee Paper TAD/TC/WP/RD(2012)9), Paris, December 2012 (https://www.oecd.org/dac/aft/MappingGlobalValueChains_web_usb.pdf) .

Figure 3: Value chain and material stream indicating the different process steps involved in the processing of CDW and the various material fractions derived



Source: IDEA Consult

The CDW value chain begins with the notion of **design**, where the concept and drawing of a building or renovation project takes the use of recycled materials into consideration. Two questions shape this phase: (i) is there the possibility to include recycled materials? (ii) will the building be conceived in a way that materials do not lose their value or re-usability upon demolition at the end of the useful life of the building?

During the **construction and building phase** itself, the focus is on the construction part of CDW, making use of waste from the construction activities, which can keep their value if the construction site is well organised and has a focus on source selection of construction wastes.

A third step (the **use phase**) includes the lifespan of the building and includes repair and maintenance in which materials are continually exchanged. This plays a role both at the demand and the supply side of CDW value chain and of CDW derived materials.

Deconstruction as a source of reuse and recycling can be split up into:

1. non-structural deconstruction: stripping the building of all demountable materials, doors, furniture, mainly for reuse and partly for high value recycling and
2. structural deconstruction of the structural components, bricks, concrete, timber, beams, predominantly for material recovery as CDW derived construction material.

Successful deconstruction is based on a thorough inventory and a planned approach.

Transport defines market conditions as for bulky CDW. For road transport a solution is usually to be found within a perimeter of a maximum of 20 to 30 km from the source of the waste. That being said, water transport allows for farther distances and larger volumes to be transported. Therefore, CDW generated in regions with access to water transport allows for greater transport distances than via road transport between generation, recycling and reuse of recycled materials.

Acceptance and controlling implies the assessment of the hazardous material potential and associated pollution potential, the nature of the material and the homogeneity of the incoming CDW. It may involve a series of tests by the recycler or by independent certified laboratories. It is a crucial step in the recycling process as the outcome of the assessments determine the gate fee, the recycling process and ultimately the potential market opportunities of the recycled materials. **Treatment** involves **stockpiling, crushing, breaking, sieving, washing, testing and monitoring.** These activities go hand in hand and can lead to creating advantages of scale as well as the increase of quality of CDW flows. Separation based on material types and recycling possibilities generates a high value recycling stream and a lower value recycling stream. High value materials can be reused directly or entered directly into a **recycling cycle**. Through this process value is added by the CDW recyclers by transferring a waste into a recycled product with a market. Valuable recyclables like metals, glass and wood are generally sorted out and recycled as a part of the construction recycling and re-use phase or sold to other industries for use. A residual stream of recycling residues might still find its way to **energy recovery,** e.g. plastics, paper, textiles or to landfill.

2.2 Conceptualising business models and business contexts

A business model is a conceptual model that describes how an organisation creates, delivers and captures value.[16] [17]In the academic literature, one can distinguish mainly two strands of definitions for business models: the first one focussing on the individual company (see e.g. Osterwalder 2005[18] and Osterwalder 2004[19]), which is the term as it is mostly understood and the second definition considering a business model to transcend the boundaries of one individual firm and dealing with the modes of interactions between companies in a particular industry or value chain (see e.g. Johnson and Suskewizc 2009[20] and Zott and Lorenzo 2011[21]). Although these interactions are certainly of paramount interest from a policy point of view, the study focusses on obtaining five business cases that can be applied to individual CDW recycling companies and projects in particular contexts. Therefore, we have chosen a definition of a business model as describing the logic of creating, delivering and capturing value by one individual organisation. Evidently, the interactions with other companies notably suppliers and client companies, are part of the business case to be developed.

Consistent with the overall analytical framework, presented in the inception report, we have developed a framework for the business model and for the business context. It has formed the basis for the methodology for identifying and selecting business models as well as of major types. A basic distinction that is made here is between business model and business context. We'll start with describing which ontology of the concept "business model" will be applied. Subsequently, the main characteristics of the business context that are relevant for the proposed study are described.

A business model can be decomposed into building blocks, in line with most business model ontologies in the academic and practitioner literature. The business models of CDW recycling facilities have been analysed according to the building blocks presented in Figure 4, which are the following:

- The **value proposition** describes which offerings of products and/or services are delivered and which are the benefits that are conveyed through these offerings.
- The **channels** building block describes how the offerings are brought to customers (commercially and physically)
- The **customer segments** building block describes which types of customers or clients are targeted. This might be closely related to the type of materials that customers are purchasing.
- The **resources** building block describes the strategic resources which contribute to the company's competitive advantage (e.g. intellectual property, customer relations, qualifications, …)
- The **processes and technologies** building block describes the main processes and technologies the company applies to create, deliver and capture value.
- The **value network** describes the main actors (companies, individuals or organisations) that are involved in the value creation, delivery or capture.
- The **organisation** building block describes the organisational aspects of the company (public, private and public/private).

[16] Osterwalder, Alexander and Pigneur, Yves. Business model generation: a handbook for visionaries, game changers and challengers. s.l. : John Wiley & Sons, 2010

[17] Van Ostaeyen, Joris. Analysis of the business potential of product-service systems for investment goods. Leuven: PhD thesis, KU Leuven, 2014. 978-94-6018-805-3.

[18] Osterwalder, A., Pigneur, Y., & Tucci, C.L. 2005. Clarifying business models: Origins, present and future of the concept. Communications of the Association for Information Science (CAIS)

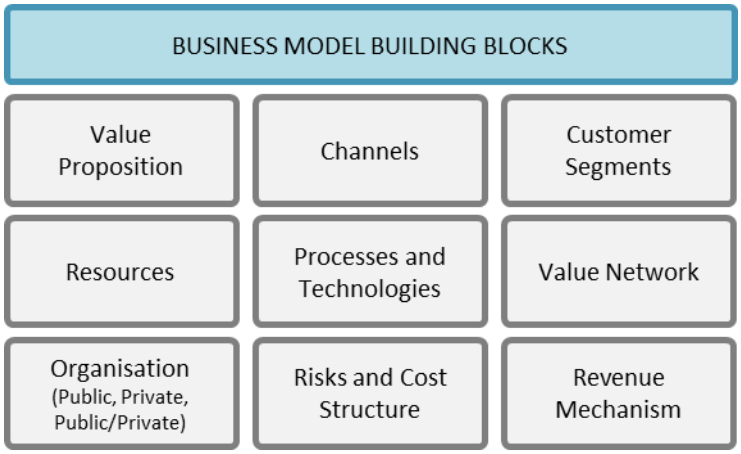
[19] Osterwalder, A. 2004. The business model ontology-A proposition in a design science approach. Dissertation 173, University of Lausanne , Switzerland

[20] Johnson, M. W., & Suskewicz, J. (2009). How to jump-start the clean economy. *Harvard business review*, *87*(11).

[21] Zott, Christoph, Raphael Amit, and Lorenzo Massa. "The business model: recent developments and future research." Journal of management 37.4 (2011): 1019-1042.

- The **risks and cost structure** building block describes the main costs and how the most important risks are assigned among the actors of the value network.
- The **revenue mechanism** describes how the company generates revenue (e.g. per ton of processed input material, per hour of demolition work).

Figure 4: Business model building blocks for a CDW facility[22] [23]



Source: IDEA Consult

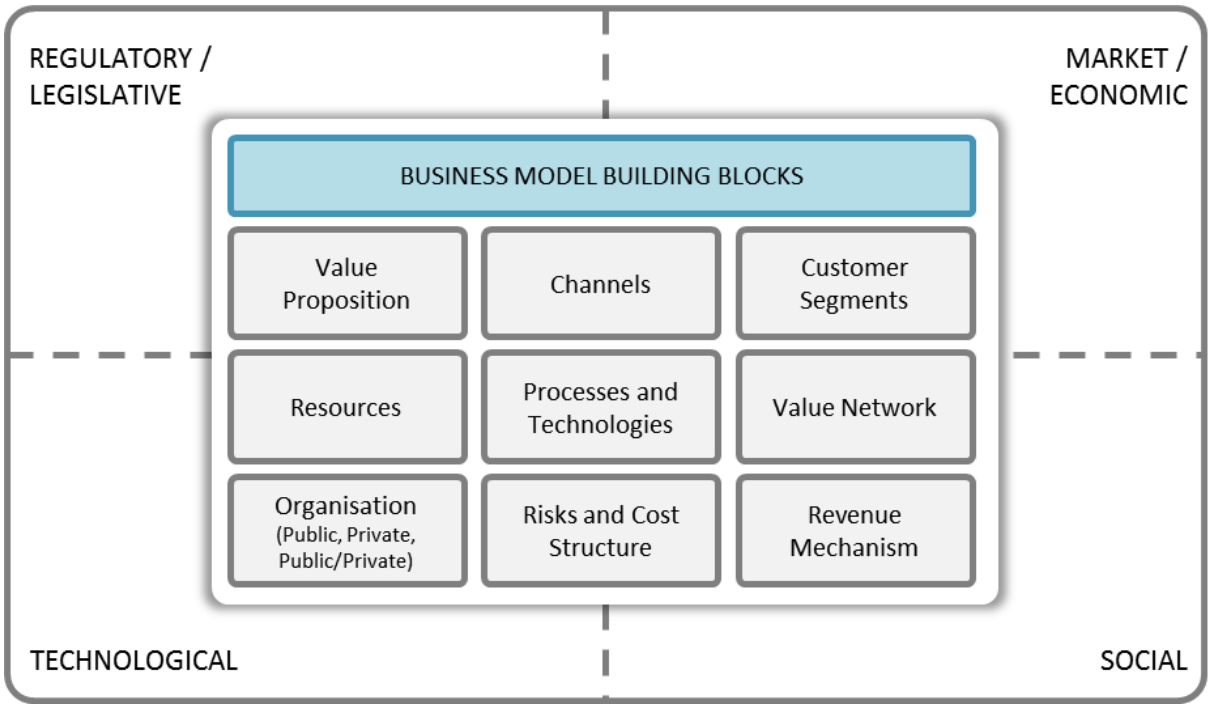
A business model is not just operating in isolation, but it is operating in a certain business context which can be stylized as having the following four main dimensions:

- The legislative and regulatory context, which is an important determinant of the viability of CDW processing business models (e.g. landfill taxes, certification, enforcement);
- The market and economic context, describing how demand and supply of different building materials are evolving, depending mainly on the available alternatives for the customers and suppliers of the CDW processing facility (e.g. local price of secondary materials, cost of demolition and disposal);
- The social context, describing the relevant social factors of the environment (e.g. availability of skilled workforce, population growth, perceptions towards using recycled materials);
- The technological context, describing the relevant state of the art and evolution of technologies (e.g. availability and expected evolution of new high-grade recycling technologies).

[22] Based on Osterwalder, Alexander and Pigneur, Yves. Business model generation: a handbook for visionaries, game changers and challengers. s.l. : John Wiley & Sons, 2010

[23] Based on Van Ostaeyen, Joris. Analysis of the business potential of product-service systems for investment goods. Leuven: PhD thesis, KU Leuven, 2014. 978-94-6018-805-3.

Figure 5: The business model framework: the position of the business model within the business context in which the company operates



Source: IDEA Consult

The aspect of profitability is essentially a performance measure of the company which is co-determined by all elements in the nine business model building blocks, as well as by the business context. The improved version of the questionnaire inquires explicitly about the company's profitability in the section covering the Revenue Mechanism. We also inquire about the company's VAT number which allows for a unique identification in the Amadeus company data set which contains the profit- and loss accounts of more than 19 million companies in Europe. Provided that the company's accounts are in the data set, we will be able to analyse the profitability performance.

With respect to the quantities of CDW processed, the improved questionnaire explicitly asks interviewees about the quantities by type of material that is processed. Furthermore the Multi-criteria Analysis (MCA) could also incorporate the contribution towards the Circular Economy Package ambitions of maintaining economy value at end of life, as well as the overall volume of treated waste as one of the evaluation criteria. This would imply that business models that have a high impact on processing large volumes achieve a higher ranking in the MCA. The aspect of cross-border business opportunities and flows is explicitly addressed in section on Value Network.

3/ Selection of countries

3.1 Method of selection

In order to best capture the current state of play for CDW recycling and the associated business cases, a careful selection of the EU countries has been made. In principle various methodologies can be used based on existing classifications of Member States, yet the underlying selection criteria and methods are not always clear or relevant. An interesting ranking has been provided by BIO by Deloitte et al[24], who developed a "Maturity Matrix" which groups the Member States in four ascending levels reflecting the Member States' performance with respect to CDW generation and management. However it is important when applying such a methodology that a transparency of the criteria is given.[25]

Specifically with the goal of this study in mind we have developed a selection based on an alternative stratification of Member States according to (i) their progress with respect to CDW recycling and (ii) according to their weight in the total EU CDW market. Business models have been sampled from major strata in the Member State distribution according to these criteria. The aim is to cover the Member States with a high maturity, potentially generating valuable good practices and the ones with a relatively poor CDW recycling performance.

Figure 6 depicts the EU MS using three indicators:

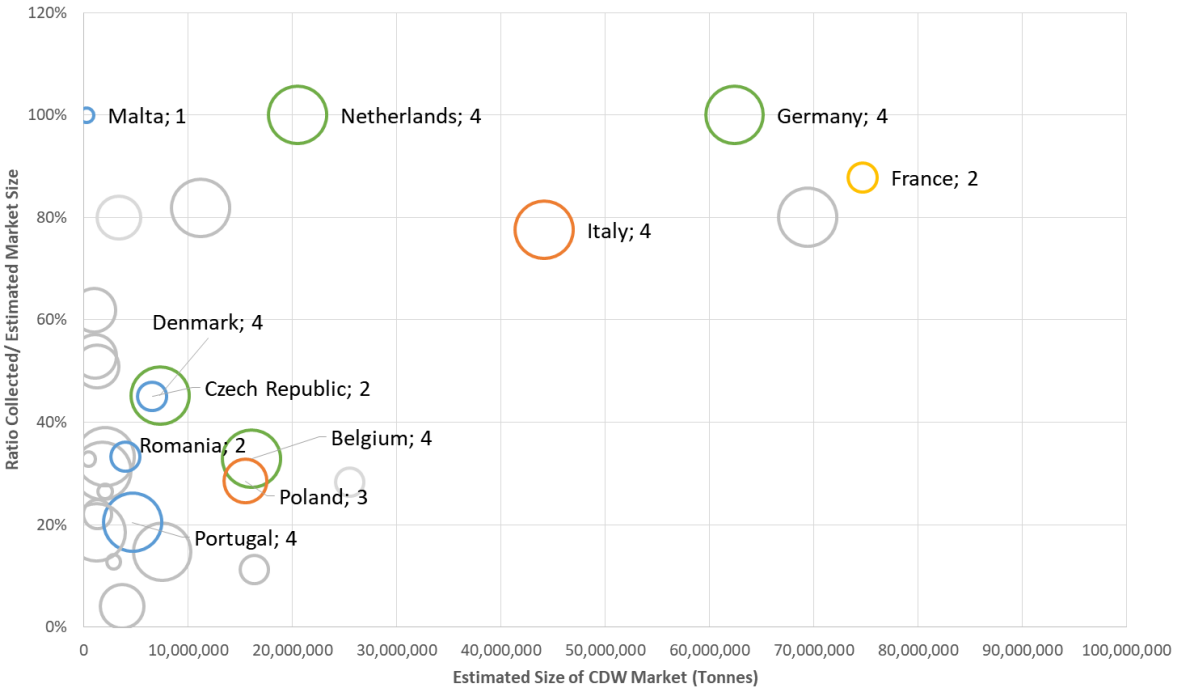
(i) **Market size** as measured by the estimated tonnes of generated CDW,
(ii) **Collection versus estimated market size ratio** on the vertical dimension and
(iii) The degree of re-use and recycling in total **treatment options** measured on a scale of four to one, where four presents the highest class of re-use and recycling.

In Figure 6 we present our selection of countries. The final selection of countries was completed in cooperation with the Commission and includes The Netherlands, Denmark, Germany, Belgium, France, Italy, Poland, Czech Republic, Portugal, Romania and Malta as well as non-EU countries of the USA and Japan. Based on the evidence indicated below, as well as in Table 1 we distinguish four groups:

1. **Member States that have a good CDW recycling performance both in terms of collection and treatment**. Here we select two smaller countries: Denmark and the Netherlands, as well as one large country: Germany. Belgium has been selected for doing pilot interviews to test the questionnaire.
2. **Member States with a large CDW market but with relatively low CDW recycling performance either in terms of collection, treatment or both**. Potential candidates are Italy, Spain and Poland.
3. **Member States with a relatively small CDW market and with a low CDW recycling performance.** Examples of countries are Romania, Czech Republic and Hungary.
4. **Member States with a large CDW market but with relatively low recycling and re-use activities.** We propose selecting France since it has a high collection ratio, yet a low score for treatment.

[24] Bio by Deloitte, BRE, ICEDD, RPS, VTT, FCT (2016) "Resource efficient use of mixed waste" for DG Environment
[25] As the BIO by Deloitte study with explanation of the methodology explaining the maturity matrix was unavailable at the time during which this study was initiated and executed, an alternative selection methodology was calculated.

Figure 6: Selection of Member States for identification of principle business models. The estimated amount of CDW generated in the EU by Member State (x-axis) related with each Member State's CDW collection ratio (y-axis) and waste treatment score (size of the circle), which ranges from four to one, where four represents the best waste treatment practices, Data: EUROSTAT [env_wasgen] database.[26] Calculation: own work.



Source: IDEA Consult

Table 1 (below) presents the countries selected as well as indicated variables from section 3.1 with precise scores and values for the indicators used, including the score in the "Maturity Matrix" by BIO by Deloitte[27] that has been presented in the terms of reference.[28]

Specifically the indicators are elaborated as follows:

- **Maturity Matrix:** elaborated by BIO by Deloitte et al. and referred to in the terms of reference.
- **Collection:** reported CDW collection data to EUROSTAT (obtained from [env_wastrt] data) on inert CDW in tonnes and kg/capita.
- **Score Collection:** This numerical representation of the collection data shows on a categorical scale which countries collect above the EU average of CDW in kg/capita.
- **Score Treatment:** Waste treatment methods based on EUROSTAT data [env_wastrt] are evaluated compared to the EU average, the score gives a relative indication of the consideration of the waste hierarchy, (e.g. preference of recycling over backfilling, incineration and landfilling)

[26] An in depth version of this figure, with all countries named is found in Annex 9/
[27] Bio by Deloitte, BRE, ICEDD, RPS, VTT, FCT (2016) "Resource efficient use of mixed waste" for DG Environment
[28] See Page 5 of the Terms of Reference for this call "Invitation to Tender number 592/PP/GRO/IMA/16/1131/9066 for the conclusion of a specific contract in application of the Framework Contract No 409/PP/2014/FC Lot 3 with reopening of competition – Study 'Development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure'" from 21.12.2016.

- **Estimated size of market:** is needed in order to calculate the percentage of CDW being recycled compared to what is generated on the market. This data is not available and is based on an own calculation by extrapolation of the Netherlands CDW generation / capita as this is the only country for which the market size compared to collection of CDW is known (100%) and adapting it using an index based on turnover of the construction sector per capita in the MS (see 10.2.2 for further details).
- **Score Estimated Market size:** This categorisation of the estimated market size in a conversion of the numerical representation and allows for a comparison to the Maturity matrix.
- **Collection/Estimated market ratio:** compares the above mentioned estimated size of market with the collection information obtained via Eurostat and serves as the indication of whether a country is meeting a 70% recycling ambition
- **Score Collection/Estimated market:** conversion of above percentage to a score (1-4) in order to make a comparison to the Maturity matrix.
- **Total Score:** is the simple added total of the (i) treatment (ii) estimated market and (iii) collection versus estimated market scores. This can be used to compare to the Maturity matrix.

Table 1: Selection of countries covered in this study with indications of maturity, collection (reported) CDW, market size, a treatment score and related ratios.

Country	Classification	Maturity matrix	Collection (tonnes)	Collection kg/capita	Treatment Score	Estimated market (tonnes)	Estimated market Score	Collection / Estimated market ratio	Collection / Estimated market score	Total score
United Kingdom	**Good** CDW recycling collection & treatment; relatively **large** market	4	55,544,858	863	4	69,401,844	4	80%	4	12
Netherlands		4	20,509,439	1219	4	20,509,439	1	100%	4	9
Sweden		4	1,841,884	191	2	16,366,965	1	*11%*	1	4
Denmark		4	3,309,996	588	4	7,324,648	1	45%	2	7
Luxembourg		4	543,775	989	4	1,781,717	1	31%	2	7
Germany		3	79,603,592	986	4	62,392,390	4	100%	4	12
Belgium		3	5,289,475	472	4	16,087,809	1	33%	2	7
Austria		3	9,174,000	1078	4	11,211,320	2	82%	4	10
Finland	**High**/*Low* collection ratio; *high*/**low** treatment score	3	1,104,925	203	4	7,501,115	1	15%	1	6
Ireland		3	148,402	32	3	3,675,284	1	*4%*	1	5
France		2	65,554,846	995	2	74,658,523	4	88%	4	10
Italy	**Large** CDW market; **low** recycling score; **low** collection / market size ratio	2	34,225,640	563	4	44,132,685	4	78%	4	12
Spain		2	7,212,433	155	2	25,491,282	3	28%	2	7
Poland		2	4,421,283	116	3	15,501,056	2	29%	2	7
Czech Republic	**Small** to medium CDW market, **low** recycling and reuse activities	2	2,959,902	282	2	6,567,847	1	45%	2	5
Portugal		2	960,585	92	4	4,690,887	1	20%	1	6
Hungary		2	2,698,023	273	3	3,374,136	1	80%	4	8
Slovakia		2	551,768	102	1	2,077,354	1	27%	2	4
Slovenia		2	229,595	111	4	1,238,425	1	19%	1	6
Estonia		2	626,139	476	3	1,011,491	1	62%	3	7
Romania		1	1,324,411	66	2	3,974,620	1	33%	2	5
Greece		1	367,018	34	1	2,866,515	1	13%	1	3
Bulgaria		1	682,074	94	4	2,049,857	1	33%	2	7
Croatia		1	289,090	68	2	1,309,508	1	22%	1	4
Lithuania		1	647,663	220	3	1,272,777	1	51%	3	7
Latvia		1	571,132	285	3	1,080,531	1	53%	3	7
Cyprus		1	152,201	177	1	462,870	1	33%	2	4
Malta		1	994,639	2338	1	245,145	1	*100%*	4	6
USA		n.a.			-	-	-	-	-	
Japan		n.a.			-	-	-	-	-	

Source: IDEA Consult own calculations on the basis of Eurostat [env_wastrt] and [env_wasgen] data, discussion with the Commission

3.2 Selected countries

The countries selected include the Netherlands, Denmark, German, Belgium, France, Italy, Poland, Czech Republic, Portugal, Romania and Malta, with also the USA and Japan, which are broken down into four major groups, plus an international selection. Our scores per Member State largely match with the results of the maturity classification from Bio by Deloitte.

Group one: Given the goal to support increased recycling of CDW in the EU in view of the circular economy objectives as well as the WFD, it is important to select countries that are dealing both with large volumes of CDW waste and performing well in recycling those wastes efficiently. These countries that do particularly well in terms treatment and/or collection may generate interesting practices and business models.

Group two: Select countries are also facing large volumes of waste, with lower ambitions towards recycling that is reflected in their statistics. Therefore, MS are included that have a relatively large share of waste and a relatively low CDW recycling score. The combination of these two conditions can be interpreted as an indication of an investment need for CDW recycling facilities.

Group three: A MS with a large to medium sized market, with a mixed score in the area of recycling, collection / market size ratio and / or the maturity matrix, results in a third group of countries that are performing some recycling and activities, however where a mixed picture leads to the necessity of improved ambition towards circularity in CDW treatment and recycling.

Group four: Represents a set of MS which face a small to medium sized market and low recycling and reuse activities across the spectrum. These countries are targeted in order to gather more information what particularly hampers CDW recycling their country in order to target possibilities for improvement.

Overall, select outliers can be observed including Malta, Sweden and Ireland. These are in all likelihood attributable to the collection data, where Sweden and Ireland score very low and Malta scores very high, creating an above average CDW per capita, which is reflected in the estimation. In order to confirm whether 2014 was an economic anomaly year in terms of overall construction activity, data[29] on Sweden and Ireland were checked for the period from 2010 to 2015 in order to determine their reliability and robustness. Based on the data, outliers in terms of seasonal or crisis fluctuations for Sweden and Ireland can be ruled out. This outcome and the overall presence of outliers points towards issues in reporting consistency for many MS. Indeed a challenge that is faced by such analyses is that it does it include reporting under other labels such as mixed waste numbers nor does it include CDW that is informally disposed of in foundations or roadworks.

3.3 Inclusion of Non-EU countries

The final selection of countries in cooperation with the Commission are the Member States highlighted in their respective categories together with the USA and Japan. The reason for including Japan and the USA are that they have comparable economies with that of the EU, yet each with their own specificities in terms of building stock and CDW recycling practices which can be insightful for this study. In terms of urban building practices these large economies are comparable, as well as in terms of infrastructure.

[29] Annual enterprise statistics for special aggregates of activities (NACE Rev. 2) [sbs_na_sca_r2], INDIC_SB Turnover or gross premiums written – million euro, extracted on Jan 3rd 2018

The material composition of the building stock evidently has its consequences for CDW recycling opportunities. Another relevant factor in the comparison is the different attitude towards renovation.[30] While EU residents tend to have a larger preference for renovating older buildings, partly because they are made with brick and concrete and therefore have longer longevity, the consumer preferences in Japan[31] and the USA tend to go for complete quick demolition and building new. Again for urban large projects practices are rather common, for instance through the stripping of large buildings to the frame and 'redressing' it with new more sustainable materials.[32] It is also noteworthy to indicate that building and demolition practices, especially in the residential segment, are substantially co-determined by cultural preferences. In this sense one can observe commonalities between building practices in the USA, Australia and Canada. As such, our selection of the United States can to a certain degree be perceived as a representation of the situation in these countries.

[30] Gao, W. et al. (2001) Energy impacts of recycling disassembly material in residential buildings. *Energy and buildings* (33) p. 553-562.
[31] Saigo, T. et al. (2011) Future Direction of Sustainable Buildings in Japan. Open house international Vol 36, No. 4 December 2011, p. 5-19.
[32] Tanikawa, H. and Hashimoto, S. (2009) Urban stock over time: spatial material stock analysis using 4d-GIS. Building Research & Information, 37: 5-6, 483-502.

4/ Questionnaire development and interviews

4.1 Questionnaire development

Reaching out to stakeholders on the field was essential to obtain a better view on the prevalent CDW recycling business models in Europe. Hitherto no systematic repository of business model data on CDW recycling exists in Europe or elsewhere. To capture this information in a systematic manner a questionnaire was developed based on the business model and business context ontology presented in Figure 5. For each of the building blocks a set of questions was formulated. The formulation of the questions went through a testing process. First internally within the research group the questions were critically assessed and subsequently a number of pilot interviews were done which ultimately led to three rounds of revisions. Aspects scrutinized were accuracy, clarity, simplicity, the expected time and effort it would take from the interviewee to answer the questions. The pilot interviews showed the necessity to prioritise the building blocks and also within the building blocks to prioritise the questions. This was done by (i) colour coding the questions and (ii) indicating an approximate timing for each of the building blocks. The final version of the questionnaire is presented in Annex 1. The answers on these questions have been used to develop the business model typology in Chapter 5/ and the analysis of business contexts in Chapter 6/.

4.2 Business model and business context for CDW recycling interviews

More than 78 invitations for interviews on the business model and business context have been sent out and 39 interviews have been completed. This implies a response rate of about 49%, which can be considered as relatively high. The aim was to conduct at least three interviews per selected Member State (see Chapter 3/). All selected countries have been covered. Beside the Member States and countries that were focussed on in the interview process, also information from other countries has been obtained, in particular the UK and Singapore. An overview of interviewed stakeholders by Member State is provided in Annex 2. In the first stage of the project the interviews have been focussed on businesses, their representative organisations and national or regional authorities including their agencies. The main goal was obtaining information on the various types of business models used and on the types of business contexts that can be identified. In later phases of the project additional interviews were done with representatives from the financial community, most notably the EIB, investment banks, investment funds and banks, with the purpose to check the usefulness of the elaborated business cases for potential investors. Details on the financial interviews and business case interviews can be found in Chapter 8/.

We emphasize the importance of contacting the national and regional authorities as a part of information gathering as, in select Member States such as Belgium (Flanders and Wallonia) and Germany CDW facilities must register with the respective authority. Although it is natural to assume that these authorities will also have the best available knowledge on the state of CDW recycling facilities in the respective country or region, this varies by Member State. Some of the national or regional authorities were able to provide interesting examples of successful CDW recycling facilities. One of the ambitions at the onset of the project was, based on the selection of countries as outlined in Chapter 3/, to obtain a better understanding the successful business models in Eastern European Member States, as well as to get evidence of exemplary established models from western European countries. The latter has certainly worked out with interesting and relevant CDW recycling business models for various material streams (stone fractions, concrete granulates, gypsum, etc.) and under different conditions (presence of waterways, different geologies, presence of primary material quarries, landfill policies). The former has been reached partially in the sense that we obtained very interesting business cases in the Czech Republic and valuable feedback on the business conditions from various Polish administrations and departments. However, company evidence was harder to obtain. This holds especially true for Romania and Malta.

5/ Typology of CDW recycling business models

Description of methodology and interview sample

In this study, the particular purpose of the representative typology for significant CDW business models is to epitomize the different ways of developing and operating CDW recycling facilities in the EU and in some non-EU countries. Information gathering about business models is strongly oriented towards high volume waste streams, as this plays the largest role in contributing to the achievement of the 70% recovery target. Business models for recycling particular high value materials have not been of central focus as they are already well established and incorporated in sustainable production methods across the EU-industry. Our business model typology should clarify in generic terms but without losing the richness of the empirical business models under study how the business models of CDW recycling facilities can be best categorized and described.

The analytical framework and corresponding business model building blocks as depicted in Figure 5 allow to exhaustively describe a certain business model in a certain business context.

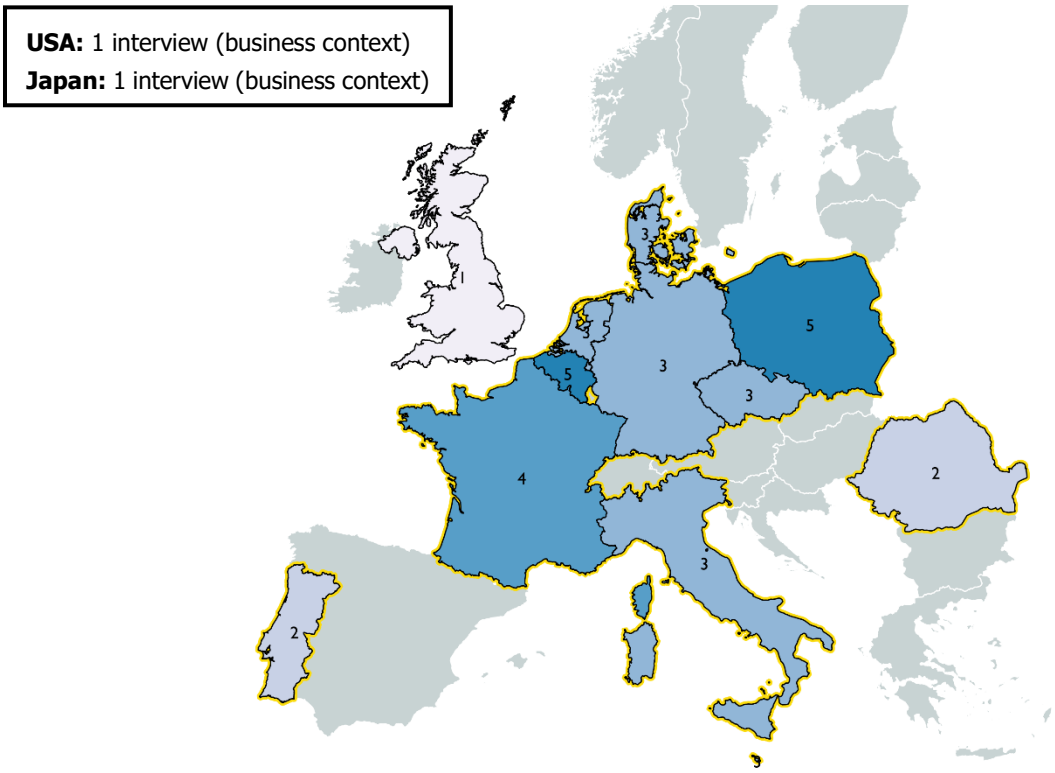
The questionnaire development, information gathering and identification of existing representative and significant business models, result in a set of comprehensive documents on existing business models that contain a full description of the business models and business contexts of each facility. All information is synthesized by deriving the most appropriate business model typology.

In practice, this is done by choosing **key distinguishing features of business models**. These key distinguishing features allow best to describe a particular generic business model found in practice and they are related to the main defining business model building blocks. After the distinguishing features are identified, a categorisation is determined by listing the main options according to each feature. A combination of 2 or 3 features then allow to describe business model type.

Fact sheets have been developed for the key types of business models in CDW recycling as identified through the typology development to clarify the key traits of that particular type. Inputs from information gathering through interviews, consortium experts and other key stakeholders have been used to populate the fact sheets presented in Chapter 5.2.

The key source of information for determining the typology consists of interviews with various stakeholders in the CDW value chain. The interview sample consists of a combination of companies and organizations, whereby the former focus on the first part of the questionnaire (business model) and the latter provide information on the second part (business context). Of the 39 interviews which have been conducted, 18 focus on business context and 21 on business model questions. The overview of the stakeholders consulted as a part of the interview phase is provided in Annex 2. This sample represents a wide variety of countries reflecting the selection indicated in Chapter 3/ and depicted in Figure 7.

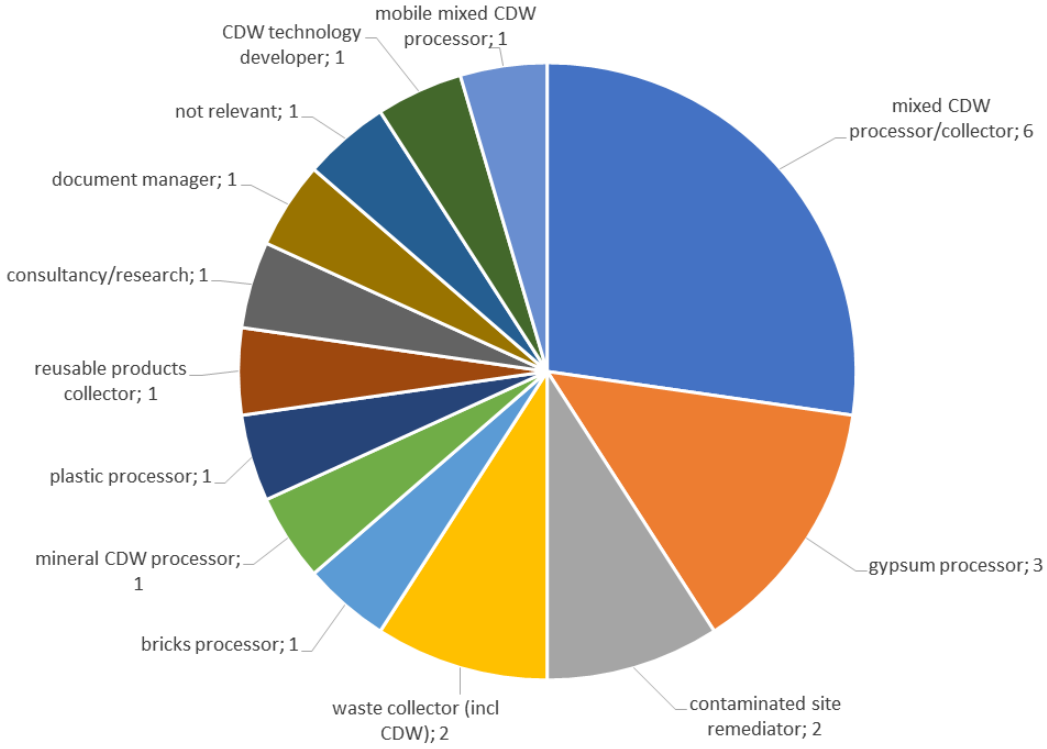
Figure 7: Indication of number of interviews per Member State on business models and business context



Source: IDEA Consult

For the interviews focusing on business models, the frequency of occurrence of the various business model types are depicted in Figure 8. The scope of the business model examples includes on the one hand companies that are actually recycling CDW, but also companies whose core activity is essential and viability for CDW recycling. Thus, also developers of technology for CDW recycling and specific service providers (e.g. companies active with selective deconstruction) are included.

Figure 8: Frequency of occurrence of the various business model types across the interview sample



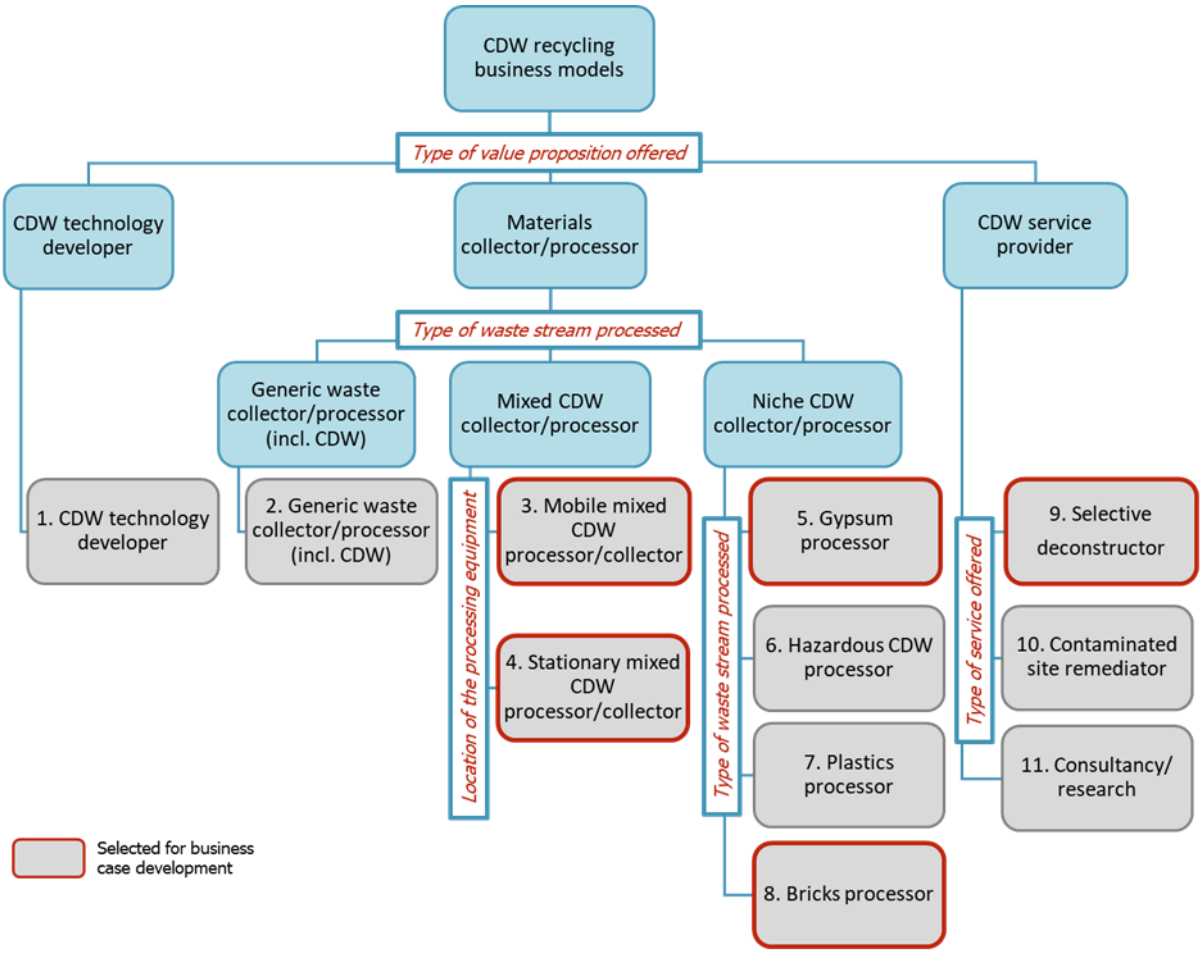
Source: IDEA Consult

5.1 Detailed explanation of the typology construction

The purpose of the typology constructed as a part of this project is to epitomize the different ways of developing and operating CDW recycling facilities in the EU and in selected non-EU countries. The business model typology should clarify in generic terms but without losing the richness of the empirical business models under study how the business models of CDW recycling facilities can be best categorized and described. Evidently, the business models distilled reflect the information that was gathered in the context of this study. It is acknowledged that further business models exist that were not covered in the information gathering process of this study. It remains that the main business models of CDW recycling are covered by this typology.

Key in the construction of a typology is the choice of *distinguishing features*. Distinguishing features describe a particular generic business model found in practice and they are related to the main defining business model building blocks.

Figure 9: Typology for CDW recycling business models distilled from the information gathered in the context of this study. Blue boxes indicate business model groups that can be further differentiated into subtype(s). Grey boxes correspond to business model types that are not further divided into subtypes. [33]



Source: IDEA Consult

The *first feature* (**Type of value proposition offered** in Figure 5) that is found to be a distinguishing characteristic based on a synthesis of all business model interviews [i4, i6, i7, i8, i10, i11, i15, i16, i18, i19, i23, i25, i26, i28, i29, i30, i31, i32, i33, i34, i36], is the type of value proposition that the company is offering. This value proposition is, in turn, closely related to how the company generates revenue or to the *revenue mechanism* that the company applies.

[33] Please note that the business models depicted reflect those that were captured as a part of the information gathering phase of this study and it is fully acknowledge that the figure does not (nor does it intend to) reflect all available business models especially niche CDW collector/processors including glass, metal, wood, among others. Business models for recycling particular high value materials such as metals, wood, glass have not been focussed on because they are already well established and incorporated in sustainable production methods across the EU-industry.

Based on value proposition type, **three main types of CDW recycling business models** are identified:

1. The **Service Provider** business model indicates a company that is focused on selling customized services related to CDW recycling (e.g. remediation of a contaminated building site), whereby it generates revenue mostly in function of the resources (hours) spent on the delivery of these services
2. The **Materials Collector/Processor** business model indicates a company that has a focus on sourcing, processing and selling various materials. The company's revenue is mostly generated through a combination of a fee per input ton processed and a fee per output ton delivered.
3. The **Technology Developer** business model refers to companies that have a focus on the development and valorisation of a particular technology, e.g. by offering technologies used for CDW recycling as an investment good.

The dominant business model found in the sample is that of a materials collector/processor (representing 16 of the 20 interviews conducted with a focus on business models). It is useful to divide this "umbrella" type into subtypes, using a second distinguishing feature.

There are various options for this second distinguishing feature. The most obvious are the type of waste streams processed by the company, the ownership structure (public/private/public-private) and the revenue mechanism (payment per input ton or per output ton). In Table 2 an overview is provided of these three candidates for the second distinguishing features as well as an indication and argumentation of their suitability for discerning business model types.

Table 2: Evaluation of three candidates for distinguishing features to discern subtypes of the Materials Processor/Collector business model

Candidate for features to discern subtypes of the Materials Processor/Collector business model	Estimation of suitability and argumentation
Revenue Mechanism	Most often, the revenue mechanism of a materials collector/processor is a mix of payment per ton of input material and payment per ton of output material, so both can't be distinguished in clear types.
Ownership Structure	Essentially, the economics of value creation and value capture are quite similar for waste processing companies, regardless of their ownership structure. In other words, ownership structure is not a suitable criterion to distinguish business model types.
Type of waste stream	Three clear types emerge in the interview sample by applying this feature, thus this option is chosen as the most appropriate.

With "type of waste stream" as the second distinguishing feature, the following three subtypes are identified:

1. The **Generic Waste Collector/Processor** business model type is, as indicated by its denomination, not focused on CDW in particular, but rather on collecting and processing waste in general. CDW is often only a small fraction of the total waste collected [i15, i16].

2. The **Mixed CDW Collector/Processor** business model type collects and processes mixed CDW of various fractions. As indicated by various interviewees [i1, i17, i24, i30], the main distinction between subtypes of the mixed CDW Collector/Processor can be based on whether they operate in a stationary plant (e.g. in urban areas) or whether they operate in a "mobile plant" (e.g. in a regional area, often moving from one building site to another). Therefore the distinguishing feature for these business models is **Location of the processing equipment**. The dominant model within the category of the mixed CDW Collector/Processor is stationary plants and this is reflected by the fact that all BM examples currently collected within this category are stationary. An interviewee indicated that in Belgium about 80% of the waste is processed through stationary collectors/processors while 20% is processed on site with mobile installations [i1].

3. The **Niche CDW Collector/Processor** business model type is focused on collecting and processing one fraction of CDW in particular. The economics of handling this fraction is very specific from one fraction to another (e.g. material prices, competitive options for customers and suppliers, technologies applied for processing). Therefore, a distinction of subtypes for the niche CDW Collector/Processor based on the specific material fraction on which it is focused (**Type of waste stream**), is the most logical choice for the final distinguishing feature.

The final feature distinction is chosen according to the rationale presented in Table 3.

Table 3: Evaluation of two candidates for distinguishing feature to discern subtypes of the Service Provider business model type

Candidate for feature to distinguish subtypes of service providers	Estimation of suitability and argumentation
Revenue Mechanism	Types can be identified for (1) companies that generate revenue based on working in man + materials mode (i.e. the price that the customer pays is determined by counting the number of hours needed to deliver the service and a fixed hourly rate) or (2) companies that generate revenue based on a lump sum calculation of project revenue ("all-in price"). Given the fact that most business model examples collected in the interviews [i7, i19, i23, i31] all indicate a mix of these types, this feature is not deemed suitable to distinguish subtypes.
Type of service offered	This feature allows to distinguish business model types based on the type of services they offer. Based on the relevant interview cases [i7, i19, i23, i31, i34], this indeed is a key feature that distinguishes essentially different ways of creating and capturing value.

5.2 Fact sheets on identified business models in CDW recycling

5.2.1 Fact sheet 1: CDW Technology Developer

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▶ **Selling equipment/machinery to process CDW**	Downstream customers: ▶ CDW processing companies ▶ Demolition companies ▶ Construction companies

Main technologies and processes	Revenue mechanism(s)
Key processes are Research & Development for creating the technologies and sales for engaging with customers **Key technologies for CDW recycling are sorting, cleaning, sieving and breaking.**	Project based revenue (for customized installations) or revenue per product sold (for standard installations) Additionally, some service revenue can be generated from aftermarket opportunities

Material streams processed	Typical investment
Depending on the specific technology developed. **This type of company does not process material streams itself but rather enables its customers to do so.**	Very case specific, depending on the technology that the company develops. Main investment in R&D.

Main risks	Examples from interviews
Main risks for this business model are: ▶ **Competing offerings or substitute technologies** ▶ **Market acceptance of the end products processed with the developed technologies (e.g. recycled materials)**	CDE Global Limited

Strengths	Opportunities
1. **Intellectual property, technological expertise and R&D** 2. **Revenue streams are not directly dependent on material price fluctuations** 3. **Direct customer relations** 4. **In general international focus**	1. Environmental regulations promoting recycling (leading to increased investment by customers in processing technologies) 2. Strategic partnerships with other technology developers 3. Alternative business models (e.g. pay-per-use, performance contracting) 4. Indirect sales channels (distributors)

Weaknesses	Threats
1. **Dependency on availability of CAPEX budgets at customers** 2. **Revenue streams are essentially on one-off basis, not recurrent**	1. Competitive or substitute offerings – especially entrance of new competitors at lower cost (e.g. CN/IN) 2. Lack of (enforcement of) regulations promoting recycling, or regulatory changes 3. Lack of market acceptance of recycled materials

Source: IDEA Consult

5.2.2 *Fact sheet 2: Generic Waste Processor (incl. CDW)*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: **Collection and treatment of waste, including CDW**	Upstream customers (providers): ▶ Citizens ▶ Municipalities ▶ Construction companies ▶ Demolition companies ▶ Waste collectors Downstream customers: ▶ Waste treatment companies ▶ Construction companies ▶ Users of secondary raw materials

Main technologies and processes	Revenue mechanism(s)
Key technologies/processes are collection with containers and technologies for crushing / sorting / screening.	Gate fee per input ton, either paid by the provider or through funding mechanism (public or private) Additionally, a payment per ton of output material

Material streams processed	Typical investment
Mixed construction and demolition waste (170904)	▶ Typically same investment as mixed CDW processor/collector (EUR 2-3 M), mainly in crushers, breakers, sieving installation and equipment for internal logistics ▶ Enough land and infrastructure needs to be available to store materials (e.g. typically 2 hectare)

Main risks	Examples from interviews
Main risks for this business model are: ▶ **Regulatory changes requiring a change in gate fee** ▶ **Reduction or absence of the markets for recovered materials**	GESAMB Lipor

Strengths	Opportunities
1. Robust business model, not dependent solely on CDW but on very diverse material streams **2. Existing distribution / collection system can be leveraged to supply/deliver materials** **3. Existing marketing and customer engagement channels can be leveraged** **4. Certain process steps can be combined with other material streams (glass/wood/metal)** **5. Knowledge base for compliance can be leveraged**	1. Partnerships with niche CDW processors can ensure that specific material streams are taken care of in the optimal way 2. Increased demand for recycled products

Weaknesses	Threats
1. No specialization in CDW in particular, risk of not treating input streams in the most effective way **2. Often not enough land available for keeping intermediate inventories** **3. Scale is needed, there should be a market for other waste streams** **4. Other sources of waste (non CDW) should be available in separated way** **5. Mismatch between action radius of CDW processing and other waste processing**	1. Contamination of input material streams with hazardous substances 2. Competition with mobile plants that offer a more cost effective and convenient solution for customers

Source: IDEA Consult

5.2.3 *Fact sheet 3: Mobile Mixed CDW Processor / Collector*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Collection and processing of inert CDW at the building site with mobile processing equipment**	Upstream customers: ▸ Construction companies ▸ Demolition companies Downstream customers: ▸ Construction companies ▸ Niche CDW processors

Main technologies and processes	Revenue mechanism(s)
Key processes are transport, crushing, sieving	Most often a fixed fee per output ton delivered, with different prices applicable for various output material fractions (e.g. broken concrete, mixed granulate, sand, broken asphalt). Sometimes a small additional revenue can be made from the metal content (e.g. Fe from reinforced concrete)

Material streams processed	Typical investment
Mixed construction and demolition waste (170904), focusing on inert fractions (concrete, stony fractions, bituminous mixtures without contaminants)	Typical investment of EUR 900 – 1,100,000 in equipment per mobile plant (including a combination machine with crusher and sieve integrated, a wheel loader and an excavator) and EUR 200 – 500,000 in land, building and infrastructure

Main risks	Examples from interviews
Main risks for this business model are: ▸ **Contaminated input flows** ▸ **Hindrance of activities due to nuisance caused to surroundings (dust, noise)** ▸ **High transportation costs** ▸ **Low occupancy of mobile plant**	Adams Polendam

Strengths	Opportunities
1. Very limited transportation of materials to the plant, flexible location **2. Flexibility on quantities, can work both on big and small wharfs** **3. More convenient for upstream customers** **4. Materials can mostly be used onsite, thus effectively avoiding any transport** **5. Need smaller scale to start up** **6. More suitable for less urbanized areas than stationary mixed CDW recycling**	1. Combining with activities of selective demolition in order to extract maximum value of waste streams 2. Partnerships with construction companies 3. Partnership or combined activities with stationary processor to have advantages of both and to share overhead 4. Combining with activities of soil remediation to have a comprehensive offering

Weaknesses	Threats
1. Always outdoors, cannot prevent nuisance (sound, dust) **2. Limited in kind of sorting it can perform (focus on breaking, sieving), difficult to separate glass, other fractions** **3. No stocking locations** **4. Difficult to do quality control on input and output fractions** **5. Capacity lower, stationary have more scale** **6. Mobile plant OEE (overall equipment effectiveness) is reduced by transportation, setup and decommissioning activities** **7. If the amount of waste per site is too low (e.g. less than 2000 tons), it is difficult to be profitable in light of high transportation costs**	1. More susceptible to contamination of input streams (e.g. asbestos) because quality control is more difficult to manage 2. "Not in my backyard" (NIMBY) could hinder operation, e.g. by limitations on the allowed time for operation

Source: IDEA Consult

5.2.4 *Fact sheet 4: Stationary Mixed CDW Processor / Collector*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Collection and processing of CDW at a fixed facility** ▸ **Sales of recycled materials, most often standardized and certified**	Upstream customers: ▸ Construction companies ▸ Demolition companies Downstream customers: ▸ Earthworks companies ▸ (Road) construction companies ▸ Niche CDW processors

Main technologies and processes	Revenue mechanism(s)
Key processes are sorting, purification, crushing, internal logistics, quality control and certification	Combination of payment per output ton of material and gate fee per input ton delivered. Distribution of revenue depends on the specific regional business context, e.g. 25/75 or 50/50

Material streams processed	Typical investment
Mixed construction and demolition waste (170904) **Suggested that at least 100Kton of materials should be processed per year before it can be economically viable**	Typical investment of EUR 2M - EUR 3M, with ca. 50% for equipment and ca. 50% for land/building

Main risks	Examples from interviews
Main risks for this business model are: ▸ **(Changes in the) regulatory framework, e.g. related to acceptance of output materials** ▸ **Market dynamics leading to price pressure on output materials** ▸ **Lack of supply of input materials (e.g. due to lower demolition activities)**	Eco Logica 2000 Lafarge Holcim GREEN SKIP SERVICES Ltd. REMEX Mineralstoff GmbH „RADKOM" Sp. z o.o. TOPMIX

Strengths	Opportunities
1. Combination of specialization (CDW) and diversification (generic streams) **2. Typically rather small investment** **3. Can adapt until they have the right scale**	1. Strategic partnership with construction companies to ensure increased demand 2. Stocking locations to be more flexible in selling output materials when prices are high 3. Process improvements that allow to valorise specific material streams (e.g. metals)

Weaknesses	Threats
1. Fixed location, transport is needed **2. Price fluctuations of recycled materials** **3. Needs considerable land area to use as intermediate stocking location** **4. Needs other downstream partners to process certain CDW fractions (e.g. metals/wood), these might not always be available** **5. Depends on construction activity**	1. Competition by mobile CDW processors that can offer more convenient collection for customers at lower cost 2. Competition by quarries in the neighbourhood 3. Lack of (enforcement of) legislation 4. Lack of certification of output materials

Source: IDEA Consult

5.2.5 *Fact sheet 5: Gypsum Processor*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Gypsum waste treatment service whereby upstream suppliers pay a gate fee per ton of gypsum waste they deliver** ▸ **Downstream customers purchase recycled gypsum powder per ton**	Downstream customers: ▸ Plasterboard manufacturers (typically 98%) ▸ Paper manufacturers (typically 2%) Upstream customers (providers): ▸ Demolition companies ▸ Mixed CDW processors/collectors ▸ Construction companies ▸ Municipal waste collectors ▸ Plasterboard manufacturers Key partners in this business model are the plasterboard manufacturers

Main technologies and processes	Revenue mechanism(s)
Key technologies/processes are separation techniques that can remove impurities (and cartons) from gypsum waste and quality control	Combination of gate fee per input ton and payment per ton of output material Typically, the gate fee is the largest share of the revenue (99%)

Material streams processed	Typical investment
Gypsum based construction materials not contaminated with dangerous substances (170802) **Typically, one facility handles 20k – 50k ton/year** **Typically, a region will generate 4-5kg per person per year of gypsum waste**	Typical investment in a new facility is ca. EUR 2M to EUR 10M ▸ 50% invested in equipment / operation ▸ 50% invested in building / land

Main risks	Examples from interviews
Main risks for this business model are: ▸ **Lack of (enforcement of) legislation regarding gypsum waste (landfill ban / high landfill tax / export ban)** ▸ **Impurities of the input material (mitigation requires adequate pre-processing of inputs, especially separation from stony fractions)**	New West Gypsum Gips Recycling A/S Ritleng Revalorisation

Strengths	Opportunities
1. **Specialization in optimal processing of high value CDW stream, with innovative technologies leading to higher yield** 2. **Partnership with primary material producers to guarantee stable demand** 3. **Stable supply of recyclable materials**	1. Environmental regulations promoting recycling (leading to a higher cost of upstream alternatives e.g. landfilling) 2. Scarcity in supply of primary materials (e.g. shortage of availability of synthetic gypsum as by-product of brown coal power plants) 3. New regulations promoting selective demolition leading to higher availability of valuable input materials)

Weaknesses	Threats
1. **Dependency on input streams that are clean enough (requiring selective demolition upstream)** 2. **Dependent on one material type in particular, thus very sensitive to price changes of upstream and downstream alternatives** 3. **Lack of financing options for development of new technologies**	1. Lack of (enforcement of) regulations promoting recycling (e.g. illegal disposal of gypsum mixed with other CDW fractions) 2. Changes in regulations (e.g. allowance of cross-border movement of CDW that enables landfilling gypsum waste in another MS) 3. Market entrance of new providers of gypsum as secondary materials (e.g. industrial processes)

Source: IDEA Consult

5.2.6 *Fact sheet 6: Hazardous CDW Processor / Collector*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Collection and processing of hazardous CDW (e.g. tar containing asphalts) at a fixed facility** ▸ **Sales of recycled materials**	Upstream customers: ▸ Infrastructure construction companies ▸ Demolition companies ▸ Generic CDW processors/collectors Downstream customers: ▸ Road construction companies ▸ Users of granulate

Main technologies and processes	Revenue mechanism(s)
Thermal cleaning for tar contaminated asphalts **Physical/chemical treatment**	Combination of gate fee per ton input material and material revenue per ton output, depending on local business context. Example: 70% gate fees, 30% output materials

Material streams processed	Typical investment
Concrete (170101) **Bricks (170102)** **Bituminous mixtures, containing coal tar (170301*)** **In general 2 types: fractions requiring thermal cleaning and fractions not requiring this**	▸ No public information available, but very high investment requirements because of need of incinerator

Main risks	Examples from interviews
Main risks for this business model are: ▸ **(Changes in the) regulatory framework, e.g. related to allowed impurities in recycled asphalt**	Recycling Kombinatie REKO B.V.

Strengths	Opportunities
1. Large quantities of materials can be processed in automated way **2. Specialized technological expertise**	1. Access to waterways allow to tap additional supply streams 2. Price hikes or insufficient supply of primary materials 3. New regulations enforcing thermal treatment of tar containing CDW

Weaknesses	Threats
1. Thermal treatment is very capital-intensive process **2. Not most effective way to make granulates** **3. Needs big scale** **4. Limited lifespan of waste stream**	1. Low competitive pricing of primary materials 2. Lack of (enforcement of) regulations 3. Possibilities to export CDW to countries that do not require contaminants to be removed (e.g. Baltic states for tar-containing asphalts)

Source: IDEA Consult

5.2.7 *Fact sheet 7: Plastics processor*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Processing of plastic waste (PE and PP) in the form of granules,** ▸ **Sales of raw materials (granules) for the plastics industry**	Upstream customers: ▸ construction companies ▸ generic CDW processors recycling sites ▸ plastic processing companies (production waste) Downstream customers: ▸ Plastic manufacturers In analogy to the gypsum processors, key partners are plastic manufacturers

Main technologies and processes	Revenue mechanism(s)
NIR sorting, magnetic and electrostatic separation, fly-and-sink and manual sorting of plastic waste, cleaning	Revenue generated with a combination of gate fee per input ton delivered and material revenue per ton of output material sold

Material streams processed	Typical investment
Plastics (170203)	▸ Typical investment not available.

Main risks	Examples from interviews
Main risks for this business model are: ▸ **Low oil prices leading to low prices of primary materials** ▸ **Impurities in input streams, inadequate sorting**	Aage Vestergaard Larsen A / S

Strengths	Opportunities
1. **Specialization in treating plastic waste in particular** 2. **Not solely dependent on plastic streams coming from CDW, but can also treat other types of plastic waste**	1. Partnerships with plastic manufacturers ensuring a stable demand of recycled products as well as inputs (production waste) that allows to stabilize supply 2. Improved sorting technologies that allow to separate different plastic types 3. Improved source separation of plastic waste, which is expected under the amended WFD

Weaknesses	Threats
1. Input materials should be clean and separated enough to be able to extract valuable recyclables. Output quality is very sensitive to impurities **2. Very hard to be competitive in pricing with primary material producers and other sources of secondary materials**	1. Low oil prices leading to a lower price of competing primary materials 2. Contamination of input material streams with hazardous and legacy substances (e.g. flame retardants, lead in PVC)

Source: IDEA Consult

5.2.8 *Fact sheet 8: Bricks processor*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▶ **Processing of bricks for reuse** ▶ **Mainly targeted at upper segment of market**	Upstream customers: ▶ Construction companies ▶ Demolition companies Downstream customers: ▶ Construction companies Key partners are companies that are architects that can influence demand and companies that are supplying input materials, e.g. those active in selective demolition activities

Main technologies and processes	Revenue mechanism(s)
Main process steps are first sorting the reusable bricks out of input material, then cleaning the bricks (remove mortar) and subsequently stapling the bricks (e.g. with robot stapler)	Revenue generated per brick sold

Material streams processed	Typical investment
Bricks (170102)	▶ Typical investment of EUR 1.2M in equipment (sorting/cleaning machine, robot stapler and wheel loader) and infrastructure/land/building needed (can often be rented) ▶ One production line with a capacity of 100 incoming tons per shift needs about 7 operators to function

Main risks	Examples from interviews
Main risks for this business model are: ▶ **Instability of input materials supply** ▶ **High brick content of input materials** ▶ **Regulatory barriers (e.g. CE marking of recycled bricks)** ▶ **Requirement of selective deconstruction**	Old Bricks

Strengths	Opportunities
1. Business model that focuses on a re-use and not on a recycling or downcycling scenario, meaning this business model has very significant environmental benefits **2. Market can exist for both low end (cheap bricks) and high-end products (special, high value bricks)**	1. Partnerships with (selective) demolition companies offering a better, stable supply of recyclable bricks 2. Environmental regulations promoting recycling and selective demolition 3. Increased demand for "authentic" building materials with natural patina, architect driven market 4. Partnership with social enterprises, e.g. to offer employment opportunities for vulnerable groups 5. Partnerships with municipal waste collection services to receive high quality input materials

Weaknesses	Threats
1. Dependency on input streams that are clean enough (requiring selective demolition upstream) but still affordable **2. Dependent on availability of enough high-quality input material but supply can be irregular** **3. Dependent on one material stream in particular and thus more risk of price fluctuations** **4. Labour intensive activity, which can be partly but not fully automated**	1. Potential contamination of input material streams with hazardous substances 2. Lack of standards for certifying recycled bricks 3. Low price setting of primary bricks 4. Cheap options for customers to process bricks as part of mixed inert fractions (e.g. to create mixed granulate)

Source: IDEA Consult

5.2.9 *Fact sheet 9: Selective deconstruction*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Custom price for selective deconstruction project based on the number of materials processed and the number of hours needed (labour and machine hours), the amount of material waste generated and the number of required transport** ▸ **Differentiation based on speed of execution**	Upstream customers: ▸ Building owners ▸ Prime construction contractor Downstream customers: ▸ Various waste processing companies (mixed or niche)

Main technologies and processes	Revenue mechanism(s)
Main process steps applied are decommissioning (removal of materials inside the building), decontamination (manual removal of contaminants e.g. of asbestos and PVC), selective deconstruction (manual with use of demolition tools), demolition of the building and transport	There are basically four revenue drivers: ▸ The time needed for the work (number of hours) ▸ The machine hours (mainly cranes) ▸ The transports (in function of amount of materials to be disposed of) ▸ The tonnes of different materials fractions

Material streams processed	Typical investment
All construction streams except soils are separated and sent further downstream for further processing by specialized companies	Significant investment (EUR 2-6M) in equipment is required, typically demolition cranes of various types and with various accessories, as well as container trucks, loaders and crane trucks

Main risks	Examples from interviews
Main risks for this business model are: ▸ **(Changes in the) regulatory framework, e.g. related to acceptance of output materials** ▸ **Contamination (asbestos)** ▸ **Safety on construction sites** ▸ **Nuisance to the environment during the work (noise, dust)**	Stallaert (Viabuild Group)

Strengths	Opportunities
1. **Starting up this type of business does not require a lot of capital** 2. **Due to selective deconstruction, a higher quality and value of recycled materials can be obtained** 3. **Due to selective deconstruction re-use is enabled**	1. Combination with business model of soil remediation or of mixed CDW processor (cross selling option) 2. In line with regulatory evolution and policy development 3. Willingness to pay more for selective deconstruction 4. New material streams emerge for reuse (e.g. cellular concrete, treated wood, plastics, isolation materials of cables)

Weaknesses	Threats
1. **Depends on construction activity** 2. **Depends on the willingness to pay extra by upstream customers because it will increase cost** 3. **Is a very labour-intensive type of work, which requires specialized personnel** 4. **Safety during deconstruction is often a concern** 5. **Effective and efficient selective deconstruction requires a lot of knowledge and an inventory exercise**	1. Competition with cheaper demolition options, selective deconstruction is generally cost-increasing 2. There is especially a risk of competitors who claim to be selective deconstruction companies but in fact are not applying best practices 3. Uncertainty of which materials are used in the building, risk of unpleasant surprises which lead to discussions with customers on budget overruns

Source: IDEA Consult

5.2.10 *Fact sheet 10: On-site Contaminated Soil Remediation*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Customized waste treatment services (CDW processing, soil remediation and building treatment)** **Main value offered to downstream customers consists of the increase of land value through the removal of soil contaminations** **Application of in-situ techniques can avoid large transport of soils.**	Upstream customers: ▸ Private (industrial) companies ▸ Public entities Downstream customers: ▸ Land owners

Main technologies and processes	Revenue mechanism(s)
Storage, treatment, disposal, in-situ technique for soil remediation (e.g. bioremediation and convective transport of contaminants)	Revenue generated per project, whereby the project revenue is customized, often based on rate per ton of input material treated in combination with a service fee per hour performed.

Material streams processed	Typical investment
Various hazardous and non-hazardous fractions	Typical investment of EUR 7 M, depending on the specific technology that is being applied

Main risks	Examples from interviews
Main risks for this business model are: ▸ **Non-compliance with all applicable regulations** ▸ **Operational risks (technical failure, human error)**	DEKONTA, a.s. UNIRECUPERI srl Lafarge Holcim GEOCYCLE

Strengths	Opportunities
1. **Revenue stream is not solely dependent on the amount of materials processed, mostly there is a diversified offering** 2. **Know how in waste management and soil remediation** 3. **Value is driven mostly by increase of land value**	1. Hybrid business model with materials processor/collector 2. Partnership with construction companies to deliver fully integrated projects 3. Public procurement opportunities 4. New regulations enforcing soil remediation

Weaknesses	Threats
1. Dependent on realization of enough projects **2. Revenue streams are essentially on one-off basis, not recurrent**	1. Lack of (enforcement of) regulations promoting recycling, or regulatory changes 2. Lack of market acceptance of recycled materials

Source: IDEA Consult

5.2.11 *Fact sheet 11: Consultancy/association*

Value proposition	Customer (downstream/upstream) and key partners
Services and products offered: ▸ **Selling consultancy or research services to various stakeholders in the CDW recycling ecosystem**	Customers: ▸ Demolition companies ▸ CDW processing companies ▸ Construction companies ▸ CDW Technology companies

Main technologies and processes	Revenue mechanism(s)
Consultancy and research are activities driven by market, industry, technology knowledge	Project based revenue, mostly in function of the days spent by various profiles.

Material streams processed	Typical investment
This type of company does not process material streams.	Limited investments. Key is attracting people with right competences

Main risks	Examples from interviews
Main risks for this business model are: ▸ **Fluctuating demand** ▸ **Liabilities (e.g. if wrong advice is given leading to contamination of material streams)**	ASM Market Research and Analysis Centre Propharm Japan

Strengths	Opportunities
1. **Intellectual property, technological expertise and R&D** 2. **Market and industry knowledge** 3. **Revenue streams are not dependent on material price fluctuations**	1. Can be integrated in selective demolition business model 2. With increase in selective demolition activities, there is an increased need for this type of services 3. Decouple revenue from hours performed but charge in function of material value that can be recuperated

Weaknesses	Threats
1. **Revenue streams are typically on one-off basis, not recurrent**	1. Fluctuating demand of services 2. Employee turnover

Source: IDEA Consult

6/ Analysis of business contexts

For the analysis of the business contexts existing relevant evidence from studies and literature were used to analyse the various relevant business contextual factors. This information was supplemented by inputs from the business model and business context oriented interviews (see Chapter 4/ for further details).

The following sections present the relevant regulatory and legislative framework conditions in each of the selected Member States as these are an essential business contextual element. Subsequently we provide an overview of the main conventional CDW recycling techniques and also the upcoming technologies. This is followed by a section detailing the key findings from the interviews across the business contextual elements. Finally, a fact sheet on the business context elements is presented, highlighting the differences between leading CDW recycling Member States and lagging Member States.

6.1 The regulatory framework conditions for selected Member States

Successful CDW management can only take place if **the appropriate policy and framework conditions** are in place. Both environmental and material-related legislation together with reference rules and criteria play a key role in creating a market for recycled materials, as to compensate for a low level of "natural" demand[34]. All of the analysed Member States (the Netherlands, Denmark, Germany, Belgium, France, Italy, Poland, Czech Republic, Portugal, Romania and Malta) have transposed the EU waste acquis into national legislation that regulates waste management in their country. For detailed analysis of the regulatory framework in the selected Member States, please see Annex 3.

Still, CDW management is regulated to different extent across the Member States. Except for Romania and Malta, all the other analysed Member States have regulations specifically targeting CDW. Thereby, the most developed regulations can be found in the Netherlands, Denmark, Germany, Belgium, France and Italy. The legislative framework of these leading countries is characterised by a variety of **legislation specifically targeting CDW management** combined with other tools promoting recycling of CDW. The most advanced legislations targeting CDW management comprise for example specifications on separation and requirements regarding the pre-treatment of CDW[35], mandatory pre-audits on demolition sites[36], mandatory departmental CDW management plans[37], as well as quota of percentage for recycled materials (including construction materials) and products in public procurement[38]. The leading countries also have rather **high landfill taxes** in place. For example, the landfill tax for CDW in Romania amounts to EUR 11 per tonne, whereby in Denmark the landfill tax is five to six times higher (the landfill tax lies between EUR 49 and EUR 64 per tonne)[39]. Consequently, the taxation has promoted the development of recycling technologies in Denmark and decreased the amounts to be landfilled[40].

[34] Based on interviews
[35] Germany: Ordinance on the Management of Municipal Wastes (Gewerbeabfallverordung), available at: https://www.gesetze-im-internet.de/gewabfv/BJNR193800002.html; Denmark: Statutory Order no. 1309/2012, available at: http://eng.mst.dk/topics/industry/environmental-inspection/danish-regulations/
[36] France: Law 2009-967 of 3 August 2009, available at: https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000020949548&categorieLien=id; Law 2010-788 of 12 July 2010, available at: https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022470434
[37] France: Law 2010-788 of 12 July 2010, available at: https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022470434
[38] Italy: D.M. n°203 del 8/5/2003, "Norme affinchè gli uffici pubblici e le società a prevalente capitale pubblico coprano il fabbisogno annuale di manufatti e beni con una quota di prodotti ottenuti da materiale riciclato nella misura non inferiore al 30% del fabbisogno medesimo", available at: http://www.sicurezzaonline.it/leggi/legrif/legrif2003/legrif2003doc/legrif2003din/din20030508203.htm
[39] The landfill taxes usually depend on the type of waste.
[40] Ibid.

Having a **landfill ban** in place for waste materials can also promote CDW recycling[41]. In the studied sample of countries, only the Netherlands, Belgium and the Czech Republic have a landfill ban in place. For example, the Dutch Decree on landfills and landfill bans (*Besluit stortplaatsen en stortverboden van afvalstoffen - Bssa*)[42] set criteria for the acceptance of waste at landfills and put in place a landfill ban for a number of waste materials. As result, **new plants for sorting of these waste materials** were opened in the Netherlands. These plants recover materials such as wood, metals, plastics and inert materials. The residual fraction is partially used to produce a secondary fuel.

Monitoring and enforcement of regulations are crucial for successful implementation of the legislative framework for CDW management[43]. Strong enforcement of regulations encourages CDW recycling and it is also very important in preventing illegal landfilling and backfilling[44].

Regulatory factors can be expressed through legislative lines, but also through tools such as permits, guidelines, specifications and certification, which need to be clarified, streamlined and advertised[45]. The legislative frameworks in the leading countries are complemented with additional **tools promoting recycling of CDW**. These include for example extended **producer responsibility schemes** and the **voluntary Dutch Demolition Code** in the Netherlands, voluntary extended producer responsibility schemes (for plastic packaging waste, PVC from construction and thermoplastics pipes) in Belgium and **certification system** for sustainable buildings in Denmark. The so called DGNB that is used by the Danish Green Building Council, covers the assessment of the whole life cycle of the building, including end-of-life and thereby CDW[46]. Indirect tools such as (the CE) marking can play a positive role to stimulate the purchase of CDW – when understood as a quality label[47].

For a full analysis and taxonomy of the key contextual factors resulting from the interviews, please see Annex 6.

6.2 Conventional and upcoming technologies for CDW recycling

A general observation that can be made with regards to CDW technologies is that to be able to produce materials from CDW that are suitable for high-grade recycling, two factors are crucial:

(i) a selective sorting at the source (selective demolition practices) and
(ii) the presence of technologies that process the selectively demolished material fractions into suitable resources. The current treatment processes of CDW fractions are driven by economic incentives and legislative obligations on the supply side (e.g. mandatory selective removal of mercury-containing fluorescent lamps) and on the demand side (e.g. a demand for processed materials).

With respect to implementing and investing in new technologies it can in indicated that the new business models incorporating those new technologies will have to fulfil at least three requirements:

(i) a (financial) incentive for the demolition companies to selectively collect the required material stream,
(ii) (ii) the possibility to produce a resource with the required specifications in an economically viable way,
(iii) (iii) (good prospects for) a demand for the produced material.

[41] Based on interviews
[42] Netherlands: Decree on landfills and landfill bans (Besluit stortplaatsen en stortverboden van afvalstoffen - Bssa), available at: https://www.ecn.nl/publications/PdfFetch.aspx?nr=ECN-E--14-037
[43] Based on interviews
[44] Ibid.
[45] Ibid.
[46] http://www.dk-gbc.dk/english.aspx
[47] Based on interviews

Stony fractions, for example, are currently mostly processed into aggregates for foundation material. New emerging technologies currently are able to produce aggregates that are suitable for the production of high-grade concrete. However, the demand for foundation aggregates is currently high enough and the emerging technologies are often more expensive than the currently used technologies.

Glass, on the other hand, has suitable recycling technologies. However, glass recycling requires a selectively collected glass fraction during the demolition works. Demolition companies would need to install another container for this collection and provide transport. These extra costs are currently mostly not compensated by the money that is received for the glass fraction. Especially since aggregate standards set limit values for glass (e.g. <2% in Flanders[48]) that allows the complete fraction to be incorporated in the stony fraction and also presents a missed business opportunity for glass and downcycling of glass if used to produce secondary aggregates instead of recycled glass.

An overview in figures of the main technologies for CDW recycling, both conventional and new ones can be found in Annex 4. In Annex 5 conventional and new technologies for each of the main materials that may be part of CDW can be found. The new and upcoming technologies are indicated in red. Technologies listed in grey colour point to optional technologies.

6.3 Main insights from the business context interviews with stakeholders

A number of key insights could be derived from the 39 interviews conducted to understand the dynamics in which CDW recycling business models need to operate. The following are subdivided into key sights on (i) market/economic context, (ii) regulatory/legislative context (links with previous chapter), (iii) technological context (links with previous chapter) and (iv) the social context.

6.3.1 Market/economic context

Most CDW recycling business models operate and compete in a specific local context.

The profitability of CDW recycling is determined by a very local market with local price dynamics of primary and secondary materials, landfilling, incineration and alternative applications.

For CDW recyclers and especially Materials Processors/Collectors, competition occurs on both sides of the value chain:

- Upstream they compete with alternative options for suppliers to dispose of their CDW (landfill, incineration for non-inert fractions, backfilling, alternative applications such as downcycling for specific purposes, export to other Member States for landfill)
- Downstream they compete with primary and other secondary materials

The profitability of a CDW Recycling business model is subject to local conditions (prices and associated costs of alternatives as well as sufficiency of supply and demand). There are very limited cross-border effects of CDW flows and in case these flows exist they are often not environmentally sound and constructed to avoid land fill bans and create a larger environmental impact due to transport [i8, i20].

[48] PTV 406.

The following are some illustrative quotes from various interviews supporting this point:

- "We do not observe a cross-border effect. CDW doesn't travel far, so it also doesn't travel over borders. Only high value CDW such as gypsum moves further distances and could qualify for cross border movement." […] "The market can vary strongly [regionally]. In some regions, natural stone is very cheap, so the recycled material has to be cheaper in order to be competitive." [i30]
- "You do not drive too far with CDW, therefore there is not a big role for the internal market. It's a regional market." [i20]
- "In Belgium, the largest competitor [for sourcing of gypsum waste] is transport to the NL and then further to Germany where it can be landfilled." [i8]

Partnerships both upstream and downstream strengthen the economic viability of CDW recycling.

Through partnerships and business symbiosis on the supply side (e.g. partnerships between materials processors and companies active in selective deconstruction) and on the demand side (e.g. partnership between plasterboard manufacturer and gypsum processor) strengthen the economic viability of CDW recycling.

- Especially the Gypsum examples demonstrate that profitable recycling of CDW is enhanced by symbiosis with companies that produce or purchase large quantities of primary materials (e.g. plasterboard manufacturers for gypsum). [i8, i9, i10]
- "The development of business model for recycling CDW depends on […] the establishment of partnerships and *business symbiosis* with other companies and relevant stakeholders." [i29]
- "In order to achieve an efficient supply, Old Bricks attempts to establish partnerships with large projects of selective demolition." [i28]

6.3.2 Regulatory/legislative context

Many interviewees stress the importance of a favourable and stable regulatory context for the economic viability of CDW recycling.

The recycling of CDW would greatly benefit from a harmonized EU legislation that is appropriately enforced in all Member States. Today, each Member State has different set of regulations and in many cases, there are even large regional differences (e.g. [i24], [i2]). The following regulatory elements are key to create a stable business environment for CDW recycling:

- **Land fill ban** on CDW (fractions) or landfill taxes that are substantial enough to enable CDW recycling
- Appropriate **certification** mechanisms for recycled products
- Mechanism to promote **selective deconstruction**
- Mechanism to allow/promote the usage of recycled materials in **Green Public Procurement**
- **Enforcement** of regulation

These aspects are illustrated by the following quotes from the interviews:

- "In CDW, investment is never the problem. […] Rather, it's a question of regulation. […] It's not the technology in Eastern Europe, nor [are] the investments that are lacking, but rather the legislative framework and market that are hampering CDW recycling." [i20]
- "Companies need to know there is a stable legislation [for CDW recycling]." [i20]
- "Regulatory context is the main lever to develop these business models and we believe that this framework should (i) at least reduce the lack of enforcement of law […], (ii) ban or tax landfilling of waste that could be treated more efficiently according to the EU waste hierarchy […] and (iii) promote the use of recycled products through public procurement." [i11]
- "It cannot be emphasized enough that it is absolutely important to have a credible long-term robust government policy that is adequately implemented. This stimulates investment in the CDW recycling sector and gives confidence to the investors." [i14]
- "Actors on the market are often SMEs. They are frustrated and are asking why it takes so long to make the new regulation." [i24]
- "I do not perceive financing, also for SME's to be an issue. […] What is needed, is a set of requirements on the material as well as a set of regulated application areas in which the recycled materials can be applied." [i30]
- "[In the Eastern European context], first and foremost there is a lack of enforced regulation. Additionally, aggregates are so cheap and plentiful (primary) because of lack of regulation that it doesn't make recycling economic." [i11]
- "Legislation is key! Without a prohibition to landfill there will be little or no recycling." [i26]

6.3.3 Technological context

There is a movement towards more high-grade recycling.

CDW recycling technology includes two types, conventional and advanced technologies for granulate as well as high-grade recycling, respectively. Several features can be distinguished in this respect:

- High-grade versus low grade recycling
- Movement towards high-grade recycling
- Conventional versus future recycling technologies

Specifically, interviewees indicate the following related to these aspects:

- "The future lies in the application of relatively more high-grade products." [i2]
- "[High-grade recycling] is necessary for the re-use of recycled materials in the production of building materials and parts, therefore it has a perspective." [i12]
- When asked about their "[…] view on which technologies are available or are expected to become available related to CDW processing?" respondents indicate as a first choice 'high-grade recycling' [i2, i14, i6, i7, i11, i12, i16, i31] followed by 'selective deconstruction' [i4, i5, i8, i14, i15, i28, i29, i31] as a technological next step for CDW recycling.
- "[…] would not put too much emphasis on technology as a barrier, the technological solutions are there." [i20]

Quality of recycled materials is a cause for concern.

Interviews make reference to quality concerns associated with the advanced application of recycled materials. Overall interview indicate the following key points related to technologies for CDW:

- Sorting and quality
- Quality concerns of recycled materials and associated technical risk

Specifically, interviewees indicate the following related to these aspects:

- "Quality guarantee is one of the main risks for producers of secondary (recycled) materials. In this respect there is competition with the virgin materials industries." [i14]
- "The main barrier in [Country X] […] is that much of the construction waste contain dangerous substances, which hinders that it can be recycled and reused as this would be harmful to human health and unsafe for the environment. The key problem is that much of the construction and demolition waste in [Country X] is not correctly sorted and declared before being submitted to municipal waste sites." [i10]
- "The greatest risk is the ability to identify the nature of contamination, especially for aggregates. There is a need to ensure things go the right way, as this impacts the price." [i11]
- "[…] better and earlier sorting of construction and demolition waste is regarded as a key prerequisite for creating larger and cleaner fractions of waste and better economies of scale for businesses in the market of recycling." [i28]

6.3.4 Social context

Acceptance presents a key barrier to the uptake of CDW recycled materials.

Recycled materials face an acceptance challenge when confronted with architects, end users and public bodies developing a procurement call. Interviews indicate that the main challenge arises from the perception that CDW are of lower quality and are even still perceived as waste, therefore hindering the possibilities for the uptake of the recycled materials in design and execution of new buildings and works. The following key elements were identified by interviewees with regards to acceptance:

- Design acceptance with quality concerns
- Negative views of recycled materials; still perceived as waste
- Low overall awareness on availability of recycled materials
- Green Public Procurement in raising acceptance

Specifically, the interviewees indicated:

- "The biggest hindering factor in Germany, […] is the lack of willingness to use recycled materials. It is not in the heads of the people that make buildings that these materials can be used. The thought process from those people is 'I don't want to build a new building with waste'. […] What is needed is that the acceptance of recycled CDW is improved. From that the technology and the capacity of production will increase. At the moment acceptance is the greatest problem." [i17]
- "It should be that public procurement is forced to make use of recycled materials above all others. At the moment there is no duty and there are no consequences of using primary materials. For a healthy competition, it is necessary that the public bodies should do more for recycled materials and especially that they should not discriminate in their own procurement documents, so there needs to be a consequence for this. It should be mandatory that there are stone-neutral invitations to tender, focussing on the size rather than the origin." [i24]

- "Secondary materials are often more expensive than primary products. It is a significant barrier, especially that people still prefer cheaper solution. On the one hand, it can be a result of limited purchasing power or societies; on the other hand, the reason is connected with traditional attitudes caused by low social awareness." [i23]
- "The biggest problem is probably the view of officials in our area to prevent waste and the use of demolition material. Automatically take demolition material for waste, which not correspond to the hierarchy of waste prevention." [i6]

6.4 Fact sheet on the business context of CDW recycling infrastructure

On the basis of the analysis of business contexts using inputs from the interviews, documented regulatory framework conditions and classification of technologies a set of defining business context parameters were identified and include those listed in the table below. The predominant business contextual elements in CDW are related to market/economic as well as regulatory / legislative aspects, whereby technological and social aspects. Distinctions between leading and lagging Member States in the European CDW recycling context are elaborated based on literature and interview findings.

Table 4: Fact sheet on the various elements of the business context, highlighting differences between advanced and lagging member states

	Advanced CDW recycling Member States (e.g. DE, NL, DK, BE)	**Lagging CDW recycling Member States (e.g. PO, IT, RO, MT, CZ, PL)**
Market / economic		
▶ **Price of material (compared to primary material)**	– Competitive – Less than that of primary substitutes (otherwise no market) – Yet in Member States with limited available natural resources, higher price margins can be obtained than in Member States with an abundance of primary materials – Role of Green Public Procurement could be expanded further	– Depending on availability of natural resources, primary material is typically less expensive – Role of Green Public Procurement highly restricted, could be expanded upon
▶ **Gate fees**	– Typically high and present	– Information not always available – Generally lower than in leading countries, but too high to compete with the low (or zero price) landfilling costs
▶ **Landfill cost**	– Typically higher, dependent on material type, could even be banned	– Generally very low, therefore not allowing for competitive position of recycled materials
▶ **Location of landfill possibilities**	– Fewer landfills available, often landfill bans, therefore recycling facilities are more likely to be found within the 30km transport radius of CDW	– Tight network and close proximity of landfills make them more accessible than recycling facilities and reduced transport costs
▶ **Amount of CDW generated per km²**	– Linked to population density – In urban areas, CDW generation is high enough to sustain stationary CDW and niche CDW business models	– Low population density suggests mobile CDW – Level of economic activity and construction lower, therefore market smaller
▶ **Land value**	– In urban areas general quite high – Rural areas, less expensive, however less market	– Lower overall, as mostly eastern EU context – Urban generally more expensive than rural
▶ **Labour cost per year**	– Generally higher – Niche CDW also has higher labour cost, safety and educational requirements (scientists, labourers combined)	– Lower, especially for conventional CDW applications that apply for these regions
▶ **Transport cost**	– High – All CDW waste is limited in transport, ca. radius of 30 km – Availability of waterways substantially increases the radius	– Medium/High – All CDW waste is limited in transport, ca. radius of 30 km – Availability of waterways substantially increases the radius

	Advanced CDW recycling Member States (e.g. DE, NL, DK, BE)	Lagging CDW recycling Member States (e.g. PO, IT, RO, MT, CZ, PL)
Regulatory / legislative		
▶ **Regulatory framework (landfill bans etc.)**	– Landfill bans in many leading Member States require recycling activity – Under this condition recycled materials are more competitive – Selective deconstruction regulation could be envisaged across Member States to encourage better quality demolition & recycling	– Regulation targets waste management – No landfill ban on CDW waste streams
▶ **Permits for activity**	– Exist – Can at times be challenging to obtain depending on urban vs. rural location and neighbour effects – Inhabitants reluctant to accept CDW recycling facilities as they are loud and dirty	– Exist, differentiate between official requirements (always) and actual practice (less implemented) – Can be very decentralised e.g. Romania (county level)
▶ **Certification procedure (and cost) of materials**	– Exists, is not equally regulated within EU – Costs of certification procedures are high	– Limited, gaps in regulation and limited recycling overall
Technology		
▶ **Conventional versus specialised technologies**	– Both. – Specialised niche recycling activities are further developed according to scientific and innovation interest, as well as legislative requirements (e.g. bitumen containing road waste)	– Implement conventional technologies – Further targeting conventional technologies encouraged to meet bulk volume target
Social		
▶ **Acceptance of recycled materials**	– Underway. Several otherwise leading Member States still face acceptance by designers / engineers – The role of Green Public Procurement is still limited, even in otherwise leading Member States	– Limited for building construction – Use in road construction and sound barriers general accepted, however price competition limits application
▶ **Acceptance of CDW recycling facilities**	– In urban areas: low. Risk complaints from inhabitants – In rural areas: also low – Location targeted towards industrial areas	– In urban areas: low, however slightly higher than in leading countries

Source: IDEA Consult

7/ Selection of business cases

The key question: which business model type fits best with the type of business context of the Member States that need CDW recycling investments in order to improve recycling amounts in view of a circular economy, maintaining value of waste at end of life, especially in lagging MS? Given the set of business models identified in with their corresponding business model factsheets and the factsheet developed in the subsequent steps of the project on the generic business context of Member States that are in need of CDW recycling investments, the answer to this question can be found using a Multi-Criteria Analysis (MCA).

MCA is a good tool to evaluate multiple alternatives. By adding evaluation questions MCA can be turned into a sensitive instrument with a holistic nature but it depends on a careful weighing process of evaluation factors as well as a large data gathering exercise. The following paragraphs illustrate the approach utilised, as well as the rationale for using a multi-criteria analysis and what we mean by it.

The rationale for using a multi-criteria analysis is fivefold:

1. it provides a systematic approach for analysing different and varied alternatives,
2. making every step of the analysis explicit by formulating criteria based on evaluation questions and assigning weights to these criteria,
3. thereby providing an instrument that allows for precise communication with a wide set of the expert community, e.g. on the weights of the various criteria and the answers on the evaluation questions,
4. which in turn contributes to robust results and
5. allows for the comparison of very heterogeneous information which either cannot be monetised or for which monetisation is not desirable.

7.1 Process of Multi-Criteria Analysis

A standard multi-criteria analysis is composed of **six major steps**, raising from the formulation of the key research question to the formulation and scoring and ranking of various alternative business models that have the best fit to the business context of those Member States that are in need of CDW recycling infrastructure.

- **Step 1:** Phrase the **question** to be answered as precise as possible

  The definition of the right research question is key to a valid outcome. In this case the question is "which business model type fits best with the type of business context of the lagging Member States in order to foster recycling in MS lagging behind on circular economy ambitions"? In the first part of the project we have identified the set of existing business models and factsheets per typology in the sample of selected countries, both in Western European Member States as in Eastern European Member States, as well as in Japan and the USA. We examine all business models and answer all evaluation questions, from the perspective of their potential application in the lagging Member States' business context which has been identified in the subsequent tasks.

- **Step 2:** Select the **business model alternatives** between which a choice has to be made or upon which a preference has to be applied. As indicated in Step 1 these are the business models that have been identified in the first part of the project and the fact sheets per relevant business model type.

- **Step 3**: Define the **underlying evaluation questions** that are used to answer this question. These are to be defined in a way to make an independent evaluation of each criterion possible. In an ideal setting the answers should not be interrelated or not depend upon each other. For the purpose of this MCA four high level evaluation questions that will be answered in a holistic sense using the data from 11 fact sheets on the business model types. The questions are as follows:

    1. What is the economic **profitability** of the business model?
    2. What is the level of **sustainability** of the business model and its contribution to improving volumes of recycled of CDW material?
    3. What is the business **stability** of the model? In how far are supply of waste material and market for recycled material guaranteed?
    4. What is the level of **compliance** of the business model with legal provisions? (e.g. on trans frontier shipment and other)

- **Step 4:** Subsequently each criterion is **scored** in a comparable way: all scores are expressed in units and scales using ordinal ranking.

    All four evaluation questions are given the same weight of 25%, meaning that all four are equally important to judge the ranking of the 11 business model types.

    The answers on the questions are obtained through an expert meeting in which all business model types are discussed and a motivated score between 0 and 5 is attributed. Both the score and its motivation are important.

- **Step 5:** Scores are **normalised**, meaning that one of the alternatives always needs to have the maximum score of 5. In this way we avoid that questions for which none of the alternatives reach a level 5 are weighed at a lower rate than 25%.

- **Step 6:** The **results** are sorted according to the normalised score. The summed-up scores for each business model case define its ranking. The result of the multi-criteria analysis is a ranked list of business models that fit best with the business environment of the lagging Member States. The top 5 are used for further analysis in Task 3.

7.2 Conclusions: Ranking of business models

Following the execution of the above indicated process of analysis, a list of the top five ranked business models could be produced. These five business models were selected as their generated the best overall normalised score with regards to the four evaluation questions. The top five business models, based on their profitability, sustainability, stability and legal compliance are: (i) Selective deconstruction, (ii) Mobile mixed CDW Processor/Collector, (iii) Stationary mixed CDW Processor/Collector, (iv) Gypsum Processor and (v) Bricks Processor.

Selective deconstruction aims at replacing demolition, which generates especially mixed waste, by a technique of prior inventory of materials plus further selective deconstruction in which separated fractions of materials are generated at source. This business model scored particularly high as the approach is fully based on reuse and circular economy, saving the quality of the material while tackling the bulk of the CDW. It is very much in line with the Circular Economy Package. Furthermore, the business model is fully in line with actual and possible future legislation and policy development, giving it a particularly high legislative compliance score.

Mobile and Stationary mixed CDW Processor/Collectors both target the bulk of CDW waste, producing granulates or other materials for further processing. Mobile facilities create less transport costs and are flexible towards the needs of the market as they can travel from wharf to wharf, however suffer from lower legal compliance as materials are typically re-integrated on-site, offering possible lower quality end-of-waste granulate. Stationary facilities benefit from urban centres with high amounts of CDW, with generally better quality materials and improved legal compliance, however at the same time are limited to urban areas and the associated market.

The **Gypsum processor**, as a niche business model and waste stream benefits from a highly sustainable recycling process that results in the same purpose (cradle to cradle), however is limited as the volume of waste that can be treated is quite restricted and overall does not represent the bulk of CDW. This waste stream relies heavily on gate fees and on the presence of a plaster board manufacturer for stability of demand and supply.

A **Bricks Processor** is also a niche CDW recycling activity that similarly allows for the recycling for the same purpose. However the market is not yet stable and highly depends on the use of selective deconstruction for the functioning of the business model. In addition, the legal framework for this waste stream (CE certification is still limited). Nevertheless the potential of this waste stream to be economically profitable for construction under the given conditions and the contributions to sustainability are significant enough to secure a place in the top 5.

The sixth ranking "General waste processor (including CDW)" differs from the Bricks Processor especially on the criteria of economic profitability, whereby a General waste processor that decides to recycling CDW faces a differentiation in the transport capability of CDW versus general waste (30 vs 60 km). In addition, the legal compliance of CDW being recycled at a generic waste processor benefits from legal familiarity, as the site has to be generally compliant, however faces some risk as the facility is not CDW specialised. Bricks score lower on legal compliance as there is a lack of CE regulation that poses a barrier at present. That being said, the general waste processor business model poses significant similarity to the mobile and stationary business models and therefore a niche CDW is appreciated in the selection of the top five business cases for further development.

The overall score results are presented in Table 5. The business model types marked in bold are to be selected for further analysis into a business case. The full analysis of the results, including the responses to the four evaluation questions and the associated score are found in Annex 7.

Table 5: Ranking of normalised CDW recycling business model scores. Top five as selected for business case development.

Business Model	Normalised Score	Rank
Selective deconstruction (9)	**17.6**	**1**
Mobile mixed CDW Processor/Collector (3)	**16.5**	**2**
Stationary mixed CDW Processor/Collector (4)	**16.2**	**3**
Gypsum Processor (5)	**15.7**	**4**
Bricks Processor (8)	**15.3**	**5**
General Waste Processor (incl. CDW) (2)	15.2	6
On-site Contaminated Soil Remediator (10)	14.7	7
Consultancy / association (11)	14.0	8
Hazardous CDW Processor/Collector (6)	13.4	9
CDW Technology Developer (1)	12.2	10
Plastics Processor (7)	9.7	11

Source: IDEA Consult

8/ Development of generic business cases

Starting from the selection of five business models, which has been presented in Chapter 7/, the next phase of the project focused on the development of these business models into five generic business cases. These business cases can be readily used by potential financers and entrepreneurs and are instrumental to improve the CDW recycling infrastructure situation in the EU.

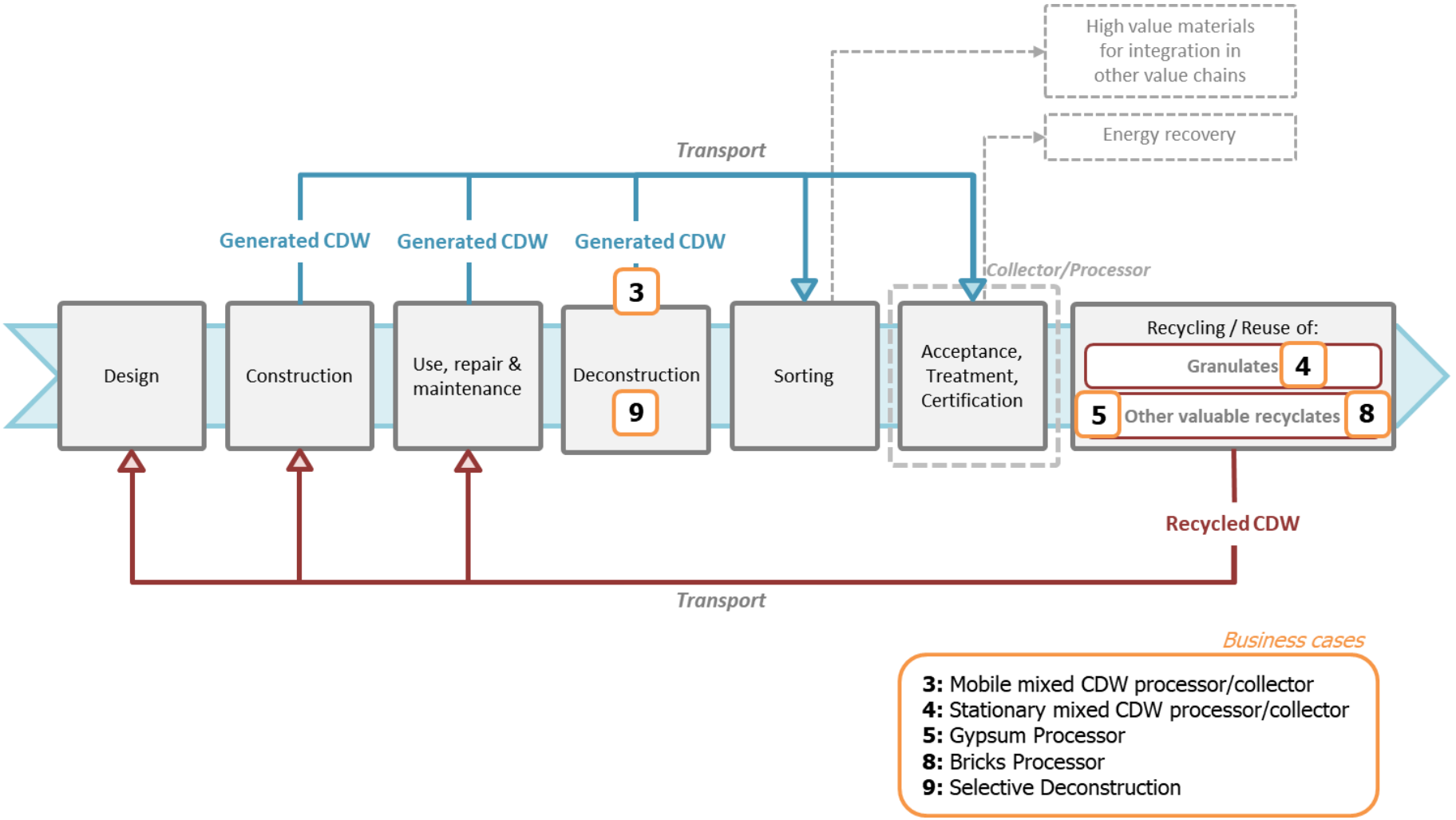
The business cases in essence are predominantly quantitative tools that can serve as bridging instruments between on the one hand the financial stakeholders (potential investors in CDW recycling businesses) and on the other hand the entrepreneurs (companies that want to start or expand a CDW recycling business). For financers, the business cases help them to quickly understand the critical success factors of such a business, which they are in most cases not very familiar with. For entrepreneurs, they help them to understand how their business plan will be evaluated by financers, how profitable it will be and how they can optimize their profitability. Additionally it allows investors and entrepreneurs alike to assess the effects of changes in the market and regulatory environment on the profitability of the business.

The five selected business models that have been elaborated included:

- **Gypsum processor**: covering the specific business model of the gypsum processor, receiving the plasterboard and other gypsum waste from external sources.
- **Brick processor:** dealing immediately with the brick recovery and processing and the preparation for resale into new structures.
- **Stationary Mixed CDW processor:** dealing with facilities treating delivered CDW for preparation of recycled materials.
- **Mobile Mixed CDW processor:** dealing with crushing, breaking, sieving and preparing CDW waste right on the demolition location itself.
- **Selective deconstruction:** which focuses on obtaining homogeneous and separable CDW streams from demolition activities as to augment the value of secondary material streams.

The placement of these five business cases along the CDW value chain is depicted in Figure 10. Note that the business cases cover the specific segment of the value chain indicated in the figure, in line with the area described in the factsheet of the business model presented in Chapter 5.2. The business cases cover the specific area of activity indicated.

Figure 10: The specific placement of five selected business cases in the CDW value chain. Note: delineation of business case covers business models, presented in Chapter 5.2.

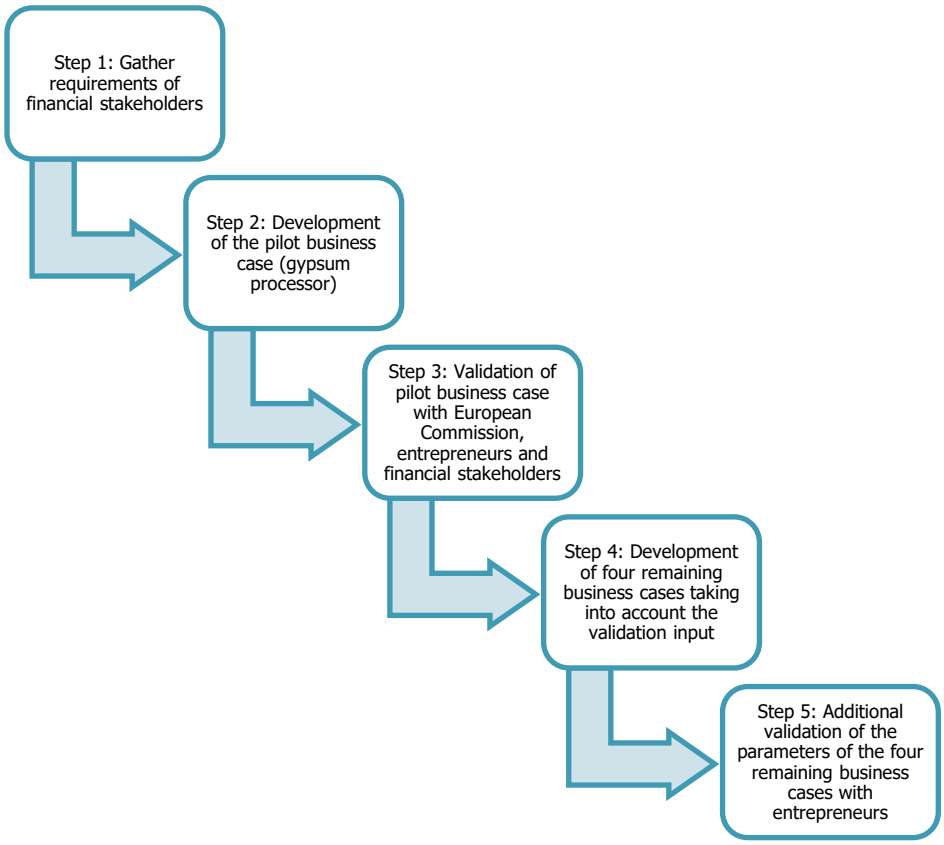


Source: IDEA Consult

8.1 Methodology of the business case development

The following methodology was applied during the creation and validation of these five generic business cases (Figure 11):

Figure 11: Main phases in the development of the business cases



Source: IDEA Consult

1. In a first step, a selection of representative **financial stakeholders** were consulted to understand their requirements. The goal of this consultation was to allow the stakeholders to give insight into how they could be supported with the generic business cases. How would they judge an investment opportunity in CDW recycling? What type of quantitative and qualitative information would they need? Which financial instruments do they deem appropriate for these investment opportunities? This first consultation was key in defining and fine-tuning the deliverables of this task. The main findings of this first consultation of financial stakeholders is presented in Section 8.8.
2. In the second step, a specific business model was selected for the development of **a pilot business case**. This pilot business case was developed, taking into account the requirements from the previous step. The main information used for this case was the interview evidence collected, additional inputs by entrepreneurs that operate this business model and literature and online research.

3. The deliverables from the pilot business case were presented to the various key stakeholders in this project:

    a. The pilot business case was presented during the 2nd monitoring and steering committee on September 12, 2017 to gather feedback from the **European Commission** on the preliminary versions of the business case deliverables. During this meeting, the Commission indicated that the deliverables are in general in line with the expected outcome of the study. The remark was made that the presented business case, which did not yet include fully validated input parameters, was too optimistic and that the parameters should be carefully reviewed in order to be in a realistic range.

    b. Subsequently, the pilot business case was presented to an **entrepreneur** who is the CEO in a gypsum processing company. He confirmed that all relevant aspects were taken into account and also indicated that specifically the gate fee (EUR per tonne gypsum that providers of recyclable gypsum should pay) was chosen within a rather optimistic range, leading indeed to a too optimistic investment scenario. This could easily be adjusted in the calculation model and he provided detailed input such that the various parameters of the model could be chosen in a realistic range. Some other changes were done, mainly related to the indirect costs.

    c. Finally, the business case was presented to two key **financial stakeholders**. The main goal of these two validation sessions was not to fine-tune the parameters of the model but rather to get their feedback on the setup and usefulness of the business case deliverables. Both stakeholders confirmed that the pilot business case deliverables would be useful to them and were presented in the right way, reflecting the right financial criteria.

4. Based on the validation with the European Commission, the entrepreneurs and the financial stakeholders, subsequently the **four other business cases** were developed in the same manner as the pilot business case. The key information used in the business cases was always coming from a senior profile (CEO, owner, operational director) in a company that is experienced in running such a business for many years. This information was complemented with various inputs from literature research, online information (e.g. publicly available price lists) and from the interview evidence collected in the previous phases of the project.

5. Per case, an **additional validation of the generic calculation model** was done by an entrepreneur experienced in running this type of business. In most cases, the same entrepreneur who provided the input during the development, was presented the developed case at a later instance and was allowed to provide detailed feedback during a teleconference session.

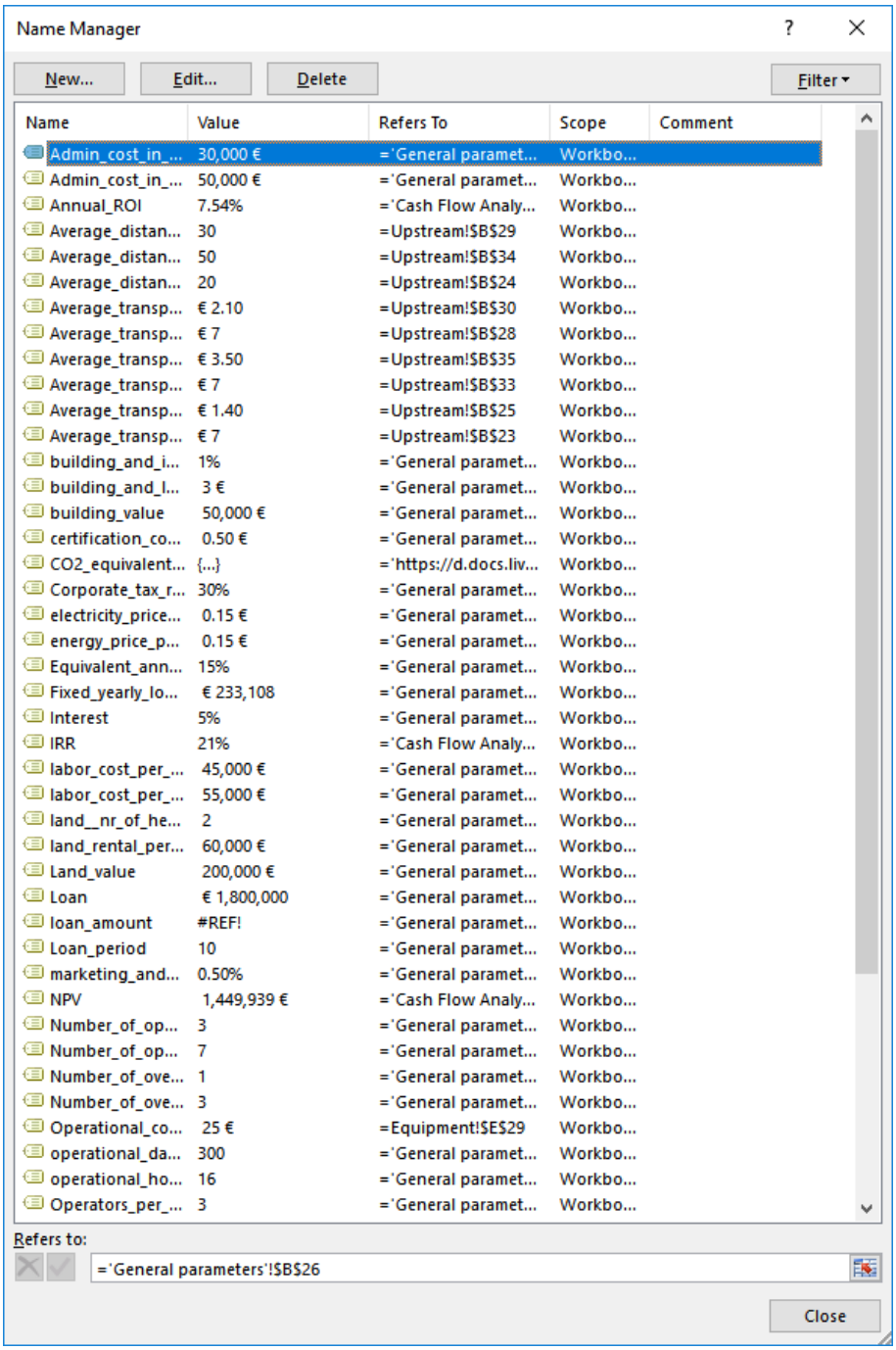
In the next Section 0, the general setup of the generic business cases is presented, which is similar for each of the 5 cases that were developed. In Sections 8.3 to 8.7 some specific information is provided on the five cases, including the key success factors of the business case, the specificities of the calculation model, some key assumptions within the particular models and the results of the sensitivity analysis performed with the quantitative model.

8.2 General setup of the business cases

Based on the requirements of the financial stakeholders, the deliverables of the business cases were chosen to be the following:

1) The main deliverable is a **spreadsheet model** that contains a quantitative evaluation of the profitability of the business model over a 10-year time horizon, in a realistic context in which the business operates. This spreadsheet model is generic, meaning that its parameters can be adjusted to a specific investment project. After adaptation to a specific business context, the financial criteria are calculated without having to change the formulas in the spreadsheet. In general, **yellow filled cells in the spreadsheet model** are parameters that can be adapted as the most applicable input for the business context under consideration. All other cells within the spreadsheet model that are not filled in yellow, are calculated fields which should not be altered. To make the formulas more clear, names were assigned to the key input and calculated parameters in the model. An overview of these names can be seen in the **"Name Manager" in MS Excel** under "Formulas". See for example in Figure 12, the name manager window for one of the cases. The spreadsheet model already includes estimates for the various input parameters that are in a realistic range. The choice was made to select the parameters as much as possible with the input of the entrepreneur in a business context in which the business model is viable.
2) Additionally, a **text document** is provided that lists some key questions that entrepreneurs should answer when they present their case to potential investors. A clear requirement from the financial stakeholders is that this document should be limited in number of pages, it should be to the point and only contain the key information that is relevant for their evaluation.

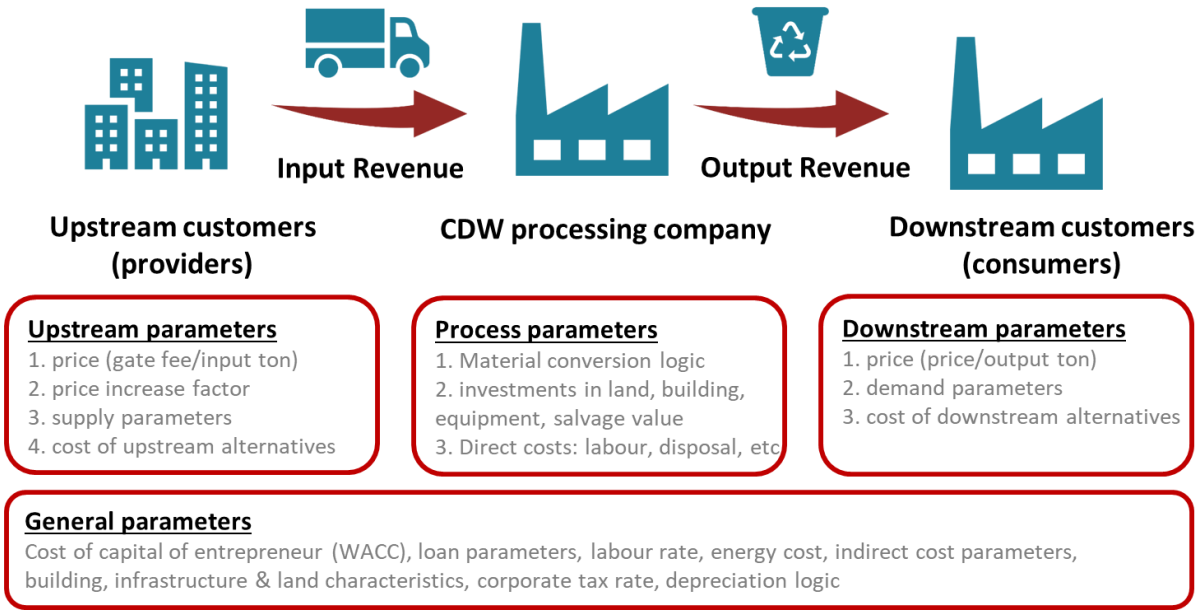
Figure 12: Example of the "Name Manager" window in MS Excel (under "Formulas"), giving an overview of the various input and calculated parameters in the spreadsheet model, the cell they are referring to and the value chosen in the model.



Source: IDEA Consult

In general, the **spreadsheet model** includes the calculation logic[49] depicted in Figure 13:

Figure 13: General setup of the calculation models for the various business cases



Source: IDEA Consult

In most business cases, customers can be found both upstream and downstream and the revenue mechanism of the company is a combination of gate fees and material sales. Therefore, the business case considers both sides of the value chain as customers.

1) Essentially, the **upstream parameters** reflect how many input materials are being sourced and at what conditions (e.g. which gate fee providers of recyclable material need to pay per tonne). These parameters will drive both the revenues and the direct costs in the business case. The upstream customers (providers of recyclable materials) are essentially seen as customers who will make a decision: they can choose to deliver the materials to the CDW processor or they can choose to deliver to one of their *upstream alternatives*. Examples of upstream alternatives are disposal of the materials in a landfill, delivery to other types of CDW recyclers, export to a landfill in a neighbouring country, etc. Therefore, the calculation model forces the entrepreneur to identify and to quantify these upstream alternatives; what is their total cost per tonne of output material for the upstream customer? For example, in case landfilling would be an alternative option, the model takes into account a transport cost towards the landfill based on a to-be-chosen distance to the landfill.
2) The **downstream parameters** reflect the output situation, whereby purchasers of recycled materials are assumed to pay a certain price per ton of output material. In analogy to the upstream part, the model assumes these downstream customers to have *downstream alternatives* (e.g. buying primary materials) and the total cost of these alternatives is to be quantified and to be compared with the prices the CDW processing company is charging.

[49] This is valid in general for the business cases bricks, gypsum and stationary CDW processors. For the Selective Deconstruction and the mobile CDW processor cases a slightly different logic is applied, as explained in Chapter 8.7 and 8.6, respectively.

3) The internal workings of the company are reflected by the **process parameters** that will mainly drive the various direct costs of these businesses. Key in the process parameters are those reflecting the *material conversion logic.* For example, for the stationary mixed CDW processor, the material conversion logic specifies how many output materials divided over the various output fractions can be derived from the input fractions, on average, as depicted in Table 6. Other process parameters indicate the various direct cost drivers: e.g. labour cost required per tonne of input or output material, energy consumption (electrical in kWh or fuel in litres per tonne of input material processed).

Table 6: Material conversion logic for the stationary mixed CDW processor business case

MATERIAL CONVERSION LOGIC	OUTPUTS ↓								
				Metals		Other materials			
INPUTS ↓	Broken concrete	Broken asphalt	Mixed granulate	Iron Scrap	Non ferro Scrap	Wood	Sand	Other CDW - non hazardous	TOTAL
Concrete	79.1%			0.40%	0.008%		20.0%	0.5%	100%
Stony fractions			78.8%	0.10%	0.008%	0.11%	20.0%	1.0%	100%
Non-hazardous bituminous mixtures		79.4%		0.05%	0.008%		20.0%	0.5%	100%

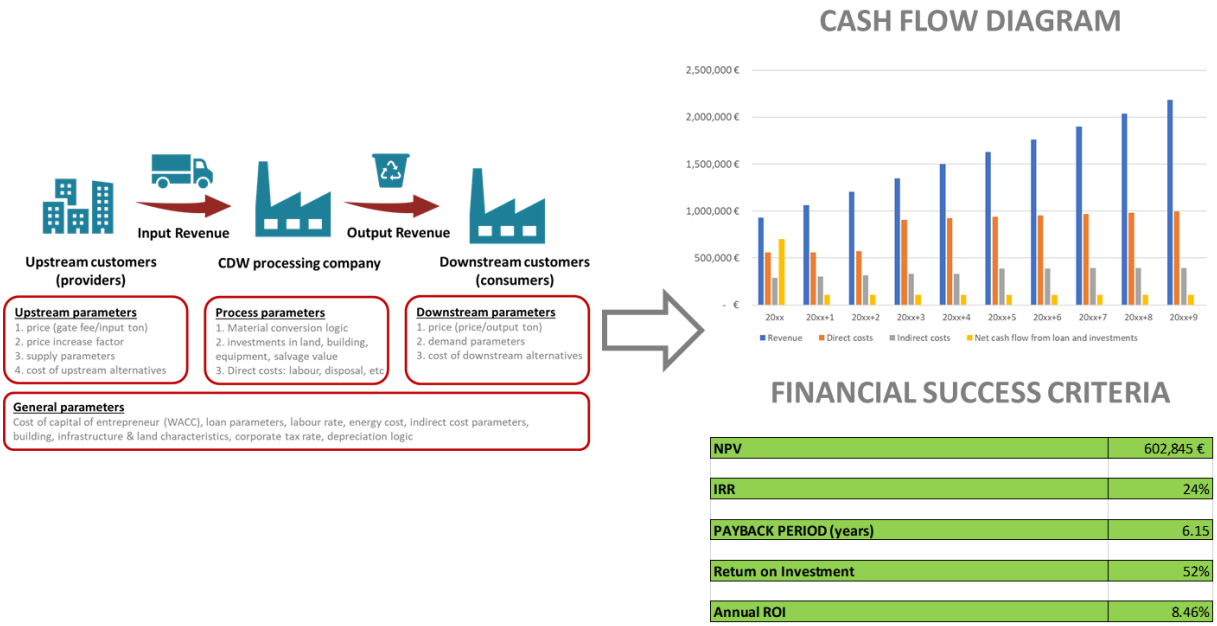
Source: IDEA Consult

4) The fourth category of parameters are some **general parameters** that reflect various aspects of the investor (e.g. what loan is made available at what interest rate over which period) and – mainly – of the entrepreneur (such as the cost of capital of the investor that is used as discount rate in the Net Present Value formula, for other examples see Figure 13).
5) For the cases *selective deconstruction* and *mobile mixed CDW processor*, the upstream and downstream parts are merged into a "Projects" tab in the spreadsheet model. Because these business models are working in a project-driven business, the main parameters that will drive their revenue and direct costs are the number of projects of various characteristics that they can sell. For example, a categorization into 3 project types is applied there, depending on the size of the building that is deconstructed.

Based on all these different categories of input parameters, a calculation of cash flows, profitability (Gross Margin and EBITA[50]) and financial success criteria is performed over a 10-year period. The output of this analysis is always presented in the tab "Cash Flow Analysis", which reflects the main outputs of the calculation models. This is schematically presented in Figure 14.

[50] EBITA = Earnings before Interests, Taxes and Amortizations, which is a financial indicator used widely by investment and business communities as a measure of efficiency and profitability.

Figure 14: Structure of the generic calculation models for the 5 business cases, depicting how the various categories of input parameters are used to calculate the outputs of the model (cash flows and investor success criteria)



Source: IDEA Consult

Based on the financial stakeholders' input, the **financial success criteria** were chosen to be the following:

1) The **Net Present Value** presents the aggregated net benefit of the total investment, calculated from the discounted cash flows for all of the 10 years. All expenses and revenues of the company were taken into account to calculate these discounted cash flows, even including those expenses related to the loans. As discount rate in this formula, a rate was chosen in each case to reflect the **Weighted Average Cost of Capital (WACC)** of the company. Determining a WACC is not straightforward, especially given that there are no publicly listed companies that have only CDW recycling as their activities on basis of which a WACC estimation can be done[51]. An estimate was chosen, taking into account the risk profile of the different business models as estimated in the SWOT analysis of the first part of the project (more risky business models assuming a slightly higher WACC than less risky business models). As a reference of the various discount rates, some industry averages as published by Prof. Damodaran of NYU Stern University were taken into account[52]. This source does not quantify these numbers for the CDW recycling sector in Europe but does have some specific data of the European "Building materials" industry which are the most relevant for this study.
2) The **Internal Rate of Return (IRR)** reflects the discount rate at which the Net Present Value of all cash flows (both positive and negative) from the investment becomes equal to zero. Based on the feedback of the financial actors, IRR is often applied as an intuitive measure of the attractiveness of an investment.
3) A very intuitive financial success criterion that reflects the risk profile of a certain investment is the **Payback Period**, which reflects the number of years before the initial investment is earned back based on its returns over the years.

[51] In case records of such a publicly listed company would be available, the *Capital Asset Pricing Model* could be applied to calculate the WACC for this company, taking into account its cost of equity and cost of debt.
[52] See the Section « discount rate estimation » on http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datacurrent.html

4) Finally, the **Return on Investment (ROI)** reflects the Net Present Value of the investment opportunity divided by the initial investment amount. Two variants of ROI are calculated, the total ROI over the 10 year time horizon and the equivalent annual ROI, which is calculated by distributing the Net Present Value as an equivalent annual, constant amount over the 10 years.

Only **debt financing** was taken into account to reflect the investor's involvement in this business. This is on the one hand to keep the complexity of the business cases under control, which cannot present all various equity financing instrument options in a single document. A loan with fixed interest rate over the total 10-year period is the most straightforward way of financing such a business and indeed also one that reflects quite well the most expected investment scenario found in practice, as confirmed during the interviews. Even if equity financing would be chosen, the return on investment as reflected through the debt financing calculation still allows the investor to grasp the attractiveness of the investment quantitatively. Moreover, based on the feedback of the financial stakeholders as well as the information provided by the various European entrepreneurs, it became clear that an investment in such a business is mainly done through loans (debt instruments) with the equipment, land and building used as collateral. The average returns of these businesses simply do not make them a very attractive option for venture capitalists, angel investors or most investment funds through equity financing. The interest rate of the loan, which can be set as an input parameter in the model, reflects the **investor's annual Return on Investment (ROI).** Therefore, the case allows the investor to set this parameter at an acceptable level and then to evaluate whether the project's return for the entrepreneur is still attractive enough.

As a summary, the investment criteria and their interpretation are listed in Table 7 below.

Table 7: Overview of the financial success criteria and their interpretation.

Financial Success Criterion	Interpretation
Net Present Value (NPV)	Aggregated net benefit of the total investment for the entrepreneur, derived by adding the discounted cash flows for all of the years, using the WACC estimate (input parameter) as discount rate. A positive return requires the Net Present Value to be more than zero. The more positive the NPV, the better.
Internal Rate of Return (IRR)	The discount rate at which the Net Present Value of all cash flows becomes zero. The higher the IRR, the more attractive and the less risky the investment. If the IRR is larger than the WACC, the investment is interesting, generally speaking.
Payback Period	The number of years it takes to earn back the initial investment. In the spreadsheet model, it can only be calculated if it is below 10 years. The shorter the payback period, the more attractive and less risky the investment is.
Return on Investment (ROI)	The NPV divided by the initial investment amount, over 10 years or calculated as a yearly constant equivalent return. The higher the ROI, the more interesting the investment.
Loan interest rate	The required interest rate for a 10-year fixed loan, which reflects the annual ROI for the investor. This interest rate is set as an **input parameter** to check if the investment is still viable for the entrepreneur based on the required annual ROI of the investor.

Additionally, based on the request of the European Commission formulated during the 2nd monitoring and steering committee on September 12, 2017, per business case some **community benefits** are calculated in the business cases. Such benefits can be related to the **avoided environmental impact** (e.g. tonnes of CO_2 impact avoided per tonne of recycled output material) as well as to the **job creation potential** of these business models (the number of jobs created by the end of the 10-year period, only including direct jobs in the business itself). Where possible, these community benefits were indeed quantified based on literature and online research, e.g. publicly available Life Cycle Assessment studies that quantify the tons of CO_2 impact avoided per brick, for example.

Since a detailed LCA study is well beyond the scope of the present study, no primary research into the environmental impact avoidance could be performed. Also, for the selective deconstruction case, an environmental impact analysis is not straightforward, because the effects on resource and energy consumption are mostly indirect.

The attractiveness of each particular business case is subject to many uncertainties and risks, which are related to either *input uncertainties* (e.g. will there be sufficient supply of recyclable input materials of sufficient quality?), *output uncertainties* (e.g. will there be sufficient demand of recycled output materials and what is the willingness to pay for these outputs?), *process uncertainties* (can the material conversion rates be attained, will the energy consumption evolve as assumed in the calculation model, will the lifetime of the equipment be as long as projected?) and *uncertainties in the general parameters* (e.g. will the tax rate be as assumed in the model, will the energy cost per kWh or per litre fuel evolve as assumed in the model parameters?). Therefore, a **sensitivity analysis** of the results based on some key uncertainties is performed for each business case. For this sensitivity analysis, the influence on these various uncertainties on the **payback period** was chosen, because it is intuitively easy to understand. Rather than a fully-fledged stochastic evaluation, which could be done in a Monte Carlo simulation but which would require the usage of stochastic simulation tools, not foreseen within the scope of this project, a sensitivity analysis was performed under the *ceteris paribus* assumption, meaning that the impact of one uncertain factor in particular is investigated, while assuming all other parameters are set at their fixed chosen value. Based on an analysis with the model, specifically the uncertain parameters that are identified as key success factors of the business case are selected for the sensitivity analysis.

In the next sections, specific information is provided for the five business cases: the main information sources applied for building the case, some key assumptions and specificities of the calculation model, key success factors of the business case and the results of the sensitivity analysis. As mentioned, the five selected business cases in are gypsum, bricks, stationary mixed CDW, mobile mixed CDW processors and the selective deconstruction. For the explanation of the key characteristics of each of these business models, we refer to the corresponding business model fact sheets as presented in Chapter 5.2. Behind the business cases an operational excel sheet and business plan are provided as supplementary documents (not in Annex) which can be used in practice.

8.3 Business case 1: Gypsum processor

Model Parameters	Main Information Sources
Upstream and downstream alternatives	Input provided by the 3 entrepreneurs operating a gypsum processor business model interviewed and feedback on the validation workshop and from EuroGypsum members.
Process parameters	Combination of input provided by entrepreneurs (mainly the entrepreneur involved for the detailed discussion and validation of the business case) as well as the deliverables from the Gypsum to gypsum project.
Community benefits: environmental impact avoided due to recycling of gypsum	Rivero, A.J., Sathre, R. and Navarro, J.G., 2016. Life cycle energy and material flow implications of gypsum plasterboard recycling in the European Union. Resources, Conservation and Recycling, 108, pp.171-181.

Key Assumption or Specific Modelling Choice	Rationale
All recycled gypsum is sold immediately to downstream customer(s)	This business model only becomes viable as soon as a specific downstream market is identified (i.e. mostly through a guaranteed supply agreement with a plasterboard manufacturer)
Discount versus primary material is quite high in the presented model (ca. 88%)	Plasterboard manufacturers require input materials of a very consistent and robust quality. Because that might be considered as a disadvantage of recycled gypsum versus primary gypsum, downstream customers are only interested in buying secondary gypsum if it is significantly cheaper than primary gypsum.
Gate fee per ton of input material of EUR 28	This is a rather high gate fee to start with even in well developed markets as noted by the entrepreneurs, but a lower one would make the investment unprofitable and there is a preference for presenting through the selection of input parameters a scenario that is optimistic enough to have a positive return (i.e. NPV > 0, IRR > WACC, payback period < 10 years), but that still should be realistic as well. Options whereby certain actors (e.g. plasterboard manufacturers) subsidize the recycling activities during the first years were not taken into consideration, nor situations where higher gate fees are combined with negative prices to the customer.
Export to landfill option presented as upstream alternative	This is the reality that one of the entrepreneurs was facing (in Benelux). Because of high landfill taxes in Flanders, the main option for upstream providers to get rid of their gypsum is to export it through the Netherlands towards Germany (Trier) where there is a landfill (mine) that charges only EUR 35 per tonne of material disposed.
Average kilogram gypsum waste per inhabitant per year	This was based on the inputs provided by 2 of the entrepreneurs interviewed who are operating this business model. No reliable official statistics exist on the supply of recyclable gypsum waste, as indicated in the deliverables of the Gypsum 2 gypsum project. Based on their experience within their specific region, an average of 5.5kg per inhabitant in the supply area is chosen.

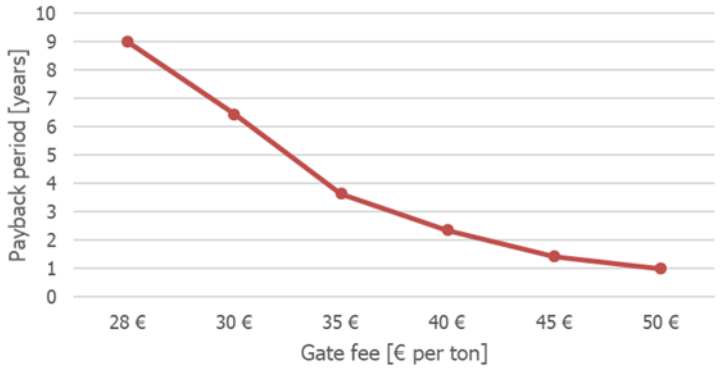
Key Success Factor of the business case	Explanation
Gate Fee per ton	This is definitely the key success factor of this business case, as can be seen in the results of the sensitivity analysis. As the main revenue is generated from upstream customers, the gate fee is the main revenue driver. The gate fee that can be charged is primarily influenced by the upstream

Key Success Factor of the business case	Explanation
	alternatives. As indicated by the entrepreneurs, in some countries upstream alternatives are so cheap that gypsum recycling is not feasible (e.g. gypsum waste in the UK can be supplied to agriculture for spreading over the land). Evidently, a lack of (enforcement of) regulation when it comes to landfilling gypsum waste makes profitable gypsum recycling impossible
Enough supply of recyclable gypsum	There needs to be enough material that can be processed in order to make enough use of the equipment and the overhead costs. A sufficient supply is key to this and this is determined by the gypsum waste generation rate and the number of inhabitants in the supply area.
Material recovery rate	The material recovery rate reflects how many % of the input material can be converted into recycled gypsum. This parameter drives both the output revenue and the costs (as costs are mainly driven by the number of input tonnes processed and because waste disposal costs depend on the amount of waste as % of the input).

Results of the Sensitivity Analysis

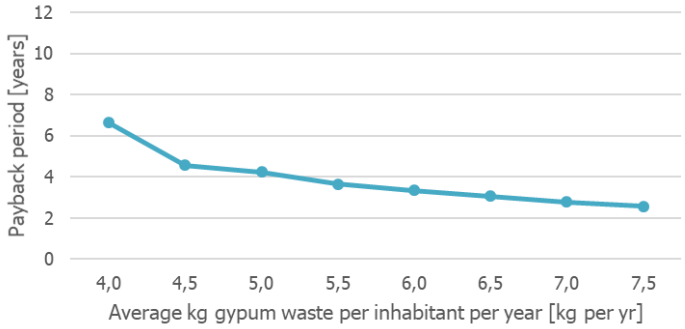
In the figures below, the sensitivity of the payback period in function of various input parameters under assumption of Ceteris Paribus is presented. This confirms the fact that the key success factors of this business model are the ones listed in the table above and reflects their relative impact.

Figure 15: Sensitivity Analysis depicting the payback period in a gypsum processing plant in function of various first year gate fees. Below EUR 28 gate fee, the payback period is more than 10 years.



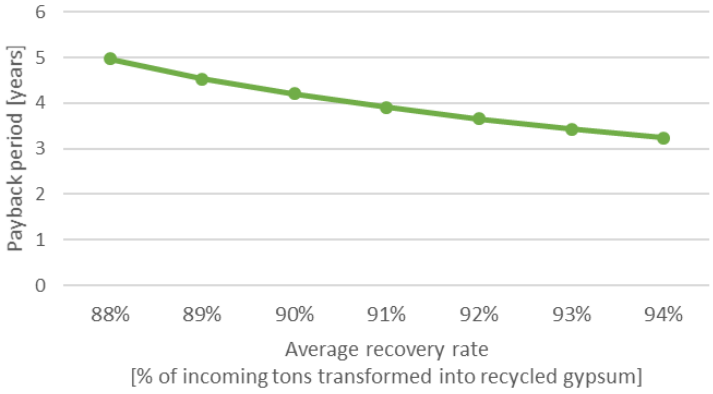
Source: IDEA Consult

Figure 16: Sensitivity Analysis depicting the payback period in a gypsum processing plant in function of the gypsum waste supply rate (kg of waste generated per inhabitant of the supply area per year)



Source: IDEA Consult

Figure 17: Sensitivity Analysis depicting the payback period in a gypsum processing plant in function of the "recovery rate", which is the % of input material that can be recovered into recycled gypsum



Source: IDEA Consult

8.4 Business case 2: Brick processor

Model Parameters	Main Information Sources
Downstream alternatives, process parameters	Detailed input provided by the Danish entrepreneur running this business model in several locations. The main downstream competition derives from the sales of new bricks.
Community benefits: environmental impact avoided due to recycling of bricks	Based on an independent study performed by the Danish Environmental Government Agency

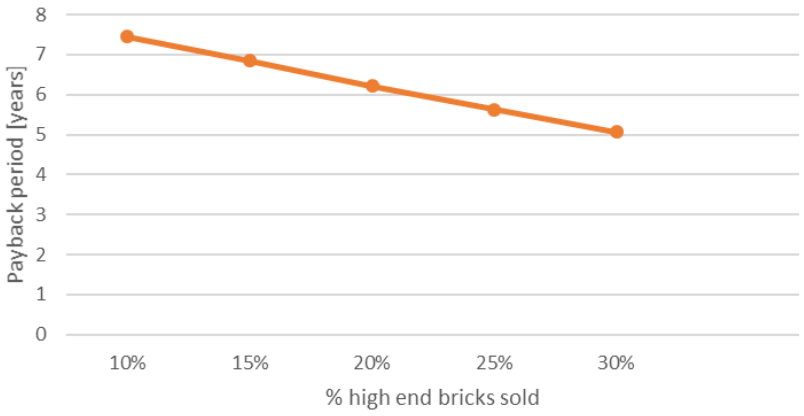
Key Assumption or Specific Modelling Choice	Rationale
Division of input streams in 3 categories (low, medium and high brick content) and output bricks in 3 categories (high end, mid end, low end)	As indicated by the Danish entrepreneur, there is a large variability in output prices of recycled bricks and also of the brick content of the input waste. Therefore, for both inputs and outputs two independent categorizations were applied (i.e. the output brick value is not modelled as a dependent on the brick content of the input).
Negative discount versus primary downstream alternatives (i.e. recycled bricks are more expensive than primary bricks)	As indicated by the Danish entrepreneur, there is a large variability in output prices of recycled bricks depending mainly on the esthetical value of the recycled bricks (e.g. patina) which in most cases allow that prices are being charged that are significantly higher than those of new bricks. This requires that there is a market for these recycled bricks, which is mainly driven by architects.
The process consists of a manual sorting station, an automated cleaning and sorting installation and a robotized stapling installation	This setup is actually being applied by the Danish entrepreneur in two separate locations. There are alternative processes that can be applied (e.g. less automation), but these are not reflected in the business case.
The number of shifts required is being calculated automatically in the model	Based on the number of input tonnes that need to be processed in a certain year as specified by the user input and taking into account the maximum capacity of the production line, the number of shifts in each year is defined automatically in the excel model. Due to this, suddenly relatively sharp drops in payback period can occur with changing the quantities processed.

Key Success Factor of the business case	Explanation
Brick content and price of the input	The bricks processor should have enough affordable input materials with a high enough brick content. Because the capacity of the installation and the direct costs are predominantly determined by the tons of input materials, getting affordable inputs with high brick content is key to this business model's profitability.
Price per recycled brick, enough market for high end bricks, certification	Of course, the business model is only viable if a market exists for recycled bricks. This requires that a certification (CE marking) exists for the recycled materials and that there is enough willingness to pay for recycled bricks.
Labour impact of the process	As the process of recycling bricks is quite labour intensive, the profitability is driven to a large extent by the labour cost, which is mainly determined by the yearly cost per operator and the number of operators required per shift.

Results of the Sensitivity Analysis

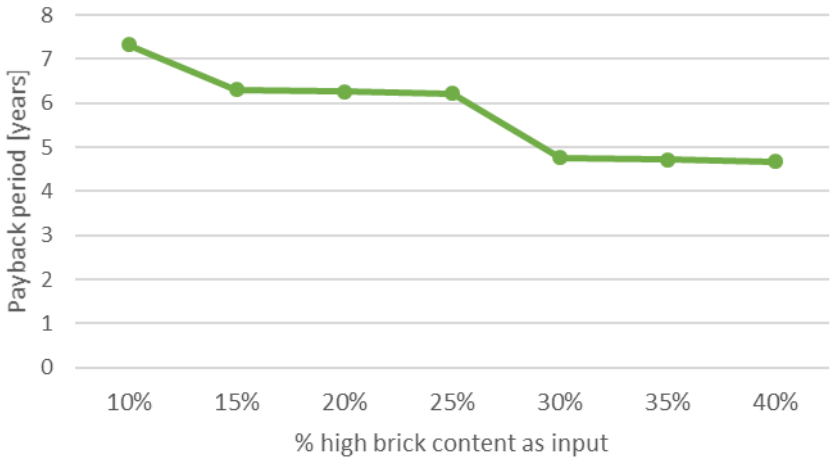
In the figures below, the sensitivity of the payback period in function of various input parameters under assumption of Ceteris Paribus is presented.

Figure 18: Sensitivity Analysis depicting the payback period in a bricks processing plant in function of various % of high end bricks sold (% of total bricks sold)



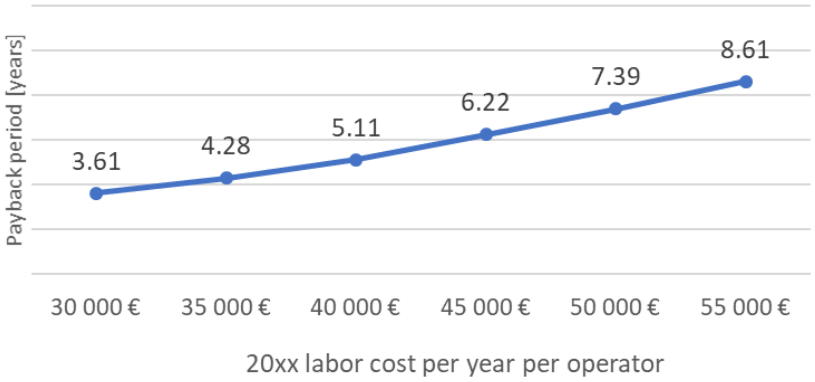
Source: IDEA Consult

Figure 19: Sensitivity Analysis depicting the payback period in a bricks processing plant in function of various % of high brick content input (% of total input). The "steps" are caused by changes in the production regime in certain years (moves from 2 to 1 shift operation, as the throughput in input tonnes per shift is fixed)



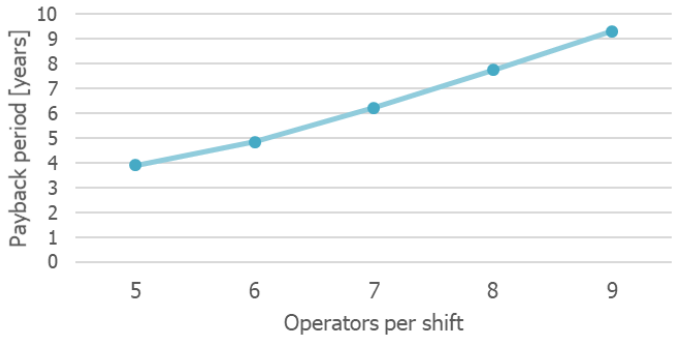
Source: IDEA Consult

Figure 20: Sensitivity Analysis depicting the payback period in a bricks processing plant in function of various yearly operator labour cost (20xx baseline)



Source: IDEA Consult

Figure 21: Sensitivity Analysis depicting the payback period in a bricks processing plant in function of the number of operators required per shift



Source: IDEA Consult

8.5 Business case 3: Stationary Mixed CDW Processor

Model Parameters	Main Information Sources
Process parameters, equipment needs and impacts	A combination of the following input was used: • Quantitative input provided by the 6 entrepreneurs interviewed that are operating this business model, whereby one Belgian entrepreneur in particular helped in providing detailed estimates based on a review of the first version of the calculation model • In the following study a lot of quantitative input could be found to estimate and validate the various parameters, e.g. related to the investments required in different processing equipment: *Guide de conception et de fonctionnement des installations de traitement des déchets du BTP* – March 2014, by *SR BTP*, Syndicat des Recycleurs du BTP http://recycleurs-du-btp.fr/wp-content/uploads/2014/06/Guide-Installations-SRBTP-2014.pdf • Process descriptions and certain process parameters were estimated/validated based on the following publication: Pacheco-Torgal, F., Tam, V., Labrincha, J., Ding, Y. and de Brito, J. eds., 2013. Handbook of recycled concrete and demolition waste. Elsevier.
Community benefits: environmental impact avoided due to recycling	Based on information provided in Pacheco-Torgal et. Al. (see supra)
Prices charged for granulates, broken concrete, sand and broken asphalt	Online price lists were consulted, e.g. of the Flemish company ABAR and these were validated/refined based on the interview with the other Belgian company that validated the business case
Division of % over various input and output materials (e.g. sand/concrete/granulate)	Based on input from the interviewed entrepreneurs and validated based on the 2016 yearly report of COPRO, the independent Belgian organization for quality control of building products, which publishes in its "Activity report 2016" the division of sales of various recycled materials (pages 50 – 57).

Model Parameters	Main Information Sources
	http://copro.eu/sites/default/files/news/Activiteitenrapport%202016_NL.pdf

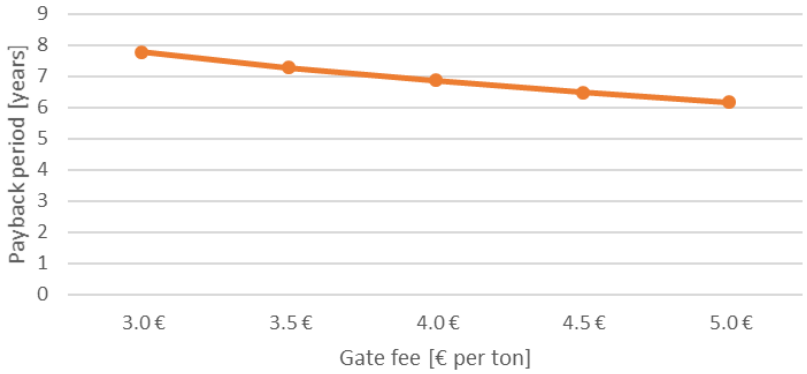
Key Assumption or Specific Modelling Choice	Rationale
The quantities of materials recycled starts from 50K tonnes in the first year and evolves towards 250K tonnes per year in the tenth year	Based on the input from the interviews with entrepreneurs, a significant amount should be recycled in order for such a business to become profitable. As is clear from the COPRO report, recycling these quantities would mean that the recycling company is in the largest segment of tonnes per year processed.
All recycled materials sold in the same year as they are processed	Several entrepreneurs indicated that often intermediate stocking of output materials is done to optimize the revenue based on fluctuating demand and output prices. To take this complexity into account in a static calculation model would lead too far. A stochastic modelling approach could be applied, but this is out of scope for the current study. This simplification is deemed appropriate because the additional revenue that can be gained through optimized intermediate stocking is partly compensated by the additional cost incurred (capital cost for storing the materials, additional internal transport costs). The investment in land reflects that such intermediate stocking activities would be possible.
The process in the model has a specific setup of machines as indicated in the tab "Equipment" of the spreadsheet model	In reality, many variants exist including various processing equipment and various steps (e.g. with or without washing), as indicated by the entrepreneurs and by the above-mentioned publications of ADEME and Pacheco-Torgal et. Al. Together with the Belgian entrepreneur who delivered detailed input for this business case, a certain realistic and quite common setup was chosen, with the processing equipment indicated in the tab "Equipment" of the spreadsheet model.

Key Success Factor of the business case	Explanation
Price per ton of mixed granulate and broken concrete	Being the main fractions that are sold as output materials, these prices will have an important impact on the profitability.
Gate fee per ton of stony fractions	This is an important revenue driver, representing the main paid fraction that is being accepted
Total number of tons processed	In order to offset the overhead costs and the investment in equipment, sufficient revenue needs to be generated in the first years.

Results of the Sensitivity Analysis

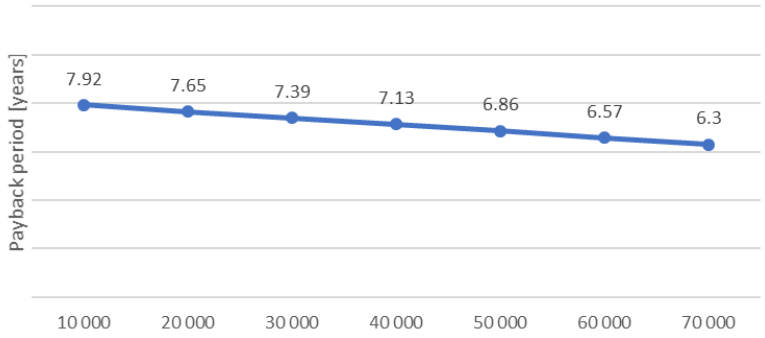
In the figures below, the sensitivity of the payback period in function of various input parameters under assumption of Ceteris Paribus is presented.

Figure 22: Sensitivity Analysis depicting the payback period in a stationary mixed CDW plant in function of changing gate fees per ton for stony fractions.



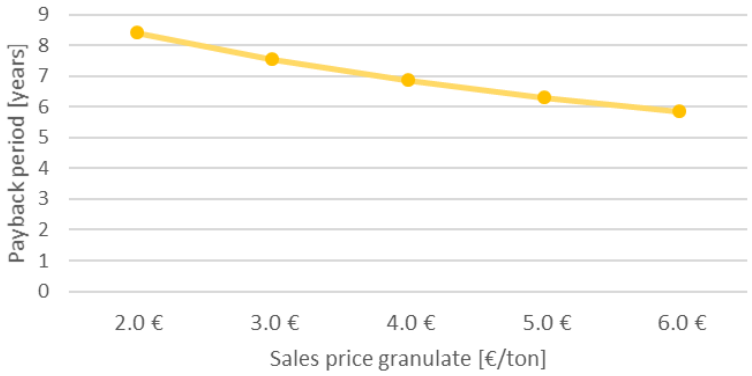
Source: IDEA Consult

Figure 23: Sensitivity Analysis depicting the payback period in a stationary mixed CDW plant in function of changing input tonnes in the first year



Source: IDEA Consult

Figure 24: Sensitivity Analysis depicting the payback period in a stationary mixed CDW plant in function of changing sales prices for granulate output fraction in 20xx.



Source: IDEA Consult

8.6 Business case 4: Mobile Mixed CDW Processor

Model Parameters	Main Information Sources
Process parameters, equipment needs and impacts	A combination of the following input was used: • By far most information was provided as quantitative input by one Belgian entrepreneur running a mobile mixed CDW processor business model • Information used for checking the setup of the model and some input parameter validation from "Construction and demolition waste management practices and their economic impacts (1999)" http://ec.europa.eu/environment/waste/studies/cdw_report.htm
Community benefits: environmental impact avoided due to recycling	Based on information provided in Pacheco-Torgal et. Al. (see supra)
Division of % over various input and output materials (e.g. sand/concrete/granulate)	Based on input from the interviewed entrepreneurs and validated based on the 2016 yearly report of COPRO, the independent Belgian organization for quality control of building products, which publishes in its "Activity report 2016" the division of sales of various recycled materials (pages 50 – 57) and lists numbers separately over mobile/stationary breakers. http://copro.eu/sites/default/files/news/Activiteitenrapport%202016_NL.pdf

Key Assumption or Specific Modelling Choice	Rationale
The capacity of the mobile plant is calculated and it is checked whether it is enough for the processed volume, underutilized or insufficient. However, the number of mobile machines needs to be set as input parameter and is not calculated automatically based on the quantities that are to be processed.	This allows more control over the choice of which investment is done in the first year. The capacity check (see the "Capacity Advice" on the Tab "Projects") reduces the risk that the user of the model would select an inappropriate setup of machines for the quantities of input materials processed. For this capacity calculation, the maximum throughput of the machines is taken into account as well as the number of days that these machines are unavailable for processing due to transportation, maintenance, setup and decommissioning.
Only combination machines in which breaker and sieve are integrated are taken into account. Only 2 variants of machines (large and standard) are taken in consideration.	As indicated by the Belgian entrepreneur, these combination machines are applied in the majority of cases, although sometimes they apply a separate crushing and sieving installation as well. Although there are many different machine types available on the market, each with different characteristics such as price, capacity, etc., only 2 realistic and representative types were taken into account based on the input provided by the entrepreneur.

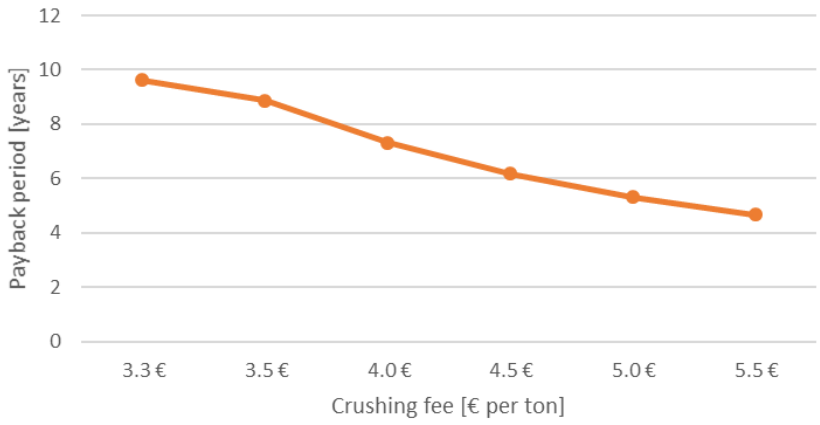
Key Assumption or Specific Modelling Choice	Rationale
Crushing Fees are calculated as a fixed fee per output tonne, which can be differentiated based on the type of output materials (e.g. different price for sand, broken concrete, granulate)	As indicated by the Belgian entrepreneur, this is the most prevalent model that can be found in practice. Another variant, which is not taken into account, is that whereby the crushing fee is determined as a fixed fee per input tonne. A third variant is a fixed fee per machine hour of the crusher. However, these models are only slightly different from the one presented here and can be found less in practice.
Projects are discerned based on the number of tonnes to be processed. There are projects of 1K, 2K, 5K, 10K and 15K input tonnes discerned	As suggested by the entrepreneur, there is a large difference in the economics of various projects which is mainly driven by the amount of materials processed. Less materials means the capacity utilization of the machines is suboptimal, given that more time is lost in transport, setup and decommissioning.
The transportation revenue is lower than the transportation cost	As indicated by the entrepreneur, the willingness to pay for transportation is low. Therefore, often discounts are agreed on transportation price which means that the processor will lose money on the transportation part which is then to be compensated by the crushing fee revenue.

Key Success Factor of the business case	Explanation
Crushing Fee per tonne of output material	Evidently, this is the key revenue driver.
Average tonnes per project	The profitability of a project is mainly driven by the amount of materials crushed. The transportation, setup and decommissioning activities are in general not profitable. Time lost on transportation is also time lost in which the same machine could be used for crushing in another project.
Total number of tonnes processed and specifically during the first years ("production ramp -up")	To utilize the capacity optimally, the total number of tons processed per year should be high enough, especially during the first of operation, in which there is a high risk that the machine(s) stay(s) underutilised.

Results of the Sensitivity Analysis

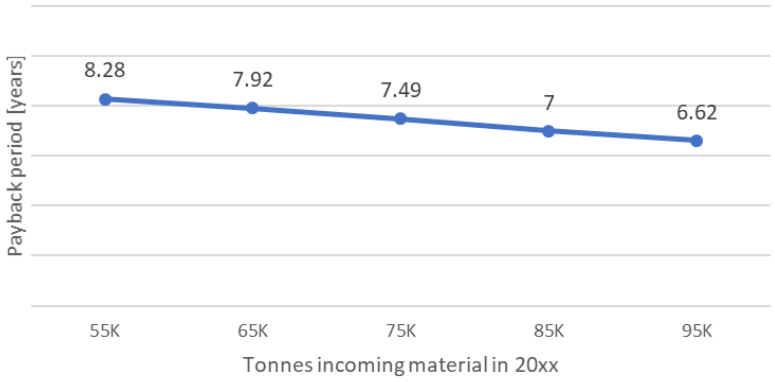
In the figures below, the sensitivity of the payback period in function of various input parameters under assumption of Ceteris Paribus is presented.

Figure 25: Sensitivity Analysis depicting the payback period in a mobile mixed CDW plant in function of changing crushing fee per tonne granulate.



Source: IDEA Consult

Figure 26: Sensitivity Analysis depicting the payback period in a mobile mixed CDW plant in function of changing number of tonnes in first year (20xx), assuming that the number of tonnes processed in the fifth year remains constant among all scenarios that are compared



Source: IDEA Consult

8.7 Business case 5: Selective deconstruction

Model Parameters	Main Information Sources
Process parameters, building characteristics (e.g. % of material types contained)	As indicated by a Belgian entrepreneur and Arcadis selective deconstruction experts, plus the following sources: ▶ Chini, A.R. ed., 2005. Deconstruction and materials reuse: an international overview. International Council for Research and Innovation in Building and Construction, CIB General Secretariat. ▶ Lassandro, P., 2003. Deconstruction case study in Southern Italy: economic and environmental assessment. In Proceedings of the 11th Rinker International Conference on Deconstruction and Materials Reuse, Gainesville (pp. 115-124). ▶ Coelho, A. and de Brito, J., 2011. Economic analysis of conventional versus selective demolition—a case study. Resources, Conservation and Recycling, 55(3), pp.382-392.

Key Assumption or Specific Modelling Choice	Rationale
The mark-ups per category (labour, machine hours, transport & disposal) are input parameters to the model	As indicated by the entrepreneur, a selective deconstruction company often calculates a project price based on the estimates for man-days, machine time, transports and tonnes of materials disposed of from various categories. For these, in the calculation of that project price, often fixed mark-ups are applied per category of cost/revenue.
A standard building composition as indicated in the tab "Project" cells E: 22 to E: 28 is assumed, representing a large concrete building.	The entrepreneur indicated there is a very large variability among the types of materials that can be found in different buildings. This is confirmed by the literature on this topic. There is no statistical information on the average composition of buildings available. Moreover, that average composition varies strongly per country, per building segment, etc. Therefore some realistic numbers as indicated by the entrepreneur were taken into account, but we do not claim that they are accurate statistical averages for the EU building stock.
Only two types of demolition cranes are taken into account in the model	Although in practice a lot of different variants exist, we only include two types in the model: standard and large cranes, see parameters in the tab "equipment". These were estimated by the entrepreneur. Additionally, some loaders, container vehicles and train trucks are taken into account.
Asbestos removal and ground works are not included in this calculation model	Although in practice these works are often performed by a selective deconstruction company as well, here only the selective deconstruction, demolition and disposal activities of

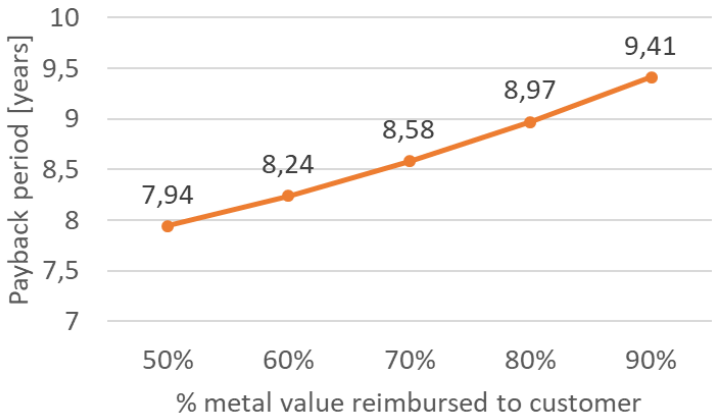
Key Assumption or Specific Modelling Choice	Rationale
	the building itself were taken into account. The rationale for this choice is that groundworks are part of the "contaminated soil remediation" business model, which was not selected using the expert MCA and the necessity of asbestos removal is a very variable and uncertain factor which would make the model much more complex.
3 types of projects are taken into account: small, medium and large. We focused on typical office or residential building, excluding industrial buildings.	As indicated by literature and the entrepreneurs, there is a huge variability in the type of projects. The characteristics of these typical project were estimated together with the entrepreneur involved in this case.
Metal revenue is partly reimbursed to the customer	As the entrepreneur indicated, metal revenue is often considered during project price calculation. Not the full gain is acquired by the selective deconstruction company but it is taken into account as a project discount in the calculation. Therefore, we assume that 100% of the revenue of selling metals to the recyclers is revenue and X% (e.g. 90%) is a direct cost and is seen as a reimbursement to the customer

Key Success Factor of the business case	Explanation
Accurate building inventory and project estimation	As the project price is often quoted based on the expected number of labour hours, the expected machine hours needed, the tonnes of materials disposed, the tonnes of metals recuperated and the number of transports, knowing exactly how many materials there are of which different types will be critical to end up with a profitable project.
Optimal trade-off of selective deconstruction and disposal	Applying more selective deconstruction of material fractions requires that more man- and machine hours are spent to get these materials out. But this will reduce the cost of waste disposal. Thus, the waste disposal fees are very important drivers of the optimal level of deconstruction versus demolition. Therefore, the
Enough large projects to be able to utilize the capacity of the equipment	Especially during the first years, there should be enough projects to earn back the initial investment in equipment etc.
Metal revenue	The revenue from selling metals is substantial in this type of deconstruction projects. As indicated above, this is often taken into account in the project price estimation. The proportion of metal revenue that is assigned to the selective deconstruction company will be an important profitability driver.

Results of the Sensitivity Analysis

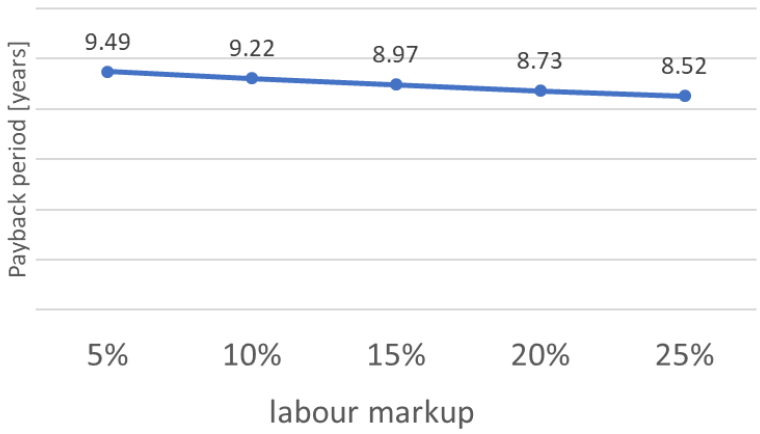
In the figures below, the sensitivity of the payback period in function of various input parameters under assumption of Ceteris Paribus is presented.

Figure 27: Sensitivity Analysis depicting the payback period in a selective deconstruction business in function of % of metal value reimbursed to customer



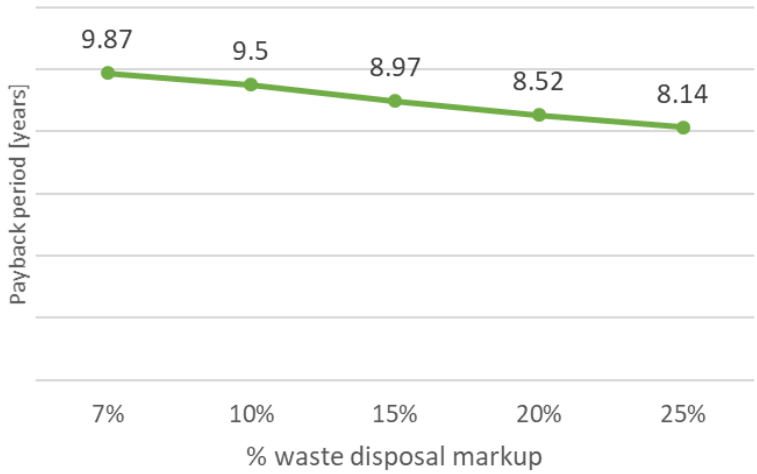
Source: IDEA Consult

Figure 28: Sensitivity Analysis depicting the payback period in a selective deconstruction business in function of % labour mark-up



Source: IDEA Consult

Figure 29: Sensitivity Analysis depicting the payback period in a selective deconstruction business in function of % waste disposal mark-up



Source: IDEA Consult

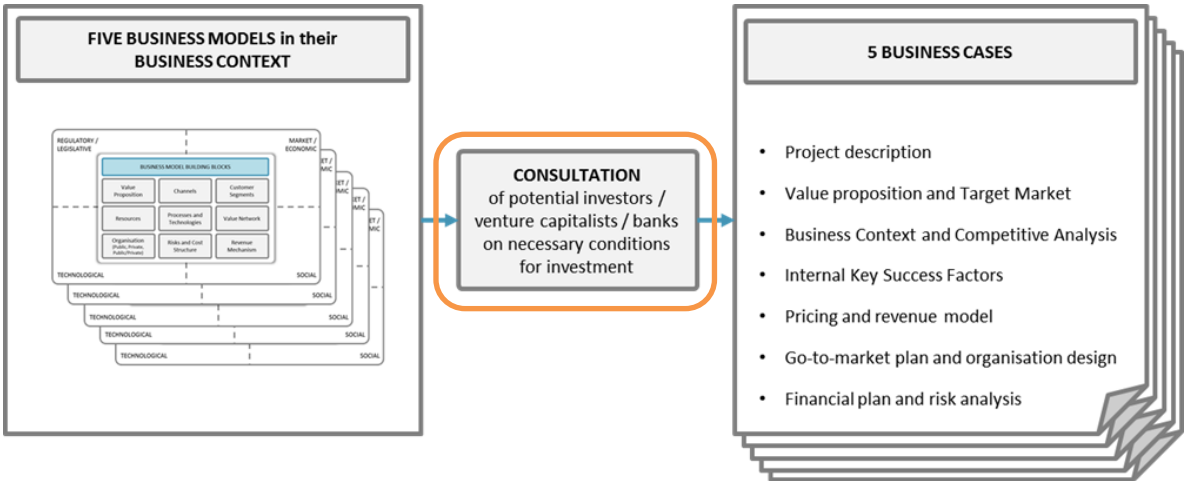
8.8 Bridging the gap between entrepreneurs and finance in CDW recycling: findings from financial interviews

8.8.1 Context & interview questions

In this study, business cases are developed in order to improve the CDW recycling infrastructure situation in the lagging EU Member States. In order to support the development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure it is necessary to bridge the gap between the entrepreneurial and financial community.

As described in Chapter 8.1 and detailed in Figure 30, the business cases have been developed in close collaboration with key entrepreneurial and financial stakeholders. For further details on this process, please also see that chapter.

Figure 30: From business models in their business context to business cases



Source: IDEA Consult

Financial stakeholders were asked a key set of questions, from which also key findings arose and are detailed here.

In this respect, financial interviews covered the follow key questions:

- What are the criteria that the [financial institution] uses to determine the eligibility of a business (plan)? e.g.
  - ROI,
  - Profitability,
  - Time span for positive cash flow,
  - Other (please specify)
- Which information does a business plan need to contain? Which elements does it need to contain? What information are you looking for?
- Is there a difference in business plan evaluation between 'Green' projects and other more conventional projects?
- What are other ways of investing and financing in comparison with the method of [financial institutions method]?
- Does [financial institution] focus on different type of clientele (entrepreneurs) than [other financial institutions]? How accessible is [your financial institutions financing] model for SMEs?

8.8.2 Findings from financial interviews

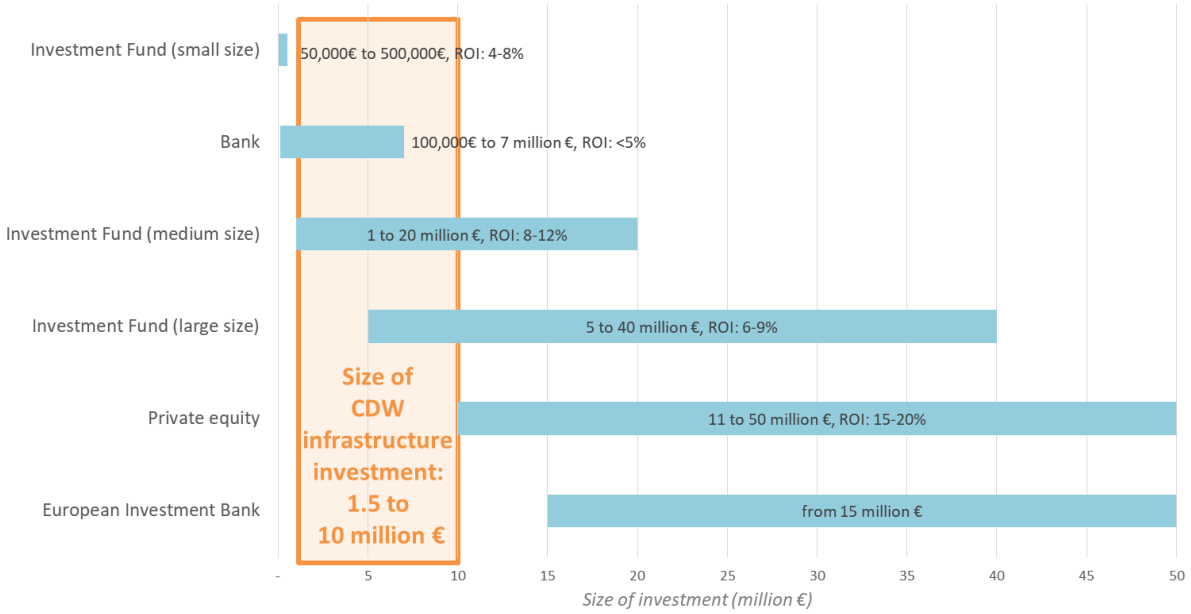
In total nine financial stakeholders were interviewed, at seven financial institutions, whereby some stakeholders have been interviewed in a first and second round. Stakeholders represented included banks, investment banks, investment funds, private equity as well as the European Investment Bank (EIB). For a full list of the stakeholders consulted please see Annex 2.

Interviews revealed that individual banks focus on different types of investment than others. Not all banks and financial institutions are specialised in the same types of investment when speaking about 'green' investment. Specifically e.g. topics such a 'green cities', 'sustainable buildings' and 'energy efficiency' investments were quite common.

Varying financial institutions have differentiated target investment size and expected ROI. This feature was particularly dominant, whereby private equity as well as venture capital (not shown) and EIB investments are the highest, banks cover the lower end of the spectrum and investment funds of varying size cover the spectrum separately. The details are depicted in Figure 31.

Matching size of investment needed with the available financial resources can pose a challenge for CDW infrastructure. The typical size of investment for CDW infrastructure was identified to lie between EUR 1.5 and 10 million. However due to the limited range of select funds, e.g. private equity and EIB investment could be out of range, where alternative solutions could be needed. In a follow-up interview with the EIB it was indicated that solutions can be found for smaller investments yet details are still to be elaborated, for more details, see the solutions presented during the Workshop in Chapter 9.3.

Figure 31: Financial interviews indications on matching size of investment and available funds



Source: IDEA Consult

9/ Validation workshop – Stakeholders' meeting

Whereas in previous tasks of the project the interaction with the various stakeholders was on an individual basis geared towards specific topics, the workshop allowed for an interactive discussion on the business cases that have been developed involving at the same time entrepreneurs, financers/investors and policy makers. The following details the aim and objective of the workshop, the main findings, EFSI and EIB financial instruments, clustering activities and other business models and the results of the post-workshop feedback from participants. The minutes, which include the participants list, are found in Annex 8/.

9.1 Aim and objective of the workshop

The value added of the workshop was in bringing stakeholders together both those from the entrepreneurial community and the financial community, as well as policy makers and regulators, serving as a platform for CDW recycling uptake. The stakeholders' views on the viability of the business cases in lagging Member States, on conditions for success, potential obstacles and solutions and transferability across Member States are important in the further use and application of the business cases. The Validation Workshop - Stakeholders' Meeting, which took place on November 16th 2017, was a pivotal point in the project's work where the preparation and development of the business cases culminated towards implementation.

The aim of the workshop was to obtain the stakeholders' views, comments, suggestions on the use and valorisation of the business cases in Member States that currently do not recycle CDW in line with the ambitions of the Circular Economy Package.

- Are the business cases viable in their view given the business environment in these Member States?
- Do the underlying key parameters capture the economics and state of the CDW market in these Member States?
- What are the implementation challenges in start-up, financing, growth phases of the company?
- What are the factors of success?
- How can perceived barriers be overcome?

9.2 Main findings

As indicated in Chapter 8/, prior to the workshop each of the five business cases was evaluated and discussed with an entrepreneur for a reality check on the business model set-up and parameters used. Also financial experts from the EIB and private institutions were consulted in order to obtain their views on the content of the business cases (completeness, clarity, adequacy, relevance).

Through the presentation of the study results and the business cases, as well as the breakout session discussions, valuable feedback was obtained for the finalisation of the study.

Main messages and suggestions from the stakeholders, entrepreneurs, financers, among others on success factors, potential barriers and solutions and transferability included the following:

- The development of these business cases is an important and unique step towards increasing CDW recycling infrastructure in Europe.
- The role of the public partner is to create the market conditions under which the CDW recycling market can flourish. The most favoured instruments include:
  - Legislation: including enforcement thereof, landfills bans, the price of landfilling, the use of recycling versus recovery targets, etc.
  - Quality assurance system: this can be achieved through traceability, certification and the introduction of standards, among others, with the aim of also increasing the acceptance of the materials.
  - Green public procurement with the use of recycled materials: this should be encouraged to help to create a market as well as raise acceptance of the use of these materials, setting the example for the market to follow.
- Barriers that needs to be overcome include:
  - Quality issues are a main challenge: the lack of trust in secondary materials could be supported by traceability, quality control, selective deconstruction, better controls of hazardous materials.
  - Price of virgin versus secondary materials: there was a general consensus that secondary materials should not be more expensive than virgin raw materials. This aspect also depend on the availability of the primary raw materials.
- Further fostering these business cases:
  - Size of projects is key for viability.
  - EFSI and InnovFin are funding mechanisms of the European Investment Bank (EIB). For EFSI the aim is to leverage and de-risk private capital, targeting so-called mid-cap companies with up to 3000 employees as well as small companies of less than 250 employees which can also apply with typical lending amounts between EUR 7.5 and 25 million. InnovFin targets very specifically projects that are oriented towards innovation and research with clear criteria to be met. Risk sharing and guarantees are also offered via EFSI and InnovFin funds.
  - Distances and transport are a key challenge to be tackled: various issues related to transport, distance and the associated cost and sustainability issues were addressed including:
    - Fuel prices such as kilometre levies in defining costs;
    - Distances between users and producers need to remain small and this means that activity takes primarily place locally. On this note it is suggested that also on-site use of CDW should be considered. If not feasible to be used directly, industrial symbiosis with other local sites, neighbouring companies or projects can be envisaged for CDW and should be further encouraged.
  - Impact oriented investors are keener to foster investment in CDW recycling infrastructure, as buildings represent one of the greatest CO_2 sources.

- The role of Extended Producer Responsibility (EPR) schemes in supporting the proposed business cases remains however an open discussion. EPR could be a powerful tool, but the problem is that it refers to the quantity of waste that has to be taken care of in relation to the quantity being put on the market. For CDW there is a problem with the time lapse as there is a long time where the materials remain in the buildings. The relation with the 'waste generated' and 'products on market' is difficult to make, therefore the application of CDW could work for some items, such as PV cells, but it is not evident to apply it for most inert materials.
- The use of pre-tax values (also known as the values before taxes, profit before income taxes) is recommended for transferability of the corporate tax rate parameter across Member States.

9.3 EFSI and EIB financial instruments

Through EFSI and InnovFin, the EIB presents clear opportunities to address the finance gap faced by CDW recycling infrastructure community. While the relatively small size of CDW recycling investments and their rather modest ROI continue to be a hurdle to attract investment funds, candidate investors are encouraged to explore specific initiatives of finance opportunities together with EIB advisors on a case by case basis. During the Workshop, the EIB gave a presentation on "Financing the circular economy: Investment and innovation in C&D waste recycling", the content of which are summarised here below.[53]

9.3.1 EIB Financing of CE and Innovation in practice

The EIB aims to create favourable investment conditions for its clients and is the worldwide largest multilateral lender. By means of direct, intermediated and indirect financing as well as risk sharing, the EIB presents several financing options for investment in circular economy and innovation. Direct financing includes projects of larger financing volume, with a generally more complex lending procedure and are typically used for projects such as highways, towers and waste treatments plants. Intermediated financing entails more risk with cross equity yet more return. This is available for smaller financing as well, whereby there is typically another intermediary.

EFSI

Funding provided by EFSI[54] has a notoriously wide scope, where among these target sectors include the development of infrastructure in the environment and natural resources fields. As this fund is executed by the EIB, it is subject to same conditions as a typical EIB loan. The aim is to leverage and de-risk private capital, targeting so-called mid-cap companies with up to 3000 employees as well as small companies of less than 250 employees which can also apply. Overall, EFSI projects must meet the following criteria:

- Economically and technically sound;
- In at least one of the EFSI eligible sectors as defined in Article 9 of the EFSI Regulation;
- Contributing to EU objectives, including sustainable growth and employment;
- Mature enough to be bankable;
- Priced in a manner commensurate with the risk taken[55].

[53] Presentation given by Jonas Byström (2017) "Financing the circular economy: Investment and innovation in C&D waste recycling" at the Workshop on November 16th 2017 held in Brussels, Belgium
[54] See http://www.eib.org/efsi/ for more details
[55] See http://www.eib.org/efsi/how-does-a-project-get-efsi-financing/index.htm

The typical lending amounts of EFSI are between EUR 7.5 and 25 million, which corresponds to a total of EUR 15 million of investment (50% EIB). In addition, due diligence for the borrower and the project are needed for all direct financings.

InnovFin

InnovFin targets very specifically projects that are oriented towards innovation and research. The criteria outlined to support the determination of eligibility indicate that a company needs to be either fast growing or an R&D or innovation driven enterprise, which means that FTEs need to grow at >10% per year over the last three years or meet one of a set of R&D or innovation criteria[56], respectively. Similar to EFSI, companies of up to 3000 FTEs are supported, through both direct and indirect financing depending on the product.

In order to support companies in selecting the most appropriate product and ensuring the appropriate support, InnovFin also features an advisory service.[57]

Indirect financing

Indirect financing typically takes form through third party banks in support of the EIB. This means that dedicated financing lines are initiated towards bank, which is used for on-lending at reduced interest rate to 'eligible' SMEs and Mid-Caps. In this case the EIB is only responsible for monitoring the on-lending to the bank directly.

Some examples presented include: (i) Rabobank Impact Loan for SMEs and Mid-Caps III in the amount of EUR 200 million and (ii) - Belfius Smart Cities Climate & Circular Economy, which amounts to EUR 200 million.

Risk sharing

Risk sharing presents a possibility for finance and investment, whereby particularly guarantees play a role. For innovative or higher risk SMEs the EIF features the InnovFin SME Guarantee and COSME guarantee. For innovative Mid-Caps the EIB has the InnovFin Mid-Cap Guarantee and EFSI, covering up to 50% of credit risk.

9.3.2 EIB and the circular economy

In the last 5 years EUR 2.6 billion have financed circular economy projects, however the construction sector has not been financed under this circular economy umbrella. Circular economy projects face a set of common risks related to the market stability (demand for used, repaired and remanufactured products is typically low, likewise the supply of certain waste streams for the development of secondary products is also uncertain), the technologies being developed and the novelty of certain business models.

There is a strong interest to increase finance to circular economy and especially construction and demolition waste infrastructure projects from the EIB, which includes a flexibility towards the possible adaptation and even creation of products. Moreover the EIB also aims at advising promoters looking at business models and supporting the overall improvement of bankability in favour of supporting circular economy projects such as CDW recycling infrastructure. Dedicated advisory support is offered to promoters via the circular economy advisory, which offers technical as well as financial advice to promoters, through the European Investment Advisory Hub (EIAH)[58] and the Innovation Finance Advisory, respectively.[59]

[56] For a list of the eligibility criteria see: http://www.eib.org/products/blending/innovfin/eligibility/index.htm
[57] See http://www.eib.org/products/advising/innovfin-advisory/index.htm
[58] See http://eiah.eib.org/ for further details
[59] See www.eib.org/circular-economy for more details

9.3.3 *EIB project assessment approach*

In order to assess a project, the EIB considers three main elements: (i) eligibility assessment, (ii) general eligibility criteria and (iii) credit assessment and structuring of funding. In order to assess the eligibility, the typical criteria apply including conformity with EIB public policy goals (innovation, SME, environment), general eligibility towards investment length, economy value, economic production and priority sector as well as eligibility of the actual costs and the specific eligibility criteria of the product / instrument in question, among others. With regards to the project viability, the maturity, technical soundness and credibility of the business plan are of essence. Finally with respect to the credit assessment and funding, particularly cash flows and repayment structure are key in assessing the ability and plan for the repayment of the loan.

9.4 Post-workshop feedback

Immediately following the workshop, participants were asked for the feedback on key issues related to fostering investments in CDW recycling infrastructure and for their appraisal of the workshop. In total, eight questions were posed, five of which were open and related to the ways forward for CDW recycling business models. In total eight responses were obtained, which is about one quarter of the participants other than from the consultants and the Commission. 75% of the respondents indicated that they were very satisfied or satisfied with the event. The remaining 25% were indifferent. Respondents indicated that an innovative approach has been developed through this study, which is very business and financially oriented.

A summary of responses to the questions is presented here:

- **What do you think about clustering several CDW activities in order to develop full service to the community and construction sector in managing all (several) kinds of CDW?**

Respondents were positive about the notion of clustering activities, indicating that it provides a holistic approach and by creating clusters also transport and transport related costs and impacts can be minimised. It was indicated that this kind of clustering could be perceived as one material value chain, ranging from demolition to processing and the development of new products from that material. One respondent added that it is often the case for a construction or demolition company that, in order to minimise costs from transport, they tried to use recycled materials for own purposes (e.g. through a new build at a demolished site).

- **How do you see the role of public partners in funding new investments in recycling infrastructure (alone or beside private entrepreneurs)? Do you have any information about such kinds of enterprises (semi-public companies or Public-Private Partnerships) in this field?**

Concerning the involvement of public partners, respondents indicated that the role is primarily non-financial. The supporting role of legislation, green public procurement, standards, as well as material contribution through the provision of land, operational permits, waste collection infrastructure and the overall organisation of the value chain and recycling activities towards more positive trends are particularly highlighted. Furthermore, public-private partnerships and the facilitation in the attainment of authorisation for recycling facilities is also highlighted. Examples of Canada and Bulgaria (Sofivest for the municipality of Sofia) as well as Ruse and Vrasta in Bulgaria are mentioned.

- **Do you think there could be some specificities for the business models in areas nearby several Member States' borders? Could the business model be affected by cross border business? Have you any experience or information about such cross-border activities in CDW recycling? Could you share it with us?**

Respondents indicated that there is a lot of activity reported in the cross-border region including Belgium, the Netherlands and Germany. It was furthered that cross-border movement is driven by costs and mostly relevant for higher value waste however that it is not driven, nor in favour of sustainability. The main reasons for the movements are attributed to gypsum waste and related to backfilling in view of the respondents.

- **Which actions do you suggest for further uptake of CDW recycling inspired by the material presented and discussion at the workshop?**

In the responses, participants indicated that actions for further uptake could include but are not limited to:

  - inclusion of manufacturers in the development of business cases and recycling strategies,
  - development of a platform for cooperation, to exchange best practices between recyclers (waste processors), producers, waste collectors and demolishers;
  - enforcement of regulation;
  - the consideration of hazardous CDW and the role of contamination in the way forward;
  - targeted investigation of the urban mine that is CDW;
  - further refinement and adaptation of the business cases to lagging member states.

- **Would you like a similar workshop to be organised about other business models?**

Respondents indicated that the notion of exploring further business models would be supported, specifying that particularly ceramics, gypsum, plastics and wood would be interesting. One respondent added that it would be of interest for addressing a waste stream as a whole.

10/ Main conclusions and discussion

In this chapter the main conclusions of the study are presented, building up a logic narrative augmented with the stakeholder input obtained via the validation workshop – stakeholders meeting. This discussion is supplemented by producing a much needed estimate of the costs of investment needed to reach both the WFD 70% recovery target, as well as the ambitions of the Circular Economy Package, for this the achievement of a 70% recycling (excluding backfilling) ambition is calculated.

10.1 Main conclusions

This study targets a novel approach – bridging the gap between financers/investors and entrepreneurs through innovative business cases, aiming to practically overcome barriers to CDW recycling through combining technical and management angles. The development of these business cases is an important step towards increasing CDW recycling infrastructure in Europe. While not all possible materials and models are covered by this study, it certainly captures the most important ones in Europe and represents a useful tool (or set of tools) to move forward the possibilities for CDW recycling investment. The business cases and the underlying simulation tools in Excel format allow assessing the influence of various market and regulatory conditions that prevail in a particular Member State or region and therefore help to bridge the information gap that very often exists between entrepreneur and potential investor. Ultimately this may be instrumental in bridging the so-called 'valley of death' between entrepreneurial endeavour and financial investment. As such the confidence in and implementation of CDW recycling businesses can be improved across the EU MS.

It appears that the necessary legislation, technology and finance are available in order to foster the development of the necessary CDW recycling infrastructure which in turn contributes towards generating a circular economy. However, that being said, work remains to be done to bring these tools to fruition. Through implementation and enforcement of existing regulations, together with appropriate implementation of technologies and entrepreneurship, improved recycling in favour of a circular economy can be brought into reach. Therefore it is critical that the relevant legislation, quality assurance systems for recycled materials and green public procurement are being implemented in the Member States lagging behind on the recycling of CDW waste. CDW recycling is indeed a challenging business that relies on stability and an appropriate business environment in order to remain viable and is easily threated by elastic and locally variable conditions.

Through EFSI and InnovFin, the EIB presents clear opportunities to address the finance gap faced by CDW recycling infrastructure. While the size and specificities of investment continue to be a hurdle, promoters are encouraged to explore specific examples of finance opportunities together with EIB advisors on a case by case basis. Possibilities for clustering of activities, blending of financial instruments and intermediated finance present possible and viable solutions. For EFSI the aim is to leverage and de-risk private capital, targeting so-called mid-cap companies with up to 3000 employees as well as small companies of less than 250 employees which can also apply with typical lending amounts between EUR 7.5 and 25 million. InnovFin targets very specifically projects that are oriented towards innovation and research with clear criteria to be met. Guarantees are also offered via EFSI and InnovFin funds and offer risk sharing opportunities. Indirect financing available via the EIB typically takes form through third party banks in support of the EIB. This means that dedicated financing lines are initiated towards bank, which is used for on-lending at reduced interest rate to 'eligible' SMEs and Mid-Caps with reduced EIB scrutiny at the project level and rather at the on-lending level.

With regard to EFSI 2.0 it is important however that the criterion of **additionality** is to be met, both from a financial point of view and from a market point of view. The criterion of additionality is essentially related to the existence of a **market failure**. Without a market failure or the existence of a sub-optimal investment situation at the local or regional level, the additionality of government funding and instruments would be (virtually) zero since the required resources could be provided by the private sector anyway. Therefore additionality remains an important condition for accessing EFSI and InnovFin funding. In other words it always remains to be proven that without the EFSI or InnovFin funding no investments would have been done, thereby avoiding what otherwise could have been taken up by local financial market players. In this respect it is worth pointing at cross-border CDW projects that typically have to deal with multiple standards and regulations of the regions in their market, and therefore might face cost disadvantages, yet benefits as well. Therefore the additionality needs to be assessed on a case by case basis. In the case of developing an entirely new CDW recycling value chain, starting from selective deconstruction and including niche models such as gypsum recycling and brick re-use, while establishing new mobile or stationary mixed CDW recycling installations, EFSI and InnovFin funding are particularly instrumental. This is especially the case in Member States where recycling has not yet emerged and where the market failure is apparent given the level of implementation of accompanying legislative and regulatory measures, and where additionality has the potential to be substantial.

The role of the public partner is to create the market conditions under which the CDW recycling market can flourish through legislation, appropriate quality assurance mechanisms and green public procurement, among others. While legislation is clearly in place, further roles for legislation are related to the enforcement of existing legislation, the introduction of further possible landfill bans (and related prices for landfilling) to favour recycling activities as well as the use of specific recycling targets (versus recovery targets) in line with the circular economy ambitions, perhaps at the level of the specific waste stream. The public partner also plays a key role in the development of quality assurance means in recycled materials through certification procedures, the introduction of material standards. The public partner has a non-monetary, yet material role in the provision of land, operational permits, waste collection infrastructure and the overall organisation of the value chain and recycling activities in order to support the transition towards more positive trends. Furthermore, the role of green public procurement must be recognised and strengthened with regards to example setting in the use of recycled materials in construction works.

Beyond finance, CDW recycling faces key barriers, including appropriate quality assurance practices related to recycled materials as well as the comparative price of primary versus secondary materials. Firstly, the lack of trust in secondary materials that still stands as a hurdle to the adoption of secondary materials, to both designers and architects as well as construction companies and contractors. Tools for traceability, quality control, as well as better control of hazardous materials could ease the path to adoption of secondary materials. Selective deconstruction can be seen as an essential activity in the CDW recycling value chain supporting quality control issues. In addition, the adoption of recycled materials also faces competition through the comparably low price of primary materials. While it is apparent that the price of primary raw materials depends highly on natural, local availability of materials, this study concludes that with the appropriate implementation of existing legislation and adequate accompanying measures such as landfill bans, quality control, traceability systems, certification CDW recycling has economic potential not only in the leading Member States, as is today, but especially in the Member States that are lacking ambition towards the maintaining the value of CDW at the end of life through recycling.

10.2 Estimated cost of investment for CDW recycling

The CEAP highlights the role of recycled materials in achieving a circular economy. CDW, as one of the bulkiest waste streams in Europe by volume, as well as a high potential for recycled material production and uptake, requires further investment in infrastructure in order to secure higher recycling rates. At present Europe does not have sufficient recycling infrastructure to support CDW recycling to reach its maximum potential recycling rates.

Assessing the cost of investment can help to bring into perspective the overall investment need associated with CDW recycling. Based on the information gathered in this study and the elaborated business cases we estimate how much CDW recycling is still needed to reach that 70% recovery target at EU level as well as a proposed target ambition in line with the Circular Economy Package assuming 70% recycling of CDW (without backfilling) as a target. Evidently the elaborated business plans that resulted from the business cases developed in this study are instrumental in reaching that target in the foreseeable future.

10.2.1 Statistical analysis of CDW waste generated

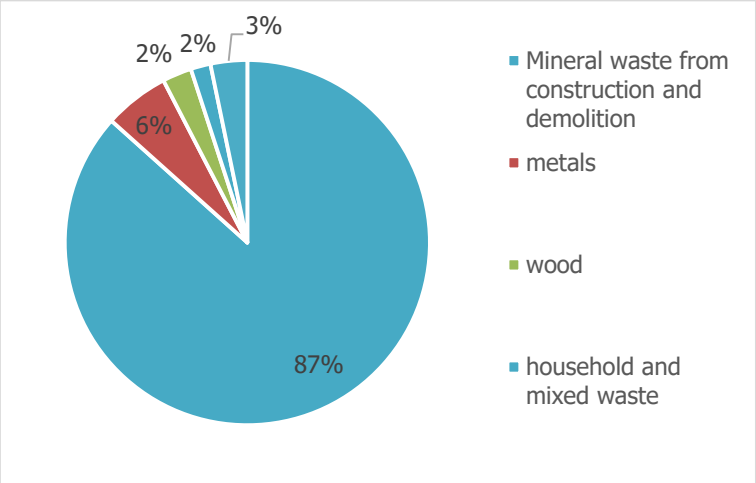
Statistics can be presented for the construction sector as well as the waste stream and can vary depending on the specific waste streams considered. The construction and demolition sector as a whole generated 859 million tonnes of waste in 2014, however taking into consideration only mineral waste from construction and demolition, metals, wood, household and mixed waste and other excluding soils and dredging spoils, which cannot be identified as construction and demolition waste, the construction and demolition sector generated 337 million tonnes, of which mineral construction and demolition waste is by far the most important fraction, representing 87% of the total. The precise numbers are found in Table 8, with a graphical representation in Figure 32.

Table 8: Overview of quantities of waste by type in tonnes (excluding soil and dredging spoils)

Quantities of waste by type	Tonnes of waste
Mineral waste from construction and demolition	291 730 000
Metals	19 430 000
Wood	8 730 000
Household and mixed waste	5 930 000
Other	10 930 000

Source: Eurostat

Figure 32: Specific waste generation by type in the Construction sector (excluding soil and dredging spoils)



To analyse compliance with the 70% recovery target, we take into account this big fraction of mineral wastes, assuming that valuable fractions like metals already achieve high recycling percentages and neglecting the other small fractions.

Based on the existing Eurostat data different strategies can be applied to assess the level of compliance. Following data are collected:

- The total amount of waste generated by the construction sector (database [env_wasgen]) includes soils and dredging spoils, largely biasing the figure.
- The total amount of "mineral waste from construction and demolition" is a better indicator included in database [env_wasgen]. We prefer statistics from the whole economy above statistics from only the construction sector. The construction sector generates 95% of the total amount of construction and demolition waste. This figure may be an underestimation because it only covers waste classified as CDW and excludes CDW fractions of mixed waste.
- The total amount of "mineral waste from construction and demolition" that is treated in a Member State is retrieved from database [env_wastrt]. This represents the total amount collected for treatment and may include import although import and export of CDW is limited.
- Data for recycling of "mineral waste from construction and demolition" is retrieved from database [env_wastrt]. Both the figures for pure material recycling and for material recycling including backfilling are retrieved.

The analysis is made comparing "mineral waste from construction and demolition" from the whole economy [env_wasgen] with the figure for recycling of mineral CDW [env_wastrt]. This figure is not consistent for all Member States, while recycling figures sometimes supersede estimated market size figures.

The analysis can also be made comparing "mineral CDW collection" figures from [env_wastrt] with "mineral CDW recycling figures from the same data source. This outcome may be an underestimate in case [env_wasgen] reports more generation than [env_wastrt].

To avoid both problems we compared the waste recycling figure with the highest waste generation figure, reported either in [env_wasgen] or [env_wastrt].

When we add backfilling to material recycling, following Member States are non-compliant to the recovery target of 70%: Belgium, Greece, Spain, France, Croatia, Cyprus, Latvia, Portugal, Romania, Slovakia and Sweden. In total 491,476,461 tonnes of CDW is recycled and 10,965,867 tonnes of CDW needs to be recycled in addition based on Eurostat statistics from 2014.

When we take into account only pure material recycling, following Member States do not meet a level of ambition that is in line with the Circular Economy Package, which is hereby estimated at 70% recycling: Belgium, Czech Republic, Ireland, Greece, Spain, France, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Portugal, Romania, Slovakia and Sweden. In total 458,082,634 tonnes of CDW are currently recycled and 16,782,668 tonnes of CDW needs to be recycled based on Eurostat statistics from 2014.

10.2.2 Analysis based on assessed CDW estimated market size

Due to the apparent inconsistencies in the figures on CDW generation in [env_wasgen] and [env_wastrt] and to count for CDW that gets mixed up with and reported as mixed waste, we propose an alternative method of assessing both the CDW generation and the percentages recovered and recycled.

In order to estimate the size of the market in tonnes, we have taken the tonnes/capita of a Member State with a nearly full collection coverage as a benchmark, namely the Netherlands (1218 kg/capita) and we have then multiplied this with the number of inhabitants in each Member State. Limitations of this estimation should of course be kept in mind, as this assumes that all Member States generate a similar amount per capita as the Dutch, which is of course not the case. However, it provides an indication for the ratio between the CDW generated and collected.

When using this approach most member States do not yet comply with the 70% recovery target, nor with a 70% recycling ambition in line with the Circular Economy Package. In total 620 million tonnes CDW is the estimated market size, which is about double than the reported quantities. 246 million tonnes is recovered, whereas 229 million tonnes is submitted to material recycling. Considering recovery, a supplementary 195 million tonnes needs to be recovered. Considering waste submitted to material recycling, a supplementary 210 million tonnes needs to be recycled.

We cannot however assume that construction and demolition activities are at the same level as in the Netherlands for all member States. We therefore calculate an index based on turnover of the construction sector per capita with The Netherlands = 1. This index is used to adapt the formula to assess estimated market quantities as follows:

(1) $$\textbf{\textit{Estimated CDW market in a Member State}} = 1218 \frac{\text{kg}}{\text{inhabitant}} * \text{index} * \text{demography}$$

In conclusion, the sum of estimated adjusted market of CDW is 410 million tonnes, which is 33% more than the reported quantities. 229 million tonnes submitted to material recycling, 246 million tonnes is recovered for which a supplementary 73 million tonnes needs to be recycled. Without backfilling a supplementary 82.5 million tonnes needs to be recycled.

10.2.3 Expected volume of CDW

Although the second approach is not based on actually reported data but on estimates that supersede the reported quantities with 33%, we assess this approach to be more reliable as it takes into account the estimated market size of CDW, independent of whether it is identified and reported as CDW. In addition, it is also more robust towards outliers in the reported statistics. Taking into account a sufficient level of caution, we assess that 73 million tonnes of CDW needs to be recovered in addition in order to reach the 70% recovery target in each Member State.

To perform the same calculation for the ambition of recycling 70% of CDW, 82.5 million tonnes are the targeted additional recycling volume.

10.2.4 Expected cost of investment

More investment in CDW recycling structure is needed in order to elevate recycling rates of CDW. Based on a set of assumptions and the data generated in the previous section, we can extrapolate an estimate of cost to reach both the 70% recovery target as well as the 70% recycling ambition in the EU using three scenarios both targeted towards 2020. The assumptions associated to this calculation include:

- shifts in treatment from disposal to recycling only, using mobile or stationary mixed CDW facilities
- waste that is predominantly mineral waste from C&D activities (see Figure 32)
- no increased quantities of CDW generated in 2020 compared to 2014
- stagnation of backfilling, assuming only recycling moving forward, where both calculations present only the cost of recycling moving forward
- quantity of waste calculation as indicated in the estimated market size calculation and analysis (see 10.2.2 and 10.2.3)
- the predominantly appropriate facilities to be either mobile or stationary mixed CDW facilities or both
- fixed costs for mobile and stationary mixed CDW as indicated in Table 9

Table 9: Indication of cost per type of facility for CDW recycling

Type of facility	**Capacity per year** (after at least two years of activity, less in first two years)	**Cost per year**
Mobile Mixed CDW Processor	115,000 tonnes per year	Cost equipment: EUR 990,000 Cost land, infrastructure, building: EUR 180,000 **Total cost: EUR 1,170,000**
Stationary Mixed CDW Processor	200,000 tonnes per year	Cost equipment: EUR 2,000,000 Cost land, infrastructure, building: EUR 1,000,000 **Total cost: EUR 3,000,000**

Source: IDEA Consult

According to the data from the year 2014, a supplementary amount of 73,000,000 tonnes need to be recovered per year in order to reach the 70% recovery target (see 10.2.2 and 10.2.3 for further details on the calculation).

Three scenarios, (i) mobile CDW facility only investments, (ii) stationary mixed CDW facility investments and (iii) both mobile and stationary mixed investments can be applied in order to assess the possible range of cost to reach the 70% recovery target.

This results in an estimated cost of in CDW recycling infrastructure of:

- Scenario 1: mobile mixed CDW recycling facilities only: EUR 742,700,000
- Scenario 2: stationary mixed CDW recycling facilities only: EUR 1,095,000,000
- Scenario 3: both mobile and stationary mixed CDW recycling facilities: EUR 918,900,000

Table 10: Indication of cost per scenario of CDW to reach 70% recovery target[60]

Scenario	Mobile Mixed CDW Processor	Stationary Mixed CDW Processor
Scenario 1: Only Mobile Facilities	**Number of facilities needed: 635** Total Cost equipment: EUR 628,400,000 Cost land, infrastructure, building: EUR 114,300,000 **Total Cost: EUR 742,700,000**	Number of facilities: None
Scenario 2: Only Stationary Facilities	Number of facilities: None	**Number of facilities needed: 365** Total Cost equipment: EUR 730,000,000 Cost land, infrastructure, building: EUR 365,000,000 **Total Cost: EUR 1,095,000,000**
Scenario 3: 50/50 Split between Mobile and Stationary facilities	Number of facilities needed: 317 Total Cost equipment: EUR 314,200,000 Cost land, infrastructure, building: EUR 57,100,000	Number of facilities needed: 183 Total Cost equipment: EUR 365,000,000 Cost land, infrastructure, building: EUR 182,500,000
	Total cost for mobile & stationary facilities: EUR 918,900,000	

Source: IDEA Consult

Similarly, according to the data from 2014, in order to achieve a level of 70% recycling in line with the Circular Economy Action Plan, an additional 82,500,000 tonnes need to be recycled (see 10.2.2 and 10.2.3 for further details on the calculation). This elevated number as compared to the first calculate above arises from the fact that current recovery practices such as backfilling are excluded in the current treatment options. Using the same scenarios, the estimated cost of in CDW recycling infrastructure to obtain an overall 70% ambition in line with the CEAP would entail:

- Scenario 1: mobile mixed CDW recycling facilities only: EUR 839,400,000
- Scenario 2: stationary mixed CDW recycling facilities only: EUR 1,237,500,000
- Scenario 3: both mobile and stationary mixed CDW recycling facilities: EUR 1,038,400,000

These results are also depicted in Table 11.

[60] Figures are rounded to hundreds of thousands

Table 11: Indication of cost per scenario of CDW to reach overall 70% recycling ambition[61]

Scenario	Mobile Mixed CDW Processor	Stationary Mixed CDW Processor
Scenario 1: Only Mobile Facilities	**Number of facilities needed: 717** Total Cost equipment: EUR 710,217,391 Cost land, infrastructure, building: EUR 129,130,435 **Total Cost: EUR 839,400,000**	Number of facilities: None
Scenario 2: Only Stationary Facilities	Number of facilities: None	**Number of facilities needed: 413** Total Cost equipment: EUR 825,000,000 Cost land, infrastructure, building: EUR 412,500,000 **Total Cost: EUR 1,237,500,000**
Scenario 3: 50/50 Split between Mobile and Stationary facilities	Number of facilities needed: 359 Total Cost equipment: EUR 355,108,696 Cost land, infrastructure, building: EUR 64,565,217	Number of facilities needed: 206 Total Cost equipment: EUR 412,500,000 Cost land, infrastructure, building: EUR 206,250,000
	Total cost for mobile & stationary facilities: EUR 1,038,400,000	

[61] Figures are rounded to hundreds of thousands

1/ Annex 1: Final Questionnaire for Interviews in Task 1 & 2

QUESTIONNAIRE TASK 1

Version 01/06/2017

Interview date: Click here to enter a date.

1

PART 1: Letter of Support

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs

Industrial Transformation and Advanced Value Chains
Acting Head of Unit Clean Technologies and Products – Sustainable Construction

Brussels, 15. 05. 2017
GROW/C1/VB/elf

Letter of Introduction

To Whom It May Concern

Subject: **Letter of Introduction regarding the study 'Development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure'**

The European Commission is currently conducting an economic study with regard to 'the development and implementation of initiatives fostering investment and innovation in construction and demolition waste (CDW) recycling infrastructure'

This study fits within the ambitious Circular Economy Package that the European Commission has adopted (2nd December 2015) and will support the "Resource Efficiency Opportunities in the Building Sector" strategy: a better functioning market for recycled construction and demolition waste. One of the key issues for the development of recycling CDW and of the market for recycled construction material is the need for sufficient CDW recycling facilities.

Therefore, the aim of this study is to identify, list and analyse business models for CDW recycling infrastructure through the EU, capturing also the business context in which such facilities operate in order to develop business cases to foster development and investment. As a result, the study is expected to develop and elaborate a set of business cases that are exemplary in their nature for the planning and design of new CDW recycling facilities, especially in countries where recycling rates are currently below the minimum Waste Framework Directive target of 70%.

A consortium led by IDEA Consult, together with Arcadis, Ecorys, REC, DTI and VITO is conducting the study.

IDEA Consult nv, Kunstlaan – Avenue des Arts 1-2, b 16, B-1210 Brussels, Tel: +32 2 282 17 10, Fax: +32 2 282 17 15, www.ideaconsult.be, Dr. Valentijn Bilsen, Senior Expert and Team Leader Green Economy

Part of the study involves a series of interviews with relevant contacts from the national/regional government, economic operators, financial experts, academic experts and customer organisations.

Commission européenne/Europese Commissie, 1049 Bruxelles/Brussel, BELGIQUE/BELGIË - Tel. +32 229-91111
Office: BREY 10/226 - Tel. direct line +32 229-52743 - E-mail : vincent.basuyau@ec.europa.eu

2

The interviews aim to gather information on business models, the business context and also to help shaping the financial components of the business cases.

In order to envisage the best possible outcome an iterative stakeholder interaction process is proposed, as the views of stakeholders are extremely valuable for the study to provide a high added value to policy making in the EU.

We would therefore appreciate your cooperation and availability for participating in the interviews. Your contribution is essential for the consultants in delivering the qualitative analysis requested in the framework of the study. It will be an opportunity for you to make a direct contribution to the improvement of the CDW recycling facility development in Europe and the achievement of the Waste Framework Directive target.

The European Commission is fully aware that some of the information to be collected may be regarded as sensitive. Therefore, we would like to assure you that all the information collected during interviews will be treated as strictly confidential. In particular, the information provided by individual interviewees will not be shared by the consultants with any third party (including the Commission services) and any data included in reports will be presented in a way that prevents the identification of the

Should you need any clarification regarding the study, please do not hesitate to contact us (Vincent Basuyau, +32 2 295 27 43 - E-mail: Vincent.BASUYAU@ec.europa.eu).

We thank you in advance for your cooperation.

Sincerely yours,

p.o.

Fulvia Raffaelli

PART 2: Introduction

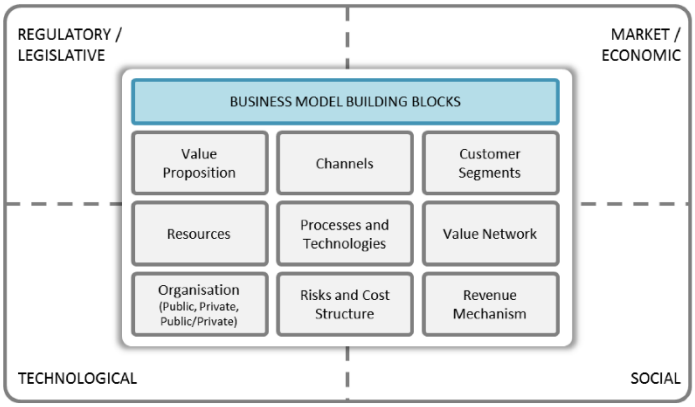
An essential part of this project is gathering evidence of existing business models that are currently used in the EU for CDW recycling facilities. This has not been done in a systematic way before, and therefore, as part of this project, we contact you to learn to know more about existing practices. The questionnaire is divided in two parts:

1) The various elements of the business model, and
2) The elements of business context.

Depending on your expertise we can start with the business model elements or that of the business context.

The various elements that we focus on for determining the business model and its context are depicted in Figure 1. Each of these elements will be inquired about in the following set of questions.

Figure 1: Conceptual elements of a business model and its context



PART 3: Questionnaire

0/ Generic information

0.1.1 ***Interviewee***

Name:

Organisation/company:

Contact address:

E-mail:

0.1.2 ***Interviewer***

Name:

Organisation/company:

E-mail:

0.1.3 *In case that you feel that other people within your organization or outside it are better placed to answer particular questions, could you please indicate whom we should contact?*

Click here to enter text.

0.1.4 *Would you be willing to participate in a short on-line questionnaire end of June, beginning of July to express your views on particular aspects of business model evidence found?*

Click here to enter text.

0.1.5 *Would you be willing to participate in the Stakeholders' Workshop 16th of November in Brussels, with the aim to validate the insights and findings in cooperation with the European Commission?*

Click here to enter text.

0.1.6 *As an introductory question, could you shortly indicate what have been the key driving factors for success of your company and what are the main obstacles, if any?*

Click here to enter text.

1/ Questions on Business Models

CLIENTS

Value Proposition

1.1 *(priority)* Value Proposition *(10 minutes)*

1.1.1 *(priority)* ***Which products and/or services are offered?***

Click here to enter text.

1.1.2 *What are the main benefits for the customers through these products and/or services?*

Click here to enter text.

1.1.3 *What are the main benefits for environment and society through these products and/or services?*

Click here to enter text.

Customer Segments

1.2 *(priority)* Customer segments and clients *(10 minutes)*

1.2.1 *(priority)* ***Which groups of customers does the company serve? (Customers are grouped or segmented based on similarity of customer needs)***

Click here to enter text.

1.2.2 *(priority)* ***Can you make a rough estimate how much percent of your revenue is generated in each of these segments?***

Click here to enter text.

Channels

1.3 Channels *(5 minutes)*

1.3.1 *How does the company bring the above mentioned value propositions physically to its customers?*

Click here to enter text.

1.3.2 *(priority)* ***Which sales channels does the company adopt to identify and engage with (potential) customers?***

Click here to enter text.

1.3.3 *(priority)* ***Which channels does the company adopt to identify and engage with (potential) suppliers of CDW?***

Click here to enter text.

6

FINANCIAL

Revenue Mechanism

1.4 *(priority)* Revenue Mechanism *(7 minutes)*

1.4.1 *How does the company generate revenue from its offering? (please **bold** what applies)*

a. By selling output material per tonne
b. By charging customers a service fee per tonne of input material
c. By charging customers a service fee per hour performed by your company
d. Other: Click here to enter text.

1.4.2 *Could you please indicate a rough percentage distribution of the income of your company over the main revenue categories?*

Click here to enter text.

1.4.3 *How profitable is the company? If your company has different activities, could you please compare approximately the profitability of the main activities?*

Click here to enter text.

Risks and Cost Structure

1.5 Risks and Cost Structure *(10 minutes)*

1.5.1 *What are the main risks in the business model for the company? How do you control these risks?*

Click here to enter text.

1.5.2 *Please indicate what are the main costs for the company to create, deliver and capture value?*

Click here to enter text.

1.5.3 *If you consider the total cost of treating a tonne of input material, what percentage would be related to:*

Labour:	Click here to enter text. %
Equipment, machinery and rolling stock:	Click here to enter text. %
Energy:	Click here to enter text. %
Materials and feedstock:	Click here to enter text. %
Waste disposal costs:	Click here to enter text. %
Other (please specify):	Click here to enter text. %

1.5.4 *What are the investments required to start a business such as your own and could you give an estimate of the capital requirements distributed over the main categories:*

Labour:	Click here to enter text.€
Equipment, machinery and rolling stock:	Click here to enter text.€
Land:	Click here to enter text.€
Buildings:	Click here to enter text.€

STRATEGY

Organisation (Public, Private, Public/Private)

1.6 *(priority)* Organisation *(5 minutes)*

1.6.1 *What is the type of organisation (public / private or public-private partnership)?*

Click here to enter text.

1.6.2 *What is the size of the company (number of employees, revenue and total asset value)?*

Click here to enter text.

1.6.3 *Please indicate the number of employees for each of the following categories (approx.):*

Blue collar workers:	Click here to enter text.
Administrative jobs:	Click here to enter text.
Management:	Click here to enter text.
Engineers, researchers:	Click here to enter text.

1.6.4 *What is the company's VAT number?*

Click here to enter text.

1.6.5 *Who are the owners of the organisation? (please **bold** selection)*

a. Individual entrepreneurs and management
b. Group of private shareholders not involved in daily operations
c. Banks and financial institutions
d. Venture capitalists, business angels
e. Listed on the stock exchange
f. Part of a larger group or integrated businesses (please tick what applies)
   i. The group is a construction business
   ii. The group is a business producing construction materials
   iii. The group is a business specialised in waste management
g. Local or central authorities,
h. Part of a Public Private Partnership

1.6.6 *Could you please briefly describe how your organization has evolved over the years in terms of ownership structure and main activities?*

Click here to enter text.

Processes and Technologies

1.7 Processes and Technologies *(10 minutes)*

1.7.1 *(priority)* ***Which waste management strategies are applied by the company?*** *(please **bold** selection)*

a. sorting and selling to downstream partners in the value chain, processing for re-use,
b. material recycling for the same purpose,
c. material downcycling for other purposes,

8

d. material upcycling for higher quality purposes,
e. energy recovery,
f. disposal

1.7.2 *(priority)* ***Which process steps are being carried out by the company?***

Click here to enter text.

1.7.3 *(priority)* ***How integrated are the different process steps?***

Click here to enter text.

1.7.4 *(priority)* ***Which technologies does the company apply?***

Click here to enter text.

1.7.5 *To which technological standards do the company's products comply? (please **bold** selection)*

a. an upgraded waste for further treatment,
b. a lower quality construction and demolition product,
c. an equal value construction and demolition product,
d. a raw material discernible/non-discernible from primary raw materials,
...

1.7.6 *(priority)* ***Which waste streams are being processed by the company and which volumes of different material fractions did your company process last year? What are the recycling percentages for each of the material fractions? (approximately). Codes in () refer to chapter 17 of the European Waste List – CDW section (please bold selection)***

Types of material	Tonnes of waste	% of which recycled
Concrete (170101):	Click here to enter text. tonnes	Click here to enter text. %
Bricks (170102):	Click here to enter text. tonnes	Click here to enter text. %
Tiles and ceramics (170103):	Click here to enter text. tonnes	Click here to enter text. %
Wood (170201)	Click here to enter text. tonnes	Click here to enter text. %
Glass (170202):	Click here to enter text. tonnes	Click here to enter text. %
Plastics (170203):	Click here to enter text. tonnes	Click here to enter text. %
Bituminous mixtures, containing coal tar (170301*):	Click here to enter text. tonnes	Click here to enter text. %
Other (non-hazardous) bituminous mixtures (170302):	Click here to enter text. tonnes	Click here to enter text. %
Iron and steel (170407):, of which recycled:	Click here to enter text. tonnes	Click here to enter text. %
Non-ferrous metals (170401-170406):	Click here to enter text. tonnes	Click here to enter text. %

9

Types of material	Tonnes of waste	% of which recycled
Cables containing oil, coal tar or other dangerous substances (170410*):	Click here to enter text. tonnes	Click here to enter text. %
Other (non-hazardous) cables (170411):	Click here to enter text. tonnes	Click here to enter text. %
Soil and stones containing dangerous substances (170503*):	Click here to enter text. tonnes	Click here to enter text. %
Other (non-hazardous) soil and stones (170504):	Click here to enter text. tonnes	Click here to enter text. %
Insulation materials containing asbestos (170601*):	Click here to enter text. tonnes	Click here to enter text. %
Other insulation materials consisting of or containing dangerous substances (170603*):	Click here to enter text. tonnes	Click here to enter text. %
Other (non-hazardous) insulation materials (170604):	Click here to enter text. tonnes	Click here to enter text. %
Construction materials containing asbestos (170605*):	Click here to enter text. tonnes	Click here to enter text. %
Gypsum based construction materials contaminated with dangerous substances (170801*):	Click here to enter text. tonnes	Click here to enter text. %
Gypsum based construction materials not contaminated with dangerous substances (170802):	Click here to enter text. tonnes	Click here to enter text. %
Construction and demolition wastes containing PCB (e.g. PCB-containing sealants, PCB-containing resin based floorings, PCB-containing sealed glazing units, PCB-containing capacitators) (170902*):	Click here to enter text. tonnes	Click here to enter text. %
Other construction and demolition wastes (including mixed wastes) containing dangerous substances (170903*):	Click here to enter text. tonnes	Click here to enter text. %
Mixed construction and demolition wastes (170904):	Click here to enter text. tonnes	Click here to enter text. %
Other : please indicate List of Waste code from chapter 17 or from other chapters):	Click here to enter text. tonnes	Click here to enter text. %

Resources

1.8 Resources *(5 minutes)*

1.8.1 Which strategic resources contribute to the company's competitive advantage? (e.g. intellectual property, customer relations, first mover advantage)

Click here to enter text.

10

1.8.2 What is the company's unique selling proposition in comparison to its competitors? (e.g. market knowledge, qualification to deliver certified output materials, legal compliance, …)

Click here to enter text.

1.8.3 What is the company's unique buying proposition in comparison to its competitors? In other words: why do providers of CDW deliver their materials to you instead of to other competitors?

Click here to enter text.

Value Network

1.9 Value Network *(5 minutes)*

*1.9.1 What are the partners upstream and downstream the company value chain? Please indicate the relevant types of activity and services, if possible who they are and why they are important for you. (please **bold** selection)*

	Whom?	Why?
Technology partners:	Click here to enter text.	Click here to enter text.
Transportation companies:	Click here to enter text.	Click here to enter text.
Demolition companies:	Click here to enter text.	Click here to enter text.
Actors influencing the purchase decisions of customers:	Click here to enter text.	Click here to enter text.
Specialised service providers:	Click here to enter text.	Click here to enter text.
Other:	Click here to enter text.	Click here to enter text.

1.9.2 Are actors involved that operate in another country or Member State and if so for which activities and which countries?

Click here to enter text.

1.9.3 If relevant, in which manner do cross -border effects play a role in the value network? Please explain.

Click here to enter text.

2/ Questions on the Business Context

REGULATORY / LEGISLATIVE

2.1 Legislative & regulatory

2.1.1 Which landfill taxes are applicable?

Click here to enter text.

2.1.2 Which specific regulations apply to the input material, the processes or to the output material? (e.g. local regulations related to selective demolition, end-of-waste criteria, sorting obligations, separate collection,…)

Click here to enter text.

2.1.3 Are (fractions of) CDW submitted to legal extended producer responsibility schemes or to other, voluntary take-back schemes? (e.g. floor coverings, PV installations, PVC …)

Click here to enter text.

2.1.4 Which specific qualifications are required by the company to carry out the processes described in 1.5.1? (e.g. qualification criteria for demolition companies, permits, licenses, registrations)

Click here to enter text.

MARKET / ECONOMIC

2.2 Market & economic

2.2.1 Which alternatives are available for customers at what price?

Click here to enter text.

2.2.2 Which competitors are active in the markets in which the company is active and what are their unique selling propositions?

Click here to enter text.

2.2.3 Describe the supply of CDW: how many tons of which types of materials are expected to become available over the next years?

Click here to enter text.

2.2.4 Describe the demand of the output materials of the company (e.g. demand for secondary materials, reusable construction elements), what are your expectations for the coming years?

Click here to enter text.

TECHNOLOGICAL

2.3 Technological

2.3.1 What is your view on which technologies are available or are expected to become available related to CDW processing? For instance:

a. High-grade recycling,
b. Enhanced landfill mining,

12

c. Extended selective deconstruction
d. Others: Click here to enter text.

2.3.2 What do you expect to be the influence on your business of these new technologies?

Click here to enter text.

2.3.3 Which technologies are available or are expected to become available related to matching supply and demand?

a. Online platforms,
b. Clearinghouse systems,
c. Others: Click here to enter text.

2.3.4 How will this influence your business?

Click here to enter text.

2.4 Social

2.4.1 What are in your view crucial social conditions for promoting CDW recycling?

Click here to enter text.

2.4.2 Is there a sufficiently skilled workforce available?

Click here to enter text.

2.4.3 How does the specific social context in which the CDW facility is situated influence its acceptance by neighbouring communities?

Click here to enter text.

2.4.4 How could the purchasing power of social groups or of the society as a whole influence the demand for secondary materials?

Click here to enter text.

2.4.5 In your view is the CDW recycling business (model) able to generate jobs for specific target groups such as unskilled labour, long-term unemployed?

Click here to enter text.

2/ Annex 2: Stakeholders consulted

Country / Type	Economic operator	First Name	Last Name	Affiliation
Belgium (Pilot country)	No	Koen	De Prins	OVAM Flemish Waste agency
Belgium (Pilot country)	No	Johny	De Nutte	COPRO
Belgium (Pilot country)	No	Ansy	Poelman	Flemish Builders Confederation (VCB)
Belgium (Pilot country)	Yes	Maarten	Hendriks	New West Gypsum
Belgium (Pilot country)	Yes	Gene	Maertens	CEO Top-mix
Belgium (Pilot country)	Yes	Annelies	Van den Eynde	Tracimat
Belgium (Pilot country)	Yes	Jeroen	Verlinden	NV Jan Stallaert
Belgium (Pilot country)	No	Willy	Goossens	Belgian Federation of Recycled granulates producers
Belgium (Pilot country)	Yes	Stefan	Carmans	Director Carmans
Belgium (Pilot country)	Yes	Guy	Geerts	Adams-Polendam
Czech Republic	No	Miroslav	Škopán	ARSM (Association for building waste recycling)
Czech Republic	Yes	Alexandr	Bolcek	AB Metal Recycling s.r.o.
Czech Republic	Yes	Aleš	Pražák	DEKONTA, a.s.
Denmark	Yes	Henrik	Lund-Nielsen	Gypsum Recycling
Denmark	Yes	Claus	Juul Nielsen	Gamle Mursten (Old Bricks)
Denmark	Yes	Jørn	Knudsen	Aage Vestergaard Larsen A/S
France	No	Christine	Marlet	EuroGypsum
France	Yes	Jean-Luc	Ritleng	Ritleng revalorisations
France	Yes	Mark	Tomlinson	Lafarge Holcim
France	Yes	Thomas	Guillot	Lafarge Holcim
France	Yes	Laurene	Guardiola	Lafarge Holcim
Germany	No	Stefan	Schmidmeyer	Baustoff Recycling Bayern e.V.
Germany	No	Jasmin	Klöckner	Bundesvereinigung Recycling Baustoffe e.V.
Germany	Yes	Berthold	Heuser	Remex
Italy	No	Giorgio	Bressi	ANPAR (National Association of Recycled Aggregates Manufacturers)

Country / Type	Economic operator	First Name	Last Name	Affiliation
Italy	Yes	Paolo	Barbieri	Eco Logica 2000
Italy	Yes	E	Perotta	UNIRECUPERI srl
Malta	No	Darren	Cordina	Environment & Resources Authority
Malta	Yes	Mary	Gaerty	Green Skip Services Ltd.
Malta	Yes	Doris	Sammut	Green Skip Services Ltd.
Netherlands	No	Geert	Cuperus	Federation International du Recyclage
Netherlands	No	Dick	Hoogendoorn	Vereniging Afvalbedrijven, the Dutch waste management industry federation
Netherlands	Yes	David	Heijkoop	Bentum recycling/Reko BV
Poland	No	Ursyula	Pawlak	Department of Waste Management and Integrated Permits, Mazovian Regional Council, Poland
Poland	No	Agnieszka	Jakubowska	Miejskie Przedsiębiorstwo Oczyszczania m.st. Warszawie
Poland	No	Agnieska	Kowalska	ASM Centrum Badań i Analiz Rynku
Poland	No	Ewa	Rozbicka	Polish Ministry of Environment
Poland	Yes	N.	N.	PPUH "RADKOM" Sp. z o.o.
Portugal	Yes	N.	N.	GESAMB
Portugal	Yes	Susana	Lopes	Lipor
Romania	No	Gabriela	Vasiliu-Isac	Waste Department of the Ministry of Environment in Romania
Romania	No	Brandusa	Petroaica	National Environmental Protection Agency, Waste Management Department
United Kingdom	Yes	Eunan	Kelly	CDE Global Limited
United States	No	Wendy	White	Arcadis USA
Japan	No	Hiroshi	Tachikawa	Propharm
Expert Selective Deconstruction	No	Jan	Verbraeken	Arcadis Belgium
Financial Stakeholder	No	Christian	Schempp	EIB
Financial Stakeholder	No	Laura	Busato	EIB
Financial Stakeholder	No	Jonas	Byström	EIB

Country / Type	Economic operator	First Name	Last Name	Affiliation
Financial Stakeholder	No	Ruben	Monballieu	Gimv
Financial Stakeholder	No	Aymeric	Olibert	Green Desk Belgium & Innovation Hub Advisory Services CBB | Corporate & Public Bank, Belgium | BNP Paribas Fortis SA/NV
Financial Stakeholder	No	Quentin	Nerincx	Green Desk Belgium & Innovation Hub Advisory Services CBB | Corporate & Public Bank, Belgium | BNP Paribas Fortis SA/NV
Financial Stakeholder	No	Luca	Bertalot	EUROPEAN MORTGAGE FEDERATION – EUROPEAN COVERED BOND COUNCIL
Financial Stakeholder	No	Guy	De Ceuster	CEO, Belfius Lease
Financial Stakeholder	No	Sarunas	Stepukonis	Baltcap – a member of Invest Europe

3/ Annex 3: Legislative framework for selected countries

Given the fact that the regulatory conditions are an important co-determinant for having a thriving CDW recycling industry, an overview was made of the most relevant regulations for each of the selected Member States as an input to develop a typology of business contexts in the following stages of the study.

The Netherlands

The **Environmental Management Act** (Wet Milieubeheer - Wm)[62] is the legislative framework for environmental management in the Netherlands. It includes the order of preference for waste management, which is leading Dutch waste management in practice. The **Environmental Protection Act**[63] is one of the most important environmental law, includes some important principles, like for example: duty of care for waste; requirement of having an National Waste Management Plan; rules for delivery, receipt, transportation and collection of industrial waste; rules for international shipments of waste; giving minister the powers to make rules in the Municipal Waste Regulation; and prohibition of landfill. The **Decree on landfills and landfill bans** (Besluit stortplaatsen en stortverboden van afvalstoffen - Bssa)[64] sets criteria for the acceptance of waste at landfills and puts in place a landfill ban for a number of waste materials.

The Dutch **landfill tax** was introduced in 1995 with the primary aim to increase the financial attractiveness of alternatives to landfilling (i.e. recycling and incineration)[65]. On 1 January 2016 the waste disposal charge was fixed at 13.07 EUR per 1,000kg.[66] This rate applies to waste that goes to landfill or is incinerated. There is no charge on waste that is recycled.

There exist **extended producer responsibility schemes** for concrete (Greendeal Duurzaam Beton[67]) and for sustainable forest management (Greendeal duurzaam bosbeheer[68]). Both schemes are voluntary. In addition, a voluntary, non-legally binding **Dutch Demolition Code** has been established, which can be applied by contractors and customers in procurement procedures.[69]

The Netherlands' history of recycling CDW

Recycling of CDW in the Netherlands started in the 1980's. The main driver was the contaminated soil issue arising from landfills. In response, the Netherlands developed its Waste Hierarchy. The implementation of the new policy consisted of landfill bans and recycling targets. A national plan was developed for CDW by all stakeholders, assigning tasks and responsibilities to each stakeholder. A specific task for the recycling industry was the development of quality assurance schemes.

Recycling started off by relatively simple crushing of inert CDW into recycled aggregates. These were used for various applications, including what now is seen as "backfilling". Crushing of inert CDW has been the prime activity for many years. As also the landfilling of mixed CDW was prohibited, new plants for sorting of this material were started up. These plants recover materials such as wood, metals, plastics and inert materials. The residual fraction is partially used to produce a secondary fuel.

The quality of recycled aggregates improved over the years. Processes improved and so did quality control. For many years now, recycled aggregates are prescribed by the Ministry of Transport purely on the basis of its outstanding technical characteristics. The environmental quality is fully assured through certification schemes that include the requirements of the Soil Quality Decree. Increasingly, recycled aggregates are also used in the production of concrete. Recycling of asphalt has gone through a similar process. Nowadays, almost all asphalt is recycled into new asphalt.

[62] http://www.asser.nl/upload/eel-webroot/www/documents/national/netherlands/EMA052004.pdf
[63] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_The%20Netherlands_Factsheet_Final.pdf
[64] https://www.ecn.nl/publications/PdfFetch.aspx?nr=ECN-E--14-037
[65] https://research.vu.nl/ws/portalfiles/portal/2046179
[66] https://www.government.nl/topics/taxation-and-businesses/contents/environmental-taxes
[67] http://www.mvonederland.nl/publicatie/green-deal-verduurzaming-betonketen
[68] https://bewustmethout.nl/
[69] http://www.sloopcode.nl/site/media/Dutch_Demolition_Code_EN.pdf

Wood recycling is also frequent, although a main alternative outlet for wood is still biomass for power generation (energy recovery).

Recycling of several other materials has proven to be more difficult. These materials constitute smaller fractions of CDW and recycling of these fractions usually requires more input. Other materials, which are being recycled progressively are:

- Flat glass*:* A collection scheme exists for flat glass initiated by the glass industry and the glass can be delivered to collection points for free. PVC windows: A collection scheme exists for PVC windows and also these can be delivered for free to collection points.
- Gypsum*:* A few years ago an agreement was made between government and industry to make the Netherlands a leader of the recycling of gypsum. Gypsum is kept separate mainly in order to not affect the quality of recycling of inert CDW.
- PVC pipes*:* One recycler has developed a recycling process for PVC pipes. PVC is micronized in order to meet the requirements for use in new PVC pipes.
- Roofing material. Bitumen roofing material can be recovered and processed and used partly in new roofing constructions and partly in asphalt.

Source: European Panel Federation (EPF), 2016, http://www.fir-recycling.com/ in English (from the European Construction and Demolition Waste Management Protocol, European Commission)

Denmark

The Danish rules for CDW recycling are laid down in four legislative documents:

1) the **Environmental Protection Act no. 879 26/06/2010**[70], which put in place a permit obligation for recycling CDW that could contaminate the environment.

2) the **Statutory Order no. 1309/2012** on waste[71], defines what CDW fractions should be separated and obliges the companies dealing with CDW to always separate hazardous waste. Moreover, companies producing CDW must ensure that significant parts of their source-separated waste are prepared for reuse, recycled or used for other final material recovery.

3) the **Statutory Order no. 1662/2010** on recycling of residual products and soil in building and construction work and on the recycling of sorted, unpolluted CDW.[72]

4) **Circular of 15 July 1985** on the use of crushed asphalt in road-construction.[73]

Denmark makes use of a **tax on waste**, which covers not only landfill, but also incineration with and without energy recovery[74]. The current landfill tax in Denmark is DKK 475 per tonne (EUR 64 /tonne) and typical landfill fee for recyclable materials is around DKK 366 per tonne (EUR 49 /tonne)[75]. The taxation has promoted the development of recycling technologies and decreased the amounts to be landfilled[76]. Landfill of hazardous waste was formerly excluded from the tax but has since 2010 been integrated in the taxing system[77]. After 1.1.2015 where the taxes for the hazardous waste is the same as the regular landfill tax of DKK 475 per tonne[78].

Denmark does not have any legal **producer responsibility scheme** related to construction materials. However, since 2011 it has a **certification system for sustainable buildings** in place, the so called DGNB that is used by

[70] http://eng.mst.dk/topics/industry/environmental-inspection/danish-regulations/
[71] Ibid.
[72] Ibid.
[73] Ibid.
[74] http://ec.europa.eu/environment/enveco/taxation/pdf/ch10_landfill.pdf
[75] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Denmark_Factsheet_Final.pdf
[76] Ibid.
[77] Ibid.
[78] Ibid.

the Danish Green Building Council.[79] It covers the assessment of the whole life cycle of the building, including end-of-life and thereby CDW.

Germany

It is the federal government that is charged with regulating waste disposal related matters in Germany. The **Circular Economy Act (**Kreislaufwirtschaftsgesetz – KrWG)[80] is the main legislative document regulating the management of waste and promoting the circular economy. It includes the five-step waste management hierarchy, in line with the EU Waste Framework Directive (2008/98/EC). Moreover, it comprises a new provision, which makes a distinction between waste and by-products and it sets criteria for an element to qualify as a by-product. The Act also defines when a substance no longer qualifies as waste. The **Ordinance on the Management of Municipal Wastes** (Gewerbeabfallverordung)[81] also contains important elements for CDW management. It describes separation and requirements regarding the pre-treatment of CDW.

The **landfill taxes** for CDW in Germany differ from region to region[82]. There are no other economic instruments in place that would incentivise the market players to recycle CDW.[83] The table below shows the order of magnitude of the fees related to the disposal of CDW according to different LoW codes[84]:

LoW code	Description	EUR/t
170102	Bricks	8
170107 (Quality Class 1)	Mixtures of concrete, bricks, tiles and ceramics	15
170107 (Quality Class 2)		30
170107 (Quality Class 3)		60
170802	Gypsum-based construction materials	80
170605*	Construction materials containing asbestos	80
170904	Mixed construction and demolition wastes	148
170301*	Bituminous mixtures containing coal tar	On demand
170504	Soil and stones	On demand
170603*	Other insulation materials consisting of or containing hazardous substances	148

Source: http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Germany_Factsheet_Final.pdf

The CDW disposal costs **differ by region** and depend on the type of CDW.[85] Municipal recycling centres on average charge 1.50 to 3 EUR per commenced 10 litres of CDW. Private companies provide construction waste containers in different sizes[86]. The costs for CDW disposal amount to around 15 EUR per ton and a lump sum fee for the transport, which depends on the size of the container but is in the range of 75 to 150 EUR.

Germany does not have any legal **extended producer responsibility scheme** related to construction materials.[87]

Belgium

Belgium consists of three regions and each of them has their own waste legislation.

[79] http://www.dk-gbc.dk/english.aspx
[80] http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Abfallwirtschaft/kreislaufwirtschaftsgesetz_en_bf.pdf
[81] https://www.gesetze-im-internet.de/gewabfv/BJNR193800002.html
[82] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Germany_Factsheet_Final.pdf
[83] Ibid.
[84] http://www.lra-fo.de/site/2_aufgabenbereiche/Abfallwirtschaft/Abfallwirtschaft/infos_deponie/Preisliste-Bauabfaelle.pdf
[85] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Germany_Factsheet_Final.pdf
[86] Ibid.
[87] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Germany_Factsheet_Final.pdf

In Flanders Region, the three most important legislations on waste include the **Materials Decree of 2012** (Materialendecreet)[88], which implements the Waste Framework Directive and its implementation order **VLAREMA**[89], as well as **VLAREM**[90], which is the implementing decree of the environmental permit decree. VLAREM contains three parts, VLAREM I, II and III, each targeting different environmental aspects including waste management. The Materials Decree of 2012 sets landfill charges depending on the types of waste. The cost of deposit consists of the costs for operating the landfill and environmental taxes to be paid to the Flemish government.

In Wallonia Region, it is the **Waste Decree of 27 June 1996**[91], which sets the legislative framework for waste management. It was amended several times since 1996. The document obliges to sort waste in separate fractions that could be further recovered before landfilling.

In Brussels Capital Region, a codification of the existing legislative acts took place under so called **"Brudalex" (arrêté-cadre)** in January 2017. It provides the legal framework for switching towards the circular economy, reducing administrative burden and stimulating the selective collection and recycling of waste.

All the regions aim at reaching the minimum 70% recovery of CDW by weight of the quantities of non-hazardous waste from construction and demolition activities by 2020.

Belgium has one of the highest **landfill taxes** and landfill tax increases in Europe, combined with a landfill ban, which according to the EEA study[92] have effectively diverted waste from landfill to recycling. On the national level, the large increases in landfill taxes in Flanders and Wallonia have driven the levels of landfilling down from 11 % in 2001 to 1.2 % in 2010, while the incineration rate has remained relatively constant[93]. On a regional basis, both Flanders and Wallonia have introduced a landfill tax, while the Brussels Capital Region, which does not have a landfill infrastructure, pays landfill tax depending on which region waste is sent to.

Overview of landfill taxes for various waste streams is presented in the box below.

[88] https://navigator.emis.vito.be/mijn-navigator?woId=41707
[89] https://navigator.emis.vito.be/mijn-navigator?woId=264
[90] https://navigator.emis.vito.be/mijn-navigator?woId=263
[91] http://environnement.wallonie.be/legis/dechets/degen019.htm
[92] EEA, Municipal waste management in Belgium, 2013, https://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwiPq4m057rUAhUIaVAKHYgLB7MQFggtMAE&url=https%3A%2F%2Fwww.eea.europa.eu%2Fpublications%2Fmanaging-municipal-solid-waste%2Fbelgium-municipal-waste-management&usg=AFQjCNGsCbh2bS2MZTrY8qnjKLGTHIcCrw
[93] Ibid.

Landfilling of flammable waste	79.56 EUR/t
Landfilling of non-flammable waste	42.44 EUR/t
Incineration without permit	159.12 EUR/t
Landfilling of household waste that cannot be incinerated in an incinerator	21.22 EUR/t
Landfilling of flammable recycling residues	79.56 EUR/t
(some categories have a lower tax rate = compensation factor)	
Landfilling of non-combustible recycling residues	42.44 EUR/t
(some categories have a lower tax rate = compensation factor)	
Landfilling of dredging sludge on a specific site therefore permitted	0.11 EUR/t
Landfilling of residues from permitted treatment facilities of sewage sludge	3.19 EUR/t
Landfilling of residues from soil sanitation	3.19 EUR/t
Landfilling of sludge residues from the cleaning of sieving sand	3.19 EUR/t
Landfilling of inert waste	11.67 EUR/t
Landfilling of ore residues	5.31 EUR/t
Landfilling of iron oxide of waste from zinc production	5.31 EUR/t
Landfilling of gypsum or calcium chloride waste	1.07 EUR/t
Landfilling of immobilised non-flammable waste	24.40 EUR/t
Source: http://scp.eionet.europa.eu/publications/WP2012_1/wp/WP2012_1	

Belgium does not have any legal **extended producer responsibility scheme** related to construction materials, but it has voluntary extended producer responsibility schemes for plastic packaging waste[94], PVC from construction[95] and thermoplastics pipes[96].

France

The first French law that sets the definition of waste, defines waste producer responsibilities and specifies the provisions concerning waste disposal and materials recovery is the **Law of 15 July 1975 concerning Waste disposal and material recovery**.[97] There exist many more waste regulations in France and there are several that focus on the CDW waste:

1. **Law 2009-967 of 3 August 2009**[98] and **Law 2010-788 of 12 July 2010**[99] made it compulsory to conduct pre-audits on demolition sites.
2. **Law 2010-788 of 12 July 2010** made departmental CDW management plans mandatory.
3. **Decree n°2014-1501 of 12 December 2014**[100] made inert waste storage facilities (ISDI) part of the Installation Classified for the Protection of the Environment (ICPE) legislation from 1 January 2015, with the aim to improve the status consistency of waste storage facilities and make it easier to penalise illegal landfill.

The French **landfill tax** is made up of two elements[101]: 1) A tax on the operation of the landfill site. This tax is all inclusive and does depend on the environmental impacts of the facility but not on the quantity of waste received. It has to be paid each year by the landfill site operator and is calculated by multiplying a basic rate by a coefficient

[94] http://www.valipac.be/Belgique/publications/valipac-une-valeur-ajoutee-pour-entreprises-belges/files/assets/basic-html/page9.html
[95] http://www.recovinyl.com
[96] http://www.emso.be/recyclage.htm
[97] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000888298
[98] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000020949548&categorieLien=id
[99] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022470434
[100] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000029893716&categorieLien=id
[101] http://scp.eionet.europa.eu/publications/WP2012_1/wp/WP2012_1

depending on the problems that may be caused by the facility. 2) A tax depending on the quantity of waste received and the environmental impacts of the site. The rate of this tax is different for hazardous and non-hazardous waste. The tax on non-hazardous waste was created on 1 January 1999. In 2015, landfill tax for "non-authorised" landfills was 150 EUR per tonne; for "authorised" landfills: 40 EUR per tonne; "authorised + ISO 14001": 32 EUR per tonne and minimum energy recovery 75%: 20 EUR per tonne.[102]The charges vary by municipality.[103] The landfill tax for CDW in France is about 6 EUR per tonne[104].

France does not have any legal **extended producer responsibility scheme** related to construction materials.[105] However, it has legal producer responsibility schemes for example for WEEE and batteries and accumulators, which might be found on construction or demolition sites. Furthermore, France has **industry sustainability standards**, as well as **public sector sustainability standards** that cover CDW.[106]

Mineral waste traceability in the French construction industry

In France, any waste producer or waste holder is responsible for waste management until its disposal or final recovery, even when waste is transported to a specialised facility in order to be treated. The French regulation requires that waste producers provide a document specifying the transportation of waste from their production site and the nature of the waste. This document must be provided before it can enter waste treatment facilities that accept non-hazardous inert waste. Producers of recycled aggregates choose to implement a waste traceability system at their treatment facilities. This traceability ensures the quality of treatment and enables users to be informed of possible uses of recycled aggregates from waste, taking into account environmental and geotechnical criteria.

Source: Cerema, 2016 (from the European Construction and Demolition Waste Management Protocol, European Commission)

Italy

The main piece of legislation of waste in Italy is the **D.Lgs 152/2006** (and amendments) «Norme in materia di ambiente (Codice ambiente)».[107] It sets the rules for regional plans for waste management and at the same time makes the regions responsible for waste management and the provinces for controlling waste management activities. There exist several legislations that regulate the CDW in Italy. The most important ones include:

1) **D.M. 5/2/98** (amended by decree 5/4/06 n. 186) "Individuazione dei rifiuti non pericolosi sottoposti alle procedure semplificate di recupero ai sensi degli articoli 31 e 33 del decreto legislativo 5 febbraio 1997, n. 22"[108], which sets the End-Of-Waste criteria for CDW.

2) **D.M. n°203 del 8/5/2003** "Norme affinchè gli uffici pubblici e le società a prevalente capitale pubblico coprano il fabbisogno annuale di manufatti e beni con una quota di prodotti ottenuti da materiale riciclato nella misura non inferiore al 30% del fabbisogno medesimo"[109], which determines a quota of 30% for recycled materials (including construction materials) and products in public procurement. The **Circolare 15/7/05 n. 5205** "Indicazioni per l'operatività nel settore edile, stradale e ambientale, ai sensi del Decreto Ministeriale 8 Maggio 2003 n. 203"[110] sets Green Public Procurement rules for construction activities.

[102] http://www.douane.gouv.fr/Portals/0/fichiers/tableau-des-taux-2017.pdf
[103] OECD, 2017, OECD/EEA database: http://www2.oecd.org/ecoinst/queries/
[104] Tong T. Kien, Le T. Thanh and Phung V. Lu, Recycling construction and demolition waste in the world and in Vietnam, 2013
[105] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_France_Factsheet_Final.pdf
[106] Ibid.
[107] http://www.camera.it/parlam/leggi/deleghe/06152dl.htm
[108] http://www.albonazionalegestoriambientali.it/Download/it/NormativaNazionale/015-DM186_05.04.2006.pdf
[109] http://www.sicurezzaonline.it/leggi/legrif/legrif2003/legrif2003doc/legrif2003din/din20030508203.htm
[110] http://www.arpa.veneto.it/temi-ambientali/rifiuti/file-e-allegati/normativa/circ_5205_2005.pdf

No specific CDW national landfill diversion policy is in place.[111] The **landfill taxes** are applied on a regional level and all regions have to implement them[112]. Law 549/1995 defines the upper and lower level of the tax as follows[113]: 1) Inert waste, including waste from the mining, extractive, building and metalworking sector (1.03-10.33 EUR per tonne); 2) Hazardous and non-hazardous waste including municipal waste (5.16-25.82 EUR per tonne). The charges on municipal waste collection/treatment vary between municipalities.[114] The rate depends both on the material and the region.

Italy does not have any legal **producer responsibility scheme** related to construction materials.[115]

Decentralised taxes on sand, gravel and rock – the case of Italy

In Italy the application of taxes on sand, gravel and rock are decentralised and have been applied since the early 1990s. There is no common national rate of tax being applied. Instead every region applies different rates at provincial and municipal levels, per cubic meter of sand, gravel and rock extracted. The revenue from the taxes are accrued by the municipalities and legislation prescribes they are earmarked for 'compensatory investments' in localities of quarrying activity. In Italy, the charge on aggregates is only one element of a very complex planning, authorisation and regulation system related to quarrying activities.

Extraction charges are not primarily aimed at reducing the quantity extracted or at promoting recycling. Instead their purpose is to contribute to the external costs associated with quarrying activities through financing land conservation investments implemented by municipalities and other institutions that share the revenues, which mostly accrue to municipalities. Results from the analysis suggest that the effect of the extraction charge has been very limited. The level of tax is generally too low (around EUR 0.41–0.57/m3) to have had any real effect on demand.

Source: EEA, Effectiveness of environmental taxes and charges for managing sand, gravel and rock extraction in selected EU countries, No 2/2008, http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwiFyYvjxaXPAhWCCBoKHTlkDakQFggeMAA&url=http%3A%2F%2Fwww.eea.europa.eu%2Fpublications%2Feea_report_2008_2%2Fdownload&usg=AFQjCNHK7j1OjkzVs0d3bLqSg0unmco-jw (from the European Construction and Demolition Waste Management Protocol, European Commission)

Poland

The recycling of CDW started in Poland in 2001, when the **Act on Waste**[116] came into force[117]. The Act defines CDW and regulated its management also for companies recycling CDW. It sets out rules for dealing with waste in a way that protects life and health of people and the environment in accordance with the principle of sustainable development, in particular in line with the principle of waste prevention, reduction, recovery and disposal of waste. According to the Act on Waste, waste producer is obliged to manage waste that he generated. Still, the waste producer or other holder of waste may transfer the obligation of waste management to another entity that have permits for waste collection or waste treatment. In order to transfer the responsibility a recovery or disposal confirmation must be provided. Moreover, the Act includes a national/regional sorting obligation, including separate collection and management of hazardous waste from construction and demolition operations.

The **landfill fees** applicable in 2015 are defined by the Decree of the Minister for the Environment of 11 August 2014 on level of fees for use of the environment in 2015[118]. The Decree specify rates for each waste code; fees for landfilling CDW range from 11.67 PLN to 165.54 PLN (about 2.7 EUR to 38.7 EUR) for tonne of waste. The price

[111] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Italy_Factsheet_Final.pdf
[112] http://scp.eionet.europa.eu/publications/WP2012_1/wp/WP2012_1
[113] ETC/SCP, 2009 Facts & Figures – Country fact sheets on waste policies. Italy http://scp.eionet.europa.eu/facts/factsheets_waste/2006_edition/Italy
[114] OECD, 2017, OECD/EEA database: http://www2.oecd.org/ecoinst/queries/
[115] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Portugal_Final.pdf
[116] http://isap.sejm.gov.pl/DetailsServlet?id=WDU20010620628
[117] Interview with Urszula Pawlak, Deputy Director of the Department of Waste Management and Integrated Permits, Mazovian Regional Council
[118] http://isap.sejm.gov.pl/DetailsServlet?id=WMP20140000790&min=1

depends on type of waste (for example landfilling concrete waste is in the lower price category and waste containing hazardous substances is in the higher price category).

On the regional level, new CDW recycling companies need a **permit** from the regional authority (governor), in order to be allowed to recycle waste[119]. The regional authority is collecting data from the already existing facilities, so they can monitor the amounts of waste being recycled and see if additional recycling capacity is needed. An important document is also the regional plan for waste management[120].

The management of CDW on municipal level (waste generated by households) is regulated by the **Act on maintaining cleanliness and order in municipalities** of 13 September 1996.[121] According to the Act, municipalities are responsible for example for ensuring easily accessible points of selective collection of municipal waste (including CDW that are municipal waste), as well as ensuring that the targets of recycling and preparing for reuse or recovery of CDW that are municipal waste are achieved (the obligation of the level of at least 70% by weight).

Poland does not have any legal **extended producer responsibility scheme** related to construction materials.[122]

The Asbestos Abatement Programme in Poland (2009-2032)

The aims of The Programme for Asbestos Abatement in Poland 2009-2032 are:
1) Removal and disposal of products containing asbestos;
2) Minimising adverse health effects caused by the presence of asbestos in Poland;
3) Eliminating negative effect of asbestos on the environment.

The programme groups activities scheduled for the implementation at a central, voivodship and local level in five subject areas:

a. Legislative activities;
b. Education and information activities addressed to children and youth, trainings for employees of government and self-government administrations, development of training materials, promotion of technologies for the destruction of asbestos fibres, organisation of national and international trainings, seminars, conferences, congresses and participation therein;
c. Activities related to the removal of asbestos and products containing asbestos from the constructions, public amenities and sites of former asbestos products producers, cleaning the premises, building landfills;
d. Monitoring of the programme implementation by means of electronic spatial information system;
e. Activities in the area of exposure assessment and health protection.

The Programme for Asbestos Abatement in Poland is published in English on website:
http://www.mr.gov.pl/media/15225/PROGRAM_ENG.pdf

Source: Polish Ministry of the Environment, 2016 (from the European Construction and Demolition Waste Management Protocol, European Commission)

Czech Republic

The **Waste Act no. 185/2001[123]** constitutes the legislative framework for waste management in the Czech Republic. It emphasises the hierarchy of waste management and promotes the principles of waste prevention,

[119] Interiview with Urszula Pawlak, Mazovian Regional Council, Deputy Director of the Department of Waste Management and Integrated Permits
[120] http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=0ahUKEwjyvLm1jNvRAhXHbRQKHQfVDOAQFggmMAE&url=http%3A%2F%2Fwww.mazovia.pl%2FdownloadStat%2Fgfx%2Fmazovia%2Fpl%2Fdefaultaktualnosci%2F1096%2F24%2F1%2Fwojewodzki_plan_gospodarki_odpadami_dla_wojewodztwa_mazowieckiego_na_lata_2016-2021_z_uwzglednieniem_lat_2022-2027.pdf&usg=AFQjCNGommjSbjKkJB5WFdMXNjuOu2Y6Yg
[121] http://isap.sejm.gov.pl/DetailsServlet?id=WDU19961320622
[122] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Poland_Factsheet_Final.pdf
[123] 1 http://www.zakonyprolidi.cz/cs/2005-294

environmental protection and public health in waste management. A key piece of legislation regarding treated CDW utilisation is the **Decree no. 294/2005**[124], which sets the criteria for landfilling and using waste on the ground surface.

CDW can be marketed as products if it fulfils the requirements of the **Government Regulation 163/2002**, which sets the technical and safety requirements for selected construction products.[125] The materials that fulfil the requirements from the Government Regulation are then no longer covered by the Waste Regulations.

A **landfill tax** was established in 1992.[126] The current charge for all landfills consists of two components: 1) the basic charge paid for municipal and other waste (18.50 EUR per tonne) and hazardous waste (62.88 EUR per tonne); 2) the risk charge (paid only for hazardous waste) (166.5 EUR per tonne).[127] The landfill tax has been set to economically disadvantage landfilling and promote reuse and recycling[128]. Therefore, until all landfills are closed, charges for landfilling will be continuously increased.[129] Czech Republic has decreed that Value Added Tax will be decreased for certain recycled materials.[130]

The Legislation no. 352/2014 introduces a **landfill ban**. From 2024 landfilling or energy recovery of recyclable municipal waste will not be allowed anymore and recyclable waste will be banned from landfilling.

There exist three mandatory **extended producer responsibility schemes** for packaging[131], vehicles and accumulators[132] and WEEE[133].

Portugal

In 2008 Portugal published the **Decree-Law 46/2008 of 12 March** (Decreto-Lei 46/2008, de 12 de março)[134], which establishes the legal framework for waste management operations resulting from construction, demolition of buildings, or from landslides.[135] The Decree creates legal conditions for the management of CDW, which focus on the prevention of hazardous waste generation, sorting at source, recycling and other forms of recovery, in order to minimise the use of natural resources and reduce landfilling.

Other regulations which affect CDW management in Portugal include: Ordinance 40/2014 of 17 February (Portaria 40/2014, de 17 de junho)[136], Decree-Law 73/2011 of 17 June (Decreto-Lei 73/2011, de 17 de junho) that sets a target for raw materials used in public construction works, which should include at least **5% of recycled materials or materials containing recycled components**[137], Decree-Law 26/2010 of 30 March (Decreto-Lei 26/2010, de 30 de março)[138], Decree-Law 183/2009 of 10 August (Decreto-Lei 183/2009, de 10 de agosto)[139], Decree-Law 18/2008 of 29 January (Decreto-Lei 18/2008, de 29 de janeiro)[140], Ordinance 417/2008 of 11 June (Portaria 417/2008, de 11 de junho)[141], Ordinance 209/2004 of 3 March (Portaria 209/2004, de 3 de março)[142] and Ordinance 335/97 of 2 September (Portaria 335/97, de 2 de setembro).[143]

[124] http://www.zakonyprolidi.cz/cs/2005-294
[125] https://www.zakonyprolidi.cz/cs/2002-163
[126] http://scp.eionet.europa.eu/publications/WP2012_1/wp/WP2012_1
[127] OECD, 2017, OECD/EEA database: http://www2.oecd.org/ecoinst/queries/
[128] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Czech%20Republic_Factsheet_Final.pdf
[129] Ibid.
[130] Ibid.
[131] http://www.zako nyprolidi.cz/hled ani?text=477%
[132] https://www.zakonyprolidi.cz/cs/2008-352
[133] https://www.zakonyprolidi.cz/cs/2005-352
[134] https://www.apambiente.pt/_zdata/Politicas/Residuos/FluxosEspecificosResiduos/RCD/DecretoLei46.pdf
[135] Interview with a CDW company, Gesamb
[136] MSSESSAOTE (2014): https://dre.pt/application/file/572271
[137] MAOT (2011): https://dre.pt/application/file/670129
[138] PCM (2010): https://dre.pt/application/file/612544
[139] MAOTDR (2009): Decree-Law 183/2009 of 10 October, https://dre.pt/application/file/493323
[140] MOPTC (2008): https://dre.pt/application/file/248099
[141] MAOTDR (2008): https://dre.pt/application/file/449509
[142] MEADRPSCOTA (2004): https://dre.pt/application/file/551687
[143] MAIEPATSA (1997): https://dre.pt/application/file/396810

The **landfill tax** in Portugal is a part of the Portuguese waste management tax (TGR), which was introduced in 2007 as an instrument to make producers and consumers aware of the associated environmental costs and to stimulate waste reduction to meet domestic objectives with regard to waste management[144]. The current waste management tax rate for landfilling of inert waste from constructions and demolition activities in Portugal is 4.27 EUR per tonne and for other waste disposal it is 6.39 EUR per tonne.[145]

Portugal does not have any legal **extended producer responsibility scheme** related to construction materials.[146]

Romania

The **Law no. 211/2011 on waste regime** [147], which is a transposition of the Waste Framework Directive, defines waste and regulated waste management in Romania. The Article 17 obliges the waste producers and local authorities to "achieve, until 2020, level of preparation for reuse, recycling and other material recovery, including backfilling operations using waste filling to replace other materials, at least 70% of mass quantities of hazardous waste from construction and demolition, excluding naturally occurring material defined in category 17 05 04 Government Decision no. 856/2002, with subsequent"[148]. There exist two other regulations relevant in the context of CDW:

1) **Law no. 101/2006**[149], which sets the legislative framework for waste management operators.

2) **Law no. 50/1991**[150], which authorises the execution of construction works and some measures for housing, as amended and supplemented.

Currently the **landfill tax** for CDW in Romania amounts to 50 lei (EUR 11 per tonne)[151]. Starting from 2016 the landfill tax in Romania should have been raised to 80 lei (18 EUR) per ton, so the Environmental Minister Graţiela Gavrilescu[152] and by the end of 2016 should have raised again. However, the enforcement of this was postponed to 2017.[153] According to the European Commission, the landfill charges (gate fees) in Romania are too low to divert waste towards higher ends of the waste hierarchy and make recycling and reuse economically attractive.[154]

Romania does not have any legal **extended producer responsibility scheme** related to construction materials.[155]

Malta

The Waste Regulations (L.N. 184 of 2011)[156] defines the legislative framework for waste management in Malta. They are the result of the EU Waste Framework Directive (2008/98/EC) being transposed into Maltese law. All provisions in the EU Waste Framework Directive related to CDW apply in Malta. Further relevant legislations include: Legal Notice 168 of 2002, Environment Protection Act (Act No. XX of 2001) – Waste Management (Landfill) Regulations[157], Legal Notice 279 of 2010, Environment Protection Act (Cap. 435) – Deposit of Waste and Rubble (Fees) (Amendment) Regulations[158], Legal Notice 344 of 2005, Environment Protection Act (CAP. 435) –

[144] http://scp.eionet.europa.eu/publications/WP2012_1/wp/WP2012_1
[145] OECD, 2017, OECD/EEA database: http://www2.oecd.org/ecoinst/queries/
[146] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Portugal_Final.pdf
[147] http://www.ecofriends.ro/en/legea-nr-211-din-15-noiembrie-2011-privind-regimul-deseurilor/
[148] http://www.ecofriends.ro/en/legea-nr-211-din-15-noiembrie-2011-privind-regimul-deseurilor/
[149] http://www.xisoft.net/legislatie.php?link=legea_101_2006.htm
[150] http://www.avocatnet.ro/content/articles/id_14405
[151] http://www.cewep.eu/media/www.cewep.eu/org/med_557/1406_2015-02-03_cewep_-_landfill_inctaxesbans.pdf
[152] http://www.econet-romania.com/news/starting-with-2016-the-landfill-tax-in-romania-will-raise-to-80-lei-18-per-ton-html/
[153] http://ec.europa.eu/environment/eir/pdf/report_ro_en.pdf
[154] Ibid.
[155] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Romania_Factsheet_Final.pdf
[156] https://www.mepa.org.mt/LpDocumentDetails?syskey=1358
[157] https://www.mepa.org.mt/LpDocumentDetails?syskey=364
[158] https://www.mepa.org.mt/LpDocumentDetails?syskey=1236

Abandonment, Dumping and Disposal of Waste in Streets and Public Places or Areas Regulations[159], Legal Notice 295 of 2007, Development Planning Act (CAP. 356) Environment Protection Act (CAP. 435) Environmental Management Construction Site Regulations[160], Approved Supplementary Planning Guidance concerning inert waste disposal in quarries[161].

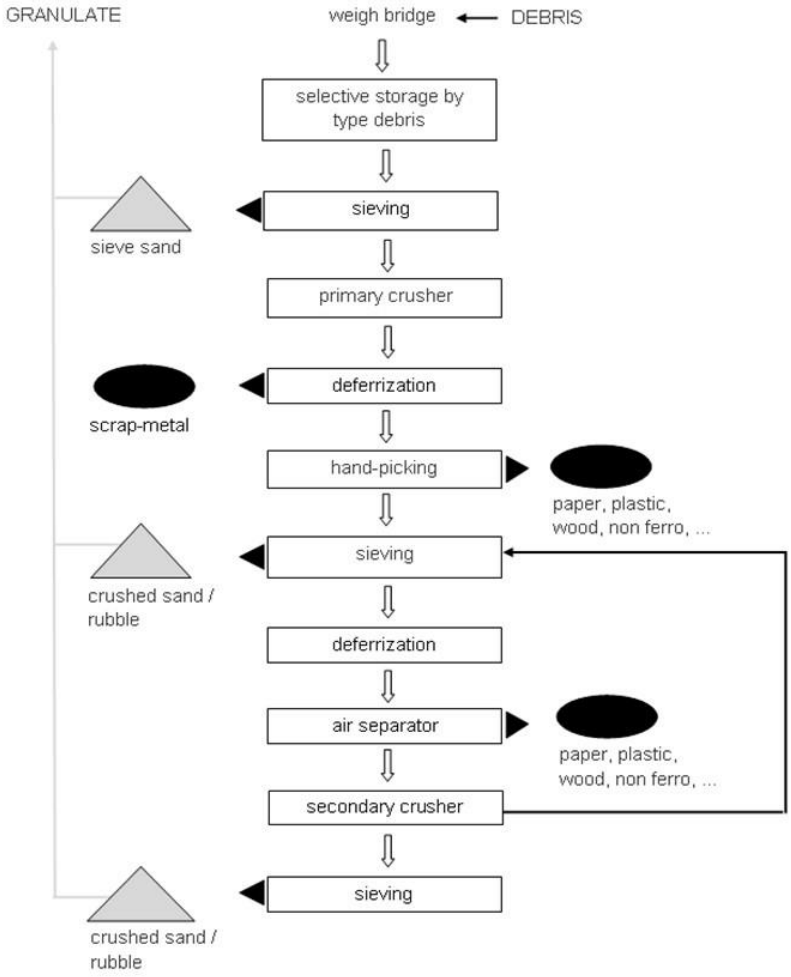
In Malta the construction **waste disposal charge** is 3.26 EUR per tonne for inert waste and 5.50 EUR per tonne for disposal of inert waste contaminated or mixed with other materials.[162]

Malta does not have any legal **extended producer responsibility scheme** related to construction materials.[163]

[159] https://www.mepa.org.mt/LpDocumentDetails?syskey=531
[160] https://www.mepa.org.mt/LpDocumentDetails?syskey=710
[161] https://www.mepa.org.mt/LpDocumentDetails?syskey=263
[162] OECD, 2017, OECD/EEA database: http://www2.oecd.org/ecoinst/queries/
[163] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_Malta_Factsheet_Final.pdf

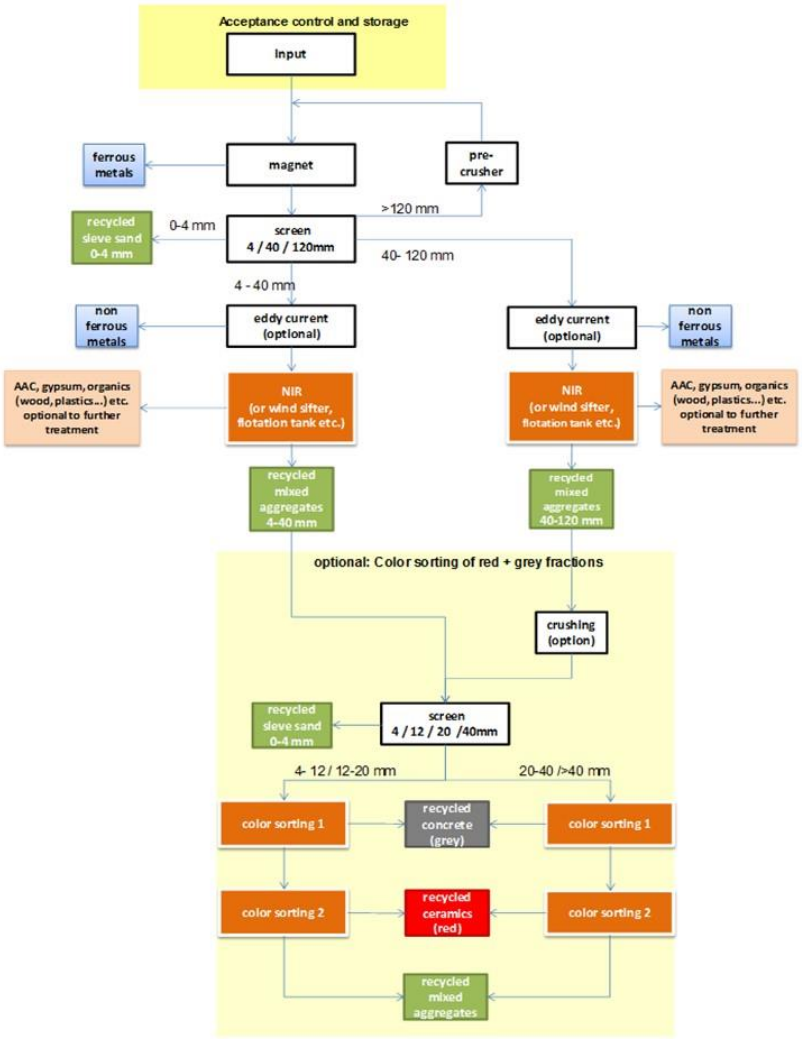
4/ Annex 4: Figures of Conventional vs future CDW recycling technologies

Figure 33: Conventional CDW recycling technology



Source: O. Lambertz, K. Broos (2012), Sorting technologies for CDW. IRCOW workshop 2013, Antwerp (BE)

Figure 34: A potential future scenario for CDW recycling



Source: O. Lambertz, K. Broos (2012), Sorting technologies for CDW. IRCOW workshop 2013, Antwerp (BE)

5/ Annex 5: Table of conventional and upcoming CDW recycling technologies

*The new and upcoming technologies are indicated in **red**. Technologies listed in **grey** colour point to optional technologies.*

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Concrete						
Concrete aggregates production	Production of concrete aggregates in certain size fractions (e.g. 0-40 mm) (see sheet 2)	(sub)foundation	Concrete fraction of CDW (limited amount of organics, gypsum, floating particles, other stony materials). The output has to fulfil requirements set in EN 206 or national regulations (e.g. PTV 406, NBN B 15-001, CUR recommendation 112)	Manual removal of bigger impurities[164]	9	
		Concrete production		Suspended belt magnet	9	
		Embankment		Sieving screens (e.g. triple deck screens)	9	
				Crusher (e.g. jaw crusher)	9	
				Density separation (e.g. wind shifter)	9	
				Mobile crushing installation (in this case, the previously listed equipment is	9	

[164] https://www.google.be/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjV0Jnt3rXVAhXCalAKHbCzApMQFggsMAA&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9783319285382-c2.pdf%3FSGWID%3D0-0-45-1590174-p177864770&usg=AFQjCNHG6PlnbLc9Ddg5oSz0suyX04Zrgg

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
				integrated in one piece of equipment)		
				Near-infrared separation[165]	7	more efficient separation of impurities (e.g. gypsum, organic contaminants)
				Colour sorting (UV-VIS)[166]	7	Possibility to separate "grey" fraction (concrete fraction) from "red" fraction (masonry fraction)
				Hyperspectral imaging sorting[167]	4	combining the removal of impurities and colour sorting in one equipment
				Advanced dry recycling (ADR) technology[168]	7	More efficient separation of impurities (e.g. wood, plastic) and fines. The fines fraction could possibly be used as a supplementary cementitious material
				Electrical fragmentation[169]	4	Selective liberation of fibres in fibre-reinforced concrete, selective liberation of aggregates from cement matrix in concrete, selective fragmentation of brick and mortar
				Inline quality assessment with laser-induced breakdown spectroscopy[170]	6	inline quality assessment
				Smart crusher[171]	7	Less energy use. More selective crushing: resulting in aggregate, sand and fraction. Selective liberation of fibres in fibre-reinforced concrete

[165] http://www.ircow.eu/media/docs/Session_02_presenation_01_IRCOW_Final_Conference_Upgraded_recycling_solutions_%20Oliver_Lambertz.pdf
[166] http://www.ircow.eu/media/docs/Session_02_presenation_01_IRCOW_Final_Conference_Upgraded_recycling_solutions_%20Oliver_Lambertz.pdf
[167] http://hiserproject.eu/index.php/news/80-news/133-sensor-based-sorting-technologies-for-an-efficient-recovery-of-concrete-and-ceramics-from-c-dw-stony-fractions
[168] http://c2ca-technology.nl/uncategorized/movie_circular_demolition_and_adr/
[169] https://www.researchgate.net/publication/309955023_Electrical_fragmentation_applied_to_the_recycling_of_concrete_waste_-_Effect_on_aggregate_liberation
[170] https://vimeo.com/channels/spectronet/213526489
[171] https://www.slimbreker.nl/why-smartcrushers.html

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
				Microwave assisted fragmentation[172]	4	Selective liberation of fibres in fibre-reinforced concrete, selective liberation of aggregates from cement matrix in concrete.

[172] https://hal-univ-tlse3.archives-ouvertes.fr/hal-00920886/document

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Mixed stony fraction						
Mixed recycled aggregates or masonry aggregates production	Production of mixed aggregates or masonry aggregates in certain size fractions (e.g. 0-40 mm) (see sheet 2)	(sub)foundation	Concrete fraction of CDW (limited amount of organics, gypsum, floating particles, other stony materials). The output has to fulfil requirements set in EN 206 or national regulations (e.g. PTV 406, NBN B 15-001, CUR recommendation 112)	Manual removal of bigger impurities[173]	9	
		Concrete production		Suspended belt magnet	9	
		Embankment		Sieving screens (e.g. triple deck screens)	9	
		Brick-to-brick (use of masonry aggregates in new bricks) (technology being developed by VITO and Dumoulin Bricks, TRL 5)		Crusher (e.g. jaw crusher)	9	
				Density separation (e.g. wind shifter)	9	
				Mobile crushing installation (in this case, the previously listed equipment is integrated in one piece of equipment)	9	
				Near-infrared separation[174]	7	more efficient separation of impurities (e.g. wood, plastic)

[173] https://youtu.be/uwpsUVXKTjo
[174] http://www.ircow.eu/media/docs/Session_02_presenation_01_IRCOW_Final_Conference_Upgraded_recycling_solutions_%20Oliver_Lambertz.pdf

				Colour sorting[175]	7	Possibility to separate "grey" fraction (concrete fraction) from "red" fraction (masonry fraction)
				Hyperspectral imaging sorting[176]	4	combining the removal of impurities and colour sorting in one equipment
				Electrical fragmentation[177]	4	Selective liberation of fibres in fibre-reinforced concrete, selective liberation of aggregates from cement matrix in concrete, selective fragmentation of brick and mortar
				Inline quality assessment with laser-induced breakdown spectroscopy[178]	6	inline quality assessment

[175] http://www.ircow.eu/media/docs/Session_02_presenation_01_IRCOW_Final_Conference_Upgraded_recycling_solutions_%20Oliver_Lambertz.pdf
[176] http://hiserproject.eu/index.php/news/80-news/133-sensor-based-sorting-technologies-for-an-efficient-recovery-of-concrete-and-ceramics-from-c-dw-stony-fractions
[177] https://www.researchgate.net/publication/309955023_Electrical_fragmentation_applied_to_the_recycling_of_concrete_waste_-_Effect_on_aggregate_liberation
[178] https://vimeo.com/channels/spectronet/213526489

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Wood						
CDW wood recycling	Processing of CDW into wood chips	Fuel	Non-hazardous wood waste	mills/crushers (e.g. hammer mill)[179]	9	
		Wood-polymer composites		sieving screens	9	
		Particle board production (for some untreated construction waste fractions)		Suspended belt magnet	9	
				Manual removal of bigger impurities	9	
				eddy-current separator	9	
				Density separation (e.g. wind shifter)	9	

[179] http://www.recyclingtoday.com/article/c-d-wood-fuel-quality/

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Metals (ferro and non-ferro)						
Since the high value of metals, we consider the metal recycling market as a mature market that does not need to be considered here.						
Main metals in CDW: steel, aluminium, copper, lead						

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Autoclaved aerated concrete (AAC)						
AAC aggregates	Production of AAC aggregates (0-8 mm)	cement-based products like cement-stabilized sand or screed	AAC waste. Important: keep gypsum impurities to a minimum (<2%)	Mill (e.g. disc mill)[180]	9	
				Sieving screen	9	
				Suspended belt magnet	9	

[180] https://www.researchgate.net/publication/295699674_Recycling_of_autoclaved_aerated_concrete_in_screed_and_stabilized_sand

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Asbestos						
Landfilling	Loose asbestos fibres will first be immobilized in a cement matrix	none	asbestos waste		9	
Thermal process	Heating asbestos fibres to destroy their fibre-structure	supplementary cementitious material	asbestos waste	oven, kiln (e.g. cement kiln, tunnel kiln, microwave oven) that is suitable for asbestos denaturation[181]	7	Turning asbestos in a non-hazardous product

[181] http://pubs.acs.org/doi/pdf/10.1021/es500551b

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Mercury-containing lamps						
Recovery of the glass, lamp caps and fluorescence powder	Recovery of the glass, lamp caps and fluorescence powder	Production of new lamps	Mercury-containing lamps	crusher[182]	9	
		scrap recycling (caps)		Sieving screens	9	
				magnetic separation	9	
				Eddy current separation	9	
				Oven (200-450 °C)	9	
				dust filters	9	
				Activated carbon filter for mercury recovery	9	

[182] http://www.indaver.be/en/installations-processes/material-recovery/lamps/

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Gypsum						
Plasterboard recycling	Separation of paper and gypsum	gypsum production	Gypsum plasterboard waste	Manual removal of bigger impurities[183]	9	
		paper recycling		magnetic separation (e.g. induced magnetic roll)	9	
				Crushers and sieving screens	9	
				Separator that separates the gypsum from the paper	9	
WPC	Use as resource in wood-polymer composites	Wood-polymer composites	Gypsum plasterboard waste	less processing steps required[184]		

[183] http://gypsumtogypsum.org/
[184] https://static1.squarespace.com/static/5330780de4b025b2a08440a4/t/5378ef86e4b003ad4657c21e/1400434566104/text+congreso+WPC2013-OPPORTUNITIES+FOR+RECYCLING+CONSTRUCTION+AND+DEMOLITION+WASTE-v2.pdf

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Glass						
Glass recycling	Processing of glass waste to obtain a resource for the production of glass or glass wool	glass	flat glass	Manual removal of bigger impurities[185]	9	
		glass wool		crushers	9	
				Sieving screens	9	
				magnetic separation (e.g. suspended belt magnet)	9	
				Eddy current separation	9	
				Density separation (e.g. wind shifter)	9	
				Optical separation (UV-VIS) for the removal of coloured glass, stone, ceramics, porcelain		

[185] http://agc-flattoflat.eu/wp-content/uploads/2017/01/Recycling-of-Glass-from.pdf

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Plastics						
Many types of plastics can be recycled in case they form a pure fraction (e.g. HDPE, PS, PVC)					9	
PVC recycling	Processing of PVC window frames for the production of new frames	PVC production	PVC waste	Crushers + sieve screens[186]	9	
				magnetic separation (e.g. suspended belt magnet)	9	
				Eddy current separation	9	
				Optical separation (UV-VIS)	9	
				selective dissolution bath	9	
				precipitation bath	9	
				drying oven	9	
Thermal process	Recycling of more complex plastic waste	Plastic recycling	CDW plastics	Manual removal of bigger impurities[187]	9	
				Shredders and sieving screens	9	
				flotation tank (separation of different kinds of plastics)	9	
				drying oven	9	
				Melting oven	9	
				Fine filter screen (to remove residual contamination)		
WPC	Use as resource in wood-polymer composites	Wood-polymer composites	CDW plastics	less processing steps required[188]		

[186] https://www.youtube.com/watch?v=-eJda084tlc
[187] http://www.acrplus.org/images/pdf/document142.pdf
[188] https://static1.squarespace.com/static/5330780de4b025b2a08440a4/t/5378ef86e4b003ad4657c21e/1400434566104/text+congreso+WPC2013-OPPORTUNITIES+FOR+RECYCLING+CONSTRUCTION+AND+DEMOLITION+WASTE-v2.pdf

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Carpet						
Desso Refinity	Process that produces purified yarn and bitumen backing	new yarn	used carpet (exception: PVC)	Refinity® process[189]	9	
		road and roofing industry				

[189] https://youtu.be/ZHGxf_ztiDg

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Roofing						
Roofing recycling	Production of shredded material (10-20 mm)	roofing production	Bituminous roofing waste (no tar, EPDM, stones, wood, and plastics. Contamination level: <2%)	shredders and sieving screens (important: avoid melting of the bitumen during shredding)[190] [191]	9	
		asphalt production	bituminous roofing waste (less strict purity limits)			

[190] https://youtu.be/HuC9E44KuL4
[191] http://asphaltmagazine.com/roofing-the-road-using-asphalt-shingles-as-binder/

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Mineral wool						
Stony wool recycling		stone wool production	Pure stone wool waste fractions	Rockwool process[192]	9	
WPC	Use as resource in wood-polymer composites	Wood-polymer composites	CDW mineral wool waste	Shredders and sieving screens[193]		

[192] http://www.rockwool.co.uk/about-us/stone-wool-benefits/sustainability/recycling-rockwool/
[193] https://static1.squarespace.com/static/5330780de4b025b2a08440a4/t/5378ef86e4b003ad4657c21e/1400434566104/text+congreso+WPC2013-OPPORTUNITIES+FOR+RECYCLING+CONSTRUCTION+AND+DEMOLITION+WASTE-v2.pdf

Technology by type of material	Description	Applications	Input requirements	Equipment (depending on purity of the input stream and requirements for the output stream)	TRL	Improvement
Mixed CDW						
Sorting installation	Sorting of mixed CDW into different fractions: wood, metal, plastics, paper/cardboard, sand fraction, stony aggregates, residuals	Depending on output fraction	Non-hazardous mixed CDW	Manual removal of impurities[194]	9	
				Magnetic separation (e.g. suspended belt magnet)	9	
				Sieving screens (e.g. drum screen)	9	
				Density separation (e.g. wind shifter, sink-float)	9	
				Eddy current separation	7	more efficient separation of impurities (e.g. wood, plastic) from the stony material
				Near-infrared separation[195]	4	combining the removal of impurities from the stony fraction and colour sorting in one equipment
				Hyperspectral imaging sorting[196]	9	Fast and accurate waste sorting robot
				Sorting robot (ZenRobotics)[197]		

[194] https://www.youtube.com/watch?v=D-knon8thyI
[195] http://www.ircow.eu/media/docs/Session_02_presenation_01_IRCOW_Final_Conference_Upgraded_recycling_solutions_%20Oliver_Lambertz.pdf
[196] http://hiserproject.eu/index.php/news/80-news/133-sensor-based-sorting-technologies-for-an-efficient-recovery-of-concrete-and-ceramics-from-c-dw-stony-fractions
[197] http://zenrobotics.com/solutions/robotic-waste-sorting/

6/ Annex 6: A taxonomy of key contextual factors: lessons from the interviews

Approach to the synthesis of the interviews

The classification of key contextual factors was done on the basis of information from 36 semi-structured interviews with relevant stakeholders in selected countries, including business leaders, business associations and government agencies. We embark in this section with a brief definition of "*context factor*" as well as a brief overview of the approach to this review.

Definition. Contextual factors are seen as variables that are exogenous to the company and its business model. Context factors thus impact the company and its decisions without being under full control of the company actions. Each contextual factor is to be seen as a **neutral** item that can be seen:

- ➔ **positively** (when playing the role of a driver)…
- ➔ …or **negatively** (when acting as an obstacle to CDW recycling activities/development).

Each factor identified in the context of this review relates to at least one of the broader categories which we defined as the following:

1. Legislative and regulatory factors
2. Market and economic factors
3. Technological factors
4. Social factors

Approach. Each interview was attributed a code composed by the letter "i" and a singular number in order to be anonymised (these therefore ranged from i1 to i36). A careful review of the interviews that were conducted by our team was then operated by using the interview guidelines to collect the information and identify the key factors. Following the initial framework and in line with the research questions for this study, a characterisation was operated through the review of each individual report. Factors were thus identified in a bottom-up fashion, picked out from the interviews when being considered as key and recurrent across the interview reports. Every statement formulated in the synthesis is thus backed by at least one reference to an interview which is found between parentheses.

Inter-links between factors. The synthesis focuses on the key contextual factors identified across the interview reports. Each factor is however not to be considered as a stand-alone variable. Each factor (and in consequence, group of factor) is to be considered as part of a whole and interacts with the existence and role of other factors (and groups of factors). This was highlighted for instance by an interviewee explaining that "*Generally a number of a key factors drive the success of their business: high construction boom, high generation of waste, limited landfill capacity, limited natural resources are driving factors for the success of their business model"* [i32] while another interviewee explained that "*On the waste market you have competition, which depends on 1) Network ; 2) Proximity 3) Ability to combine in one comprehensive offer ; 4) The proximity and ability to combine all services into a one comprehensive offer is very valuable*" [i11]. This is important for instance when considering the role of regulation in the development of the CDW market[198]. However, no single pattern could be identified due to the diversity of materials, methods and business models under the scope. The right level of analysis thus appeared to be the one of the factors and not the one of the interactions between each factor.

198 An interviewee highlighted for instance that "*you can't make the success of one market / material dependent on the failure of the other by pulling it down with a tax. Recycling has to be pushed forwards, but not by taking down competing industries in this way. There is a need to achieve a setting in which a balanced competition can be obtained. That recycling with all of its traits and environmental considerations can be moved forward*" [i24]

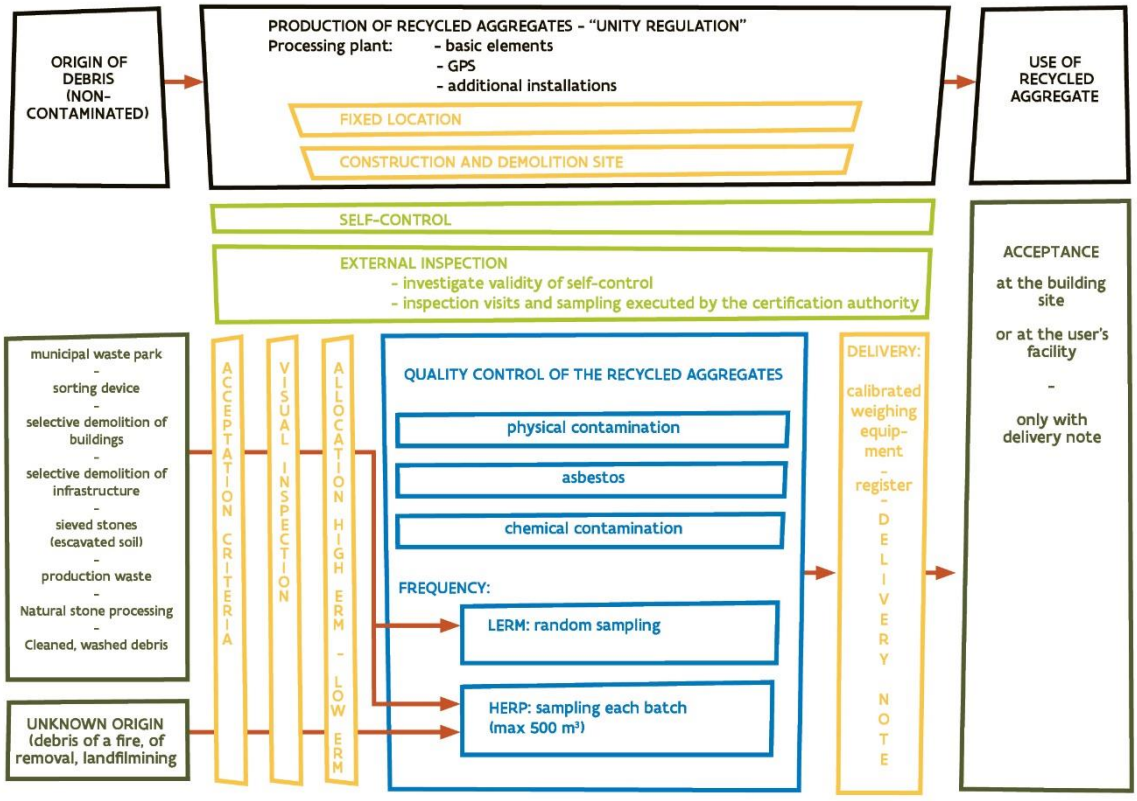
Legislative and regulatory factors

Legally-based market. Both environmental and material-related legislation together with reference rules and criteria play a key role in creating a market for recycled materials [i1, i4, i17, i20, i24, i30, i34] as to compensate for a low level of "*natural*" demand. By lowering the price of CDW recycled materials compared to virgin materials, regulation plays a critical role in terms of creating a market place for CDW [i1, i26, i34, i36]:

"*It cannot be emphasised enough that it is absolutely important to have a credible long-term robust government policy that is adequately implemented. This stimulates investment in the CDW recycling sector and gives confidence to the investors*" [i14]

Regulatory factors can be expressed through legislative lines but also tools such as permits, guidelines, specifications and certification[199] which need to be clarifier, streamlined and advertised [i17, i21]. Indirect tools such as (the CE) marking can even play a positive role to stimulate the purchase of CDW – when understood as a quality label [i4, i4b, i5b, i8]. An example of regional framework is provided in Figure 35 below:

Figure 35: Schema eenheidsreglement (scheme of integrated regulation in Flanders on CDW)



Source: Koen De Prins (2017) OVAM

The importance of regulatory factors can touch upon the balance between recycling and landfill storage of CDW (such as referred to for instance by i12, i20, i23, i26 and i34[200]). Regulation even has an influence on the

[199] Examples of regulatory lines in Flanders include for instance the VLAREM, VLAREMA (as well as the so-called 'materialendecreet') at the legislative level, which can cover the all value chain up to the regulation of excavating activities (see also i2); but also the use of environmental permits ('Milieuvergunningdecreet'), certification ('COPRO') and guidelines ('eenheidsreglement') (i1).

[200] The latter 2 explaining in that respect that "*Landfill prohibition is key*" [i26] and that "*limited landfill capacity [and] landfill ban*" are "*essential conditions*" for the success of CDW recycling [i34]. This was referred to by another interviewee who stated that "*the prohibition to landfill CDW acts as a firm limit*" [i1]

technologies used as it implies certain normative factors such as material type, size, etc. are to be taken into account to allow for a possible control [i1, i2, i7, i8].

Although perceived as one of the most (if not the most) critical factor to ensure a CDW market, legislative and regulatory variables should not be seen as a stand-alone group. It can however impact a number of other areas. An interviewee explained in that respect that the "*Regulatory context is the main lever to develop these business models and believe[s] that this framework should: 1) At least reduce the lack of enforcement of law; 2) promote selective deconstruction to increase recycled CDW; 3) Ban or tax landfilling of waste that could be treated more efficiently according to the EU waste hierarchy; 4) enable Member States to include as material recycling the mineral fraction of waste co-processed in their recycling targets; 5) promote the use of recycled products through public procurement; 6) enable concrete norms to include more recycled aggregates*" [i11].

Circumvention and need for enforcement. Besides offering opportunities, legislative changes can lead to negative spill-overs, for instance when changes facilitate circumvention which is seen as a risk [i8] and challenge [i7]. An interviewee even explains that "*Demotivating factors are illegal landfilling, backfilling, as soon as people are able to get rid of a material somewhere in nature, they do*" [i20]. Frequency and control over the norms – reinforcement overall – is thus also critical [i1, i17] in that respect and monitoring as well as enforcement are needed, including when it leads to sanctions [i9, i14[201], i15, i17, i36]. An interviewee explained that "*by far the biggest block of recycling is not the lack of regulation but the lack of enforcement of regulations. Where the regulations are strongly enforced, there is also encouragement for economic activity*" [i11].

Harmonisation. Harmonisation is a key factor that can be seen from different perspectives. An interviewee explained for instance that in the country (s)he belong to, "*in order to obtain the recycling target a specific legal framework is needed to coordinate better the construction licencing system (…)The practice showed a need for better coordinated implementation*" [i13]. Another interviewee explained for instance that the legislation could become "*more stringent and internationally consistent*" which would lead to a reduction of cross-border transport problems' reduction as there would be a cost reduction for operating across Member States while diverging regimes pose asymmetries [i8]. This is confirmed by another interviewee who insisted on the fact that "*it is only useful to arrange EPR schemes at EU level*" [i14]. Such harmonization would also be critical to improve the acceptance toward CDW recycling [i17]. Another interviewee indicated that cross-border trading would evidently be made simpler in case of harmonized legislation, yet that there were also advantages in a system that would allow fine-tuning the legislation for optimisation of CDW recycling in the region or Member State [i36].

The role of the EU was said to be important when coming to drive the path toward a better regulatory framework for CDW, for instance through the EoW Directive and underlying criteria [i2, i8]. An interviewee explained for instance that "*The development of norms is important in order to ensure that recycling activities are taken up more. This could be achieved with criteria at EU level*" [i17[202]]. The need for criteria such as in the areas of demolition and recycling as well as regarding specific topics such as end-of-waste was actually pointed by several interviewees [i4, i4, i5, i9].

Value Chain regulatory coverage. The value chain coverage (which can range from the excavation to more CDW-specific steps such as storage, processing, transport and use) is an important dimension of the regulatory framework that will apply to a particular region and/or country [i1, i2, i10]. An interviewee explained in that regard that "*The problems related to regulation also involve transport regulation and management of raw materials*" [i11].

Regulation as a barrier to innovation. Regulatory conditions are variable from a region/country to another [i2] which can even lead to negative spill-overs[203]. Only one interviewee [i8] directly referred to the administrative

[201] Who among other comments explained that "*the control and enforcement is also important for an effective policy*"

[202] Adding that "*These criteria should also take into consideration the environmental impact (environmental sustainability) of this waste stream with various treatments (e.g. transport should be limited). Due to the nature of the waste it makes sense to collaborate and find regulations and norms on a broader basis, even if the waste stream itself is strongly regional*"

[203] One of the interviewees referred for instance to a region afraid of low grade CDW streams uses because of the compulsory certification lifting expectations in the neighbor region [i2]

burden that is to link to the variations found between national regulatory frameworks. Another one stated regarding regulatory barriers that "*there are also legislative and regulatory barriers in relation to CE marking requirements for recycled goods. It is obligatory to CE mark construction products as a result of the Building Goods Regulation. In order to CE mark the product, the manufacturer must manufacture and declare the product in accordance with a harmonized standard. For new materials, tests are performed according to current rules, but for recycling stones it can be impossible to document all the specific requirements. This means that the players have a regulatory unresolved issue.*" [i10]

Market and economic factors

Stable access to material. In a market that can prove to be uncertain (see for instance i34), a stable [i10, i28] access to resources is important. As put forward by an interviewee, "*if we have a decrease of availability and access to resources, then the process is at risk. We need to ensure that the recycling can happen as best as possible*" [i9]. In that respect location of the CDW recycling site is key. It was indicated that proximity to large and middle sized cities is an advantage for CDW recyclers that rely on economies of scale (minimum volumes needed to become profitable – i36). Another interviewee depicted the dependence of his/her company on "*an efficient supply*" of material [i28].

Price competition with other materials and methods. As one interviewee pointed formulated *"waste business has always been a business where the waste goes to the cheapest point*" [i8]. The first market factor is indeed the one of price competitiveness as highlighted in different instances – see for example i6, i10, i18 or i36– and can even prove to be problematic to some[204]. Price competition toward other substitute materials (i9, i18, i23, i24, i30, i34 among others) but also toward other methods: one interviewee stated for instance that "*if you want to start recycling in [CountryX] you will have a problem because [CountryY] still has landfills open where you can bring your waste for EUR 7 [per tonne]""*[i8].

Regulation plays a critical role there when considering the fact that it stimulates and can even create demand for CDW [i1, i4, i11, i15]; an interviewee for instance referred to the fact that "*aggregates are so cheap and plentiful (primary) because of lack of regulation that it doesn't make recycling economic*" [i11].

Another interviewee pointed at landfills[205] and public incinerators as the key competition to CDW recycling [i20] while another interviewee explained that "*the only alternative [to recycling] is landfilling, but the most part of the inert wastes go to recycling. Inert landfills are more expensive and usually only particular type of waste are landfilled (natural clay soils, contaminated soils, asbestos)*" [i4]. The main competition to CDW from the material side comes from (new) virgin material providers who are also very often (by extension of their initial activities) providers/users of recycled materials [i4, i6, i12, i14]. The price relation to (incl. new) virgin materials is a central and key factor for CDW [i1, i2, i4, i7, i8, i10, i36]. The recurring question is thus: "is the CDW material cheaper than the virgin one?" and "how to make CDW recycling cheaper than landfill disposal"?

Financial context. The financial context was referred to in several cases, mainly when considering the recent financial crisis [i1, i4, i7] but also regarding exchange and interest rates which ca have an influence on the overall CDW company capacity [i7]. In addition, an interviewee also referred to the lack of appropriate public finance (incl. accessible R&D support) for smaller companies in the area of CDW [i9, i25] which is far from being overcrowded by private financiers[206], or for more mature companies that do not qualify for start-up public support [i17]. Boosting investments and financing in the area however requires the presence of a pre-existing framework that appears to be missing in some countries [i20].

Proximity. Location (incl. when considering on-site providers) is an important element to be taken into account as transport distances (from recycling facilities, construction/demolition sites…) and availability play a role when considering the reliability of a business [i1, i4, i4, i8, i11, i14, i17, i22] – most likely for cost, availability and timing-related reasons[207].

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[204] See for instance I7 where the interviewee explains that the weight of the price in tender evaluation is an obstacle to the success of the company.

[205] Also targeted by another interviewee who explained "*Without prohibition to landfill there will be little or no recycling because the price of landfilling will be less than the price of recycling*" [i26]

[206] An interview highlighted that "*Banks don't step in because they are afraid, and they are not willing to take the risk (…) Most banks don't want to work with small companies. But there could be, e.g. an EIB for SMEs that targets funding for SMEs only" [i25]*

[207] An interviewee explains for instance that in the case of his/her organization, the "*distance to the treatment centre is important: they can only cover a maximum distance of 30 km from the demolition site to the treatment centre*" [i11]

Network benefits and partner-related risks. The availability of partners from which a company can derive and consolidate an operational and reliable value chain network is also critical [i4, i7[208], i8, i9[209], i10, i10, i32]. The predominant weight of the demand side of the value chain is here to be taken into account. One of the interviewees explains for instance that "*In crisis periods like today the main risk is the bankrupt of the clients and the consequent non-payment by enterprises"* and interestingly adds that *"this risk is difficult to avoid and control because the economical reliability of the clients, especially the new ones, is often unknown"* [i4]. Another referred to the fact that partners along the value chain (from both demand and supply sides) are of critical importance but need to be proposed a particular value to change habits at the different stages of the chain [i10, i11, i29, i32].

Demand. Market demand is thus critical and so is information flows' optimisation. Awareness is in that respect still to be improved if not just created[210] [i17, i21, i23]: as one of the interviewees explained, "*Abroad, there is a greater demand for materials due to the absence of these materials or their high prices. In our country, no one has yet discovered the potential of these materials and if so, its use is very limited due to the over-use of new materials*" [i6a]. An interviewee referred to the importance of awareness in a particular form: "*The biggest hindering factor in Country I, especially Region X, is the lack of willingness to use recycled materials. It is not in the heads of the people that make buildings that these materials can be used. The though process from those people is "I don't want to build a new building with waste"*" [i17]. In the contrary, another interviewee referred to another country where 'good will' could be observed despite of some slight price unbalance between CDW and regular materials – although tied to the existence of appropriate regulatory conditions [i20].

Time. Time also appears to be an important factor (an interviewee refers for instance to the so-called "First mover advantage") and relates to the acceptance [i4]

[208] In which case the interviewee referred for instance to the issue of financial risks (delayed payments, interest or exchange rates, etc.)…

[209] ...while this case rather refers to the importance of a "*collaborative approach*".

[210] An interviewee recommended for instance the inclusion of recycling into construction and architecture curricula – see [i17]

Technological factors

As showed in Annex 4 & 5, most technologies currently mobilised in the sector passed the commercialisation stage and show a strong level of maturity (see also i10, i10, i11, i17 and i20). Key technical issues remain which require more attention to the technological side of CDW activities[211].

Quality. While some market segments seem to reach a certain level of saturation, an increase in quality is seen as a competitive advantage, which highlights the importance of specific range of materials as well as technologies which can be seen as more efficient and effective in terms of processing CDW [i1, i2, i4, i6c, i9, i11, i12, i14, i15, i16, i17, i19[212], i20, i26, i29, i32]. While an interviewee explains that "*Quality guarantee is one of the main risks for producers of secondary (recycled) materials. In this respect there is competition with the virgin materials industries*" [i14], another interviewee makes the link to high-grade materials and explained that "*the future lies in the application of relatively more high-grade products*" for which colour-grade sorting and electro-fragmentation but also clearinghouse systems [i2, i4, i4, i5] show (among others) interesting potential. Another interviewee explained that "*The main barrier in [Country V] for better value-creation and recycling of construction waste is that much of the construction waste contain dangerous substances, which hinders that it can be recycled and reused as construction materials as this would be harmful to human health and safety and the environment. The key problem is that much of the construction and demolition waste in [Country V] is not correctly sorted and declared before being submitted to municipal waste sites*" [i10].

TRL. It is to be noticed that depending on different physical constraints (such as the pollution level or life span of a product), CDW materials will be more or less "*easy*" to separate and recycle [i1, i4, i9, i10, i14, i21, i27, i28, i29] while this step is of crucial importance in the success of the CDW recycling activity. Still, many technologies remain at a low Technology Readiness Level (TRL) and require further development to be both technically and economically reliable [i2, i8]. The same applies to material research as current standards and reference properties have to be matched [i2, i8, i18]. Three interviewees even pointed at the lack or even absence of infrastructure for waste recycling as a key barrier [i21, i23, i29, i30[213]]

Technical risk/uncertainty. Technical uncertainty and possible mismatches between certain materials and structures can prove to be a hampering factor for certain technologies/materials to reach a full market deployment (see for instance i8). An interviewee explains for instance that in the activity of his/her organisation, "*The greats risk is the ability to identify the nature of contamination, especially for aggregates. There is a need to ensure things go the right way, as this impacts the price*" [i11]. The separation process [i1, i2, i4, i6, i9, i11, i12, i14, i15, i16, i17, i19, i20 and i24] thus presents a level of technical risks for instance linked to the need to minimize potential contamination and "*better and earlier sorting of construction and demolition waste is regarded as a key prerequisite for creating larger and cleaner fractions of waste and better economies of scale for businesses in the market of recycling*" [i28].

IPR. An interviewee also explained that it was impossible to enforce a patent for which they filed; (s)he also mentions that China visits are avoided and that some of their business features are not made public or shared in order to avoid copies [i8]. IPR were also highlighted by another interviewee in the area [i32] who performs a lot of R&D to develop new recycling processes.

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[211] As a matter of example, one source explains that "*The main barrier in [CountryZ] for better value-creation and recycling of construction waste is that much of the construction waste contain dangerous substances, which hinders that it can be recycled and reused as construction materials as this would be harmful to human health and safety and the environment. The key problem is that much of the construction and demolition waste in Denmark is not correctly sorted and declared before being submitted to municipal waste sites*" [i10]

[212] In Japan, the technology trend can be characterised by an increase in automation and the robotisation of relevant recycling processes (source: i19)

[213] By extension, as the interviewee considered "*the presence of waste treatment and storage facilities*" as one of the two key success factors during his/her interview [i31]

Social factors

The main way to approach social factors in the EU context is in that specific case through a focus on "***demand***" and **expectations** from the consumer side.

- **Acceptance** can still be a strongly influencing factor [i4, i8, i9, i17, i20, i32 and i34] considered by some as a critical barrier: "*what is needed is that the acceptance of recycled CDW is improved. From that the technology and the capacity of production will increase. At the moment acceptance is the greatest problem"* [i17]. One of the interviewees explains for example that "*it is difficult to have a good acceptance by the neighbouring communities in the case of every type of waste management plants*" [i4] while another interviewee explains that protests arise when (a) new building(s) is/are being erected [i8].
- One should however not underestimate the **social view** on CDW: the main benefits of the value proposition presented or sought by interviewees are for instance expressed in terms of environmental benefits (see for example i3, i4, i4, i6, i7, i10b, i11, i16, i19, i26, i27, i29, i31) and offer jobs for low-skilled workforce [iI4, i5, i6, i7, i8, i14, i23, i25, i26, i29]. One of the interviewees even engaged into a partnership "*to establish a new education program in selective demolition addressing disadvantaged unemployed who want to re-enter the labour market*" [i27].
- An interviewee explains that "*At the moment the demand of recycled materials is poor, but the Green Public Procurement (GPP) could be a great driving force the next year*" [i4, i4, i14, i24[214], i30, i43] – suggesting that the **public sector** can support the social trend toward a circular economy (such as through the sustainable procurement of construction work but also fiscal incentives – see i14[215], i23 and i34). An interviewee explains for instance that "*It should be that public procurement is forced to make use of recycled materials above all others. At the moment there is no duty and there are no consequences of using primary materials. For a healthy competition, it is necessary that the public bodies should do more for recycled materials and especially that they should not discriminate in their own procurement documents, so there needs to be a consequence for this. It should be mandatory that there are stone-neutral invitations to tender, focussing on the size rather than the origin"* [i24].

[214] "*Especially in the public procurement of public buildings and structures the use of secondary raw materials in [Country II] is often completely excluded. In the procurement documents the staff either name specific materials that are primary materials and thus indirectly exclude secondary materials, or they actually specifically indicate that no RC construction material should be used in the bid because they think it is garbage, and we don't build with garbage. There have been one or two scandals in the past that have fed into this image (…)Additionally, there is also the problem that the employees writing the public procurement are not aware of the latest regulations or even make use of the same old procurement documents, and fail to consider the developments of technologies and materials in the meantime.*" [i24]

[215] Among other comments in that respect, the interviewee explained for instance that "*The government could take a more pro-active role by fully endorsing and applying Green Public Procurement. This relates to 2 aspects: material specification and tax incentives (e.g. low VAT tariff)*"

7/ Annex 7: Selection of business cases – Detailed explanations & scoring of business models

Business model type 1: "CDW Technology Developer"

Selling equipment/machinery to process CDW.

Economic profitability

In general technology development can be profitable, although not in every context. It might not be interesting to develop home technology while the technology is already available for import from western Member States.

Score: 2/5

Sustainability

Technology largely support better sorting of wastes; basic techniques like mechanical sorting, sieving, breaking as well as high tech solutions like automatized sorting based on image processing… This enhances the recyclability of the CDW fractions and thus the ability to reach the recovery targets.

Score: 4/5

Stability

The demand for new technology is low. The investment climate is not favourable in eastern European Member States. Old and second hand technology can compete the business model type.

Score: 2/5

Compliance

Compliance issues when using technology are noise, dust, water use intensity, energy intensity… Better technology however helps enhancing better compliance. Technology should be adapted to national context, e.g. on soil protection, it should also be in line with end-of-waste criteria.

Score: 3.5/5

Business model type 2: "Generic waste processor (incl. CDW)"

Collecting and treating all kinds of industrial and municipal waste, among which construction and demolition waste. Either recycling or disposing the waste itself or handing it over to a next step in the waste treatment chain.

Economic profitability

Big generic waste companies have achieved the right level of scale and can benefit from processes and technologies and downstream networks developed for non CDW wastes, like plastics, metals, glass… They are however usually organised on a market larger and farther away than 30 km, which is a limit distance for profitably collecting the heavy weight CDW. A mismatch of area coverage between CDW and other waste streams can occur.

Score: 3/5

Sustainability

The business model type can easily attain integrated sustainable solutions for glass metals, plastics and wood sub fractions, etc. If small, a generalist company might however miss specific expertise to treat CDW sustainably. If big, this is less an issue. Big integrated companies will be settling near urbanized areas where waste is available, they might miss the fine network to cover CDW generated outside a perimeter of 30 km around these urbanised centres.

Score: 3.5/5

Stability

Integrated waste companies offer a one-stop-shop and gain as such stability. They are less dependent from e.g. conjuncture dips in the construction markets as they have also market for other fractions. The logistical system is already in place, e.g. shared containers, for other waste fractions.

The disadvantage is the less favourable investment climate in the Eastern European Member States. They might also suffer competition from specialised or mobile CDW actors.

Score: 3.5/5

Compliance

Due to other waste stream they are used to handle, these companies should have a large knowledge base on legislation and compliance. However, due to the number of waste streams being treated, knowledge of CDW is not specialised.

Score: 4/5

Business model type 3: "Mobile Mixed CDW Processor/Collector"

Mobile breakers moving from wharf to wharf, generating usually secondary granulates on site.

Economic profitability

Compared to fixed installations (type 4), these business model types include smaller scale companies, flexible and with lesser investment costs.

Score: 4.5/5

Sustainability

The companies operate on site, thus entailing less transport impact. They are able to react on local CDW activities. There mobile installations are however limited and might less be able to perform enhanced sorting.

Score: 4/5

Stability

A high level of stability because they are less bound to one region.

Score: 4/5

Compliance

A lower level of compliance, because due to their mobility and flexibility there are more risks on unregulated activity. They are less easy to inspect and they might offer lower quality end-of-waste granulate directly for reuse on the wharf.

Score: 2.5/5

Business model type 4: "Stationary Mixed CDW Processor/Collector"

Collecting and treating all kinds of construction and demolition waste in a fixed installation. Either recycling or disposing the waste itself or handing it over to a next step in the waste treatment chain.

Economic profitability

This type of company has the right scale, adapted to the CDW market, combined with the right expertise on this specific niche. It benefits from a combination of specialization and diversification. Its investments drive towards CDW, unlike generic waste companies. An economic disadvantage is that they still need third downstream partners to treat waste fractions such as metals, wood (unlike generic waste companies who have these facilities in-house). They cannot keep all profits in one's own hand. They also need large space to stock waste.

Score: 4/5

Sustainability

This business model type is able to treat the bulk of CDW generated in urbanized areas, although it may not be possible to cover waste outside the 30 km radius due to transport costs. As most construction takes place in urbanized areas it will largely contribute to reaching volumes of CDW recycling in line with the WFD recovery target. This kind of company might not always have a suitable solution for each waste stream (unlike the general waste treatment company) and therefore have to landfill anyways.

Score: 4/5

Stability

This business model type largely depends on the supply of CDW and thus on the evolutions n the construction markets. It is vulnerable to recession and also depends upon the market value of specific secondary materials.

Score: 3/5

Compliance

This company type, unlike general waste companies, may have less experience with trans-frontier shipments, with PCB's, with other waste legislative aspects in the margin of its core business. Working with waste mixtures entails risks of doing things wrong. Nevertheless this type of company should have expert knowledge on the core CDW.

Score: 4/5

Business model type 5: "Gypsum Processor"

Gypsum waste treatment service whereby upstream suppliers pay a gate fee per ton of gypsum waste they deliver, downstream customers purchase recycled gypsum powder per ton.

Economic profitability

Downstream profitability is difficult because of big competition from chemical sector where gypsum is a residual product. This is an issue when important chemical industry is present, which is not always the case. The main economic part is gate fee. Economic profitability can largely be enhanced in case of close collaboration (industrial symbiosis) with the user of the secondary material.

Score: 4/5

Sustainability

Large amounts of gypsum are already recycled, but the volume of gypsum waste is quite low compared to the bulk of other CDW therefore it is not a vital voluminous waste stream.

Score: 3/5

Stability

Stability highly depends on the national context / market and the national industry landscape. In collaboration with another company a larger level of stability can be obtained.

Score: 3/5

Compliance

A large level of compliance can be achieved in this niche. Some examples of businesses have even reached the full cradle2cradle statute. A small risk on treatment of recycling residue remains present.

Score: 4.5/5

Business model type 6: "Hazardous CDW Processor/Collector"

Collecting polluted or hazardous CDW fractions and cleaning or decontaminating it for further treatment.

Economic profitability

This kind of activity requests a lot of investment for a relatively small quantity of waste. Due to better construction techniques and less use of pollutant components the market for contaminated CDW may shrink on the longer term. E.g. tar contaminated asphalt or CDW containing asbestos.

Score: 3.5/5

Sustainability

Decontamination of CDW contributes highly to sustainability. Decontamination will remain for a while an essential step in the circular economy, cleaning up legacy substances out of the recycling cycles. Nevertheless the quantities of hazardous and contaminated material are rather low compared to the bulk of CDW, which means that the impact of the business model type on reaching bulk amounts of recycling in line with the WFD 70% recovery target will be modest. Transport costs may also contribute to environmental impact.

Score: 3/5

Stability

The business case model may enter into competition with export to existing installations in western European Member States. The quantities of available waste may decrease into time.

Score: 2/5

Compliance

The compliance of these techniques is high because highly inspected, nevertheless because of the nature of the material high risks may occur.

Score: 4/5

Business model type 7: "Plastics Processor"

Processing of plastic fractions of CDW (PE and PP) in the form of granules and sales of secondary raw materials for the plastics industry.

Economic profitability

The actual downstream profitability is low because of downstream competition with qualitative high and low prices primary raw materials and because of competition with low cost alternatives. High quality recycling of plastics is technically complex because of the need to obtain pure fractions and the large diversity of plastic types and combinations used in construction.

Score: 2/5

Sustainability

The contamination risk is rather high because of a large fraction of PVC which contains all kinds of stabilisers and additive materials. The quantity of plastic CDW is rather low compared to the total amount of CDW which means that this business model will only partially contribute to reaching the overall recovery target of 70%.

Score: 2/5

Stability

The market may be over-supplied by plastics waste and secondary raw materials when the Chinese borders for plastic waste treatment will close in 2018. The supply market may also be variable and depend upon the market evolutions in construction.

Score: 2/5

Compliance

Due to contamination risk the business model has a compliance related risk.

Score: 3/5

Business model type 8: "Bricks Processor"

Careful deconstruction and processing of bricks for reuse.

Economic profitability

Two kinds of business case can be developed; recovery of high quality vintage bricks to be reused in decorative facades, or recovery of bricks as alternative to virgin bricks. The first approach aims at quality, the second one at price. Both can be profitable, although the second one may be more adapted to eastern European Member States.

Score: 4/5

Sustainability

The focus is fully sustainable, oriented on reuse without loss of added value and for the same purpose. Because only a limited (although still important) fraction of CDW consists of bricks its recycling will only partially contribute to realising the overall target of 70% CDW recovery as outlined in the WFD. Bricks can be kept into reuse cycle for a few rounds but not eternally.

Score: 3.5/5

Stability

Stability is hindered when not all markets use bricks in the same way. Selective deconstruction is necessary, but without regulations selective deconstruction will only occasionally occur. Legislation and policy development, with its focus on reuse and on circular economy favours the business model type in the long term. The stability risk is present but diminishing.

Score: 3.5/5

Compliance

The approach is compliant, although CE marking may be as source of problems. The generation of secondary bricks is not yet a standardized process.

Score: 3/5

Business model type 9: "Selective Deconstruction"

Replacing demolition, which generates especially mixed waste, by a technique of prior inventory of materials plus further selective deconstruction in which separated fractions of materials are generated at source.

Economic profitability

Selective deconstruction is more expensive than traditional demolishing, requiring more labour and time. It is however a not capital-intensive approach, which means that its profitability depends largely on fee costs. It is therefore fit for eastern European Member States.

Score: 3.5/5

Sustainability

The approach is fully based on reuse and circular economy, saving the quality of the material while tackling the bulk of the CDW. It is well-fit to achieve the 70% recovery target.

Score: 5/5

Stability

The business model type depends upon the economic evolution of the construction market, both on the front-end (deconstruction) as on the back-end (selling reuse material). It also depends on legislation imposing selective deconstruction in specific cases. The stability is however higher than for niche players.

Score: 3/5

Compliance

The business model is fully in line with actual and possible future legislation and policy development.

Score: 5/5

Business model type 10: "On-site Contaminated Soil Remediation"

Collecting and treating all kinds of industrial and municipal waste, among which construction and demolition waste. Either recycling or disposing the waste itself or handing it over to a next step in the waste treatment chain.

Economic profitability

The business model type is founded on legal obligations (where existing). Its main revenue is not the recovered material but the increased value of the land.

Score: 4/5

Sustainability

The business model is sustainable as it helps remediate historic and new pollution. It will however not contribute to reaching the 70% recovery target for CDW. Onsite soil is no CDW.

Score: 2.5/5

Stability

The business model type is market independent because polluted soils will still be present for a long time. It is however strongly dependent from Member State legislation on obligatory soil remediation and on the redevelopment market for polluted sites.

Score: 3/5

Compliance

The model is compliant as it is an instrument to implement legislation. There are however risks on sanitation below the legal norms.

Score: 4/5

Business model type 11: "Consultancy/Association"

Offering technical, legal or organisational/strategic consultancy to market players in the field of CDW management.

Economic profitability

When legislation of market conditions become more elaborate or complex, consultancy can contribute to the well-functioning and profitability of other business models. Consultancy can however be expensive, certainly in low revenue market conditions, where companies are tempted to do without and to solve problems and issues internally.

Score: 3.5/5

Sustainability

The business model type supports sustainability of others in an indirect way. It offers strategic contribution to policy and implementation of regulation.

Score: 4/5

Stability

The model is largely dependent from the market for services, which is the first market to suffer from business cycle dips.

Score: 2.5/5

Compliance

Consultancy contributes to the compliance of others, although consultancy can also serve to advise companies on how to minimize the burdens of compliancy or to search for the grey areas.

Score: 3/5

Overview of scores

Business model type	Economic profitability	Sustainability	Stability	Compliance
1. CDW Technology Developer	2/5	4/5	2/5	3.5/5
2. Generic Waste Processor (incl. CDW)	3/5	3.5/5	3.5/5	4/5
3. Mobile Mixed CDW Processor/Collector	4.5/5	4/5	4/5	2.5/5
4. Stationary Mixed CDW Processor/Collector	4/5	4/5	3/5	4/5
5. Gypsum Processor	4/5	3/5	3/5	4.5/5
6. Hazardous CDW Processor/Collector	3.5/5	3/5	2/5	4/5
7. Plastics Processor	2/5	2/5	2/5	3/5
8. Bricks Processor	4/5	3.5/5	3.5/5	3/5
9. Selective Deconstruction	3.5/5	5/5	3/5	5/5
10. On-site Contaminated Soil Remediation	4/5	2.5/5	3/5	4/5
11. Consultancy/Association	3.5/5	4/5	2.5/5	3/5

Normalisation of scores

These scores need to be normalised on economic profitability and stability, to achieve a maximum value of 5 for the most preferred alternative:

Business model type	Economic profitability	Sustainability	Stability	Compliance
1. CDW Technology Developer	2.2	4.0	2.5	3.5
2. Generic Waste Processor (incl. CDW)	3.3	3.5	4.4	4.0
3. Mobile Mixed CDW Processor/Collector	5.0	4.0	5.0	2.5
4. Stationary Mixed CDW Processor/Collector	4.4	4.0	3.8	4.0
5. Gypsum Processor	4.4	3.0	3.8	4.5
6. Hazardous CDW Processor/Collector	3.9	3.0	2.5	4.0
7. Plastics Processor	2.2	2.0	2.5	3.0
8. Bricks Processor	4.4	3.5	4.4	3.0
9. Selective Deconstruction	3.9	5.0	3.8	5.0
10. On-site Contaminated Soil Remediation	4.4	2.5	3.8	4.0
11. Consultancy/Association	3.9	4.0	3.1	3.0

8/ Annex 8: Minutes of the Validation Workshop Nov. 16th 2017

IDEA
CONSULT thinking ahead

16 November 2017
Workshop Minutes:

Development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure

Workshop Minutes | 23 November 2017

Prepared for:

European Commission

DG for Internal Market, Industry, Entrepreneurship and SMEs

Industrial Transformation and Advanced Value Chains

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1

TABLE OF CONTENTS

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2/ Objectives

ABOUT THE WORKSHOP: The aim of the workshop is to provide cross-validation feedback on the business cases developed within this study. The targeted achievement is the validation of the business cases through stakeholder participation and formulation of steps towards the practical implementation. Stakeholders include policy makers from EU and national authorities, investors, and entrepreneurs.

AIM OF THE STUDY: The aim of the overall study is to stimulate the uptake of good business practices in lagging Member States and fostering investment and innovation in Construction and Demolition Waste (CDW) recycling.

3/ Agenda

Time	Activity
9:45 to 10:00	**Registration**
10:00 to 10:15	**Introduction (Plenary)** - Frame, aim and targeted achievement – Elisabeth Hamdouch, Deputy Head of Unit (European Commission DG GROW Unit C.1)
10:15 to 11:00	**Session (Plenary)** - Introduction to the results: Dr. Valentijn Bilsen (IDEA Consult) - Results of the study: Dr. Ir. Joris Van Ostaeyen (Van Ostaeyen Consulting) ○ Business model typology ○ **Five selected business cases**
11:00 to 11:30	**Testimonials (Plenary)** - Presentations by Construction and Demolition Waste (CDW) recycling companies with a link to the business cases ○ Mark Tomlinson – Business Development Manager, Lafarge Holcim (FR) ○ Claus Juul Nielsen – CEO and owner, Gamle Mursten (DK) ○ Gene Maertens – CEO, Top-Mix (BE)
11:30 to 11:45	Coffee break
11:45 to 12:45	**Interactive breakout sessions** - **Focus**: discussion of business case key parameters, simulation of outcomes focussing on application in lagging Member States
	Breakout session 1 **"Niche business model"** a) Bricks processor b) Gypsum processor **Breakout session 2** **"Mixed CDW processor"** a) Mobile mixed CDW processor / collector b) Stationary mixed CDW processor / collector
12:45 to 13:45	Networking lunch
13:45 to 14:15	**Session on findings from Breakout sessions (Plenary)** - Presentation of results of breakout sessions and feedback on overall findings
14:15 to 15:00	**Financial session (Plenary)** - Financing the Circular Economy – Jonas Byström (European Investment Bank)
15:00 to 15:15	Coffee break
15:15 to 16:00	**Panel discussion (Plenary)** - **Focus**: How to ignite the entrepreneurial actions for Construction and Demolition Waste recycling in lagging Member States? Steps for concrete action. Moderator: Dr. Valentijn Bilsen (IDEA Consult) Speakers: ○ Vincent Basuyau (European Commission DG GROW Unit C.1) ○ Jonas Byström (EIB) ○ Claus Juul Nielsen – (Gamle Mursten – DK) ○ Gene Maertens – (Top-Mix – BE) ○ Jef Bergmans (VITO – BE) ○ Steen B. Lohse (Social Capital Fund – DK)
16:00 to 16:15	**Closing remarks (Plenary)** - Main take homes and next steps

4/ Workshop notes

4.1 Introduction

Elisabeth Hamdouch (DG GROW, Unit C.1) welcomed the participants on behalf of the European Commission (EC) and presented key initiatives of the EC in the area of sustainable buildings, namely the Waste Framework Directive and its target of recycling 70 % Construction and demolition waste (CDW) in the European Union by 2020; Circular Economy Package, Framework for Environmental Performance of buildings; European Construction and Demolition Waste Management Protocol; Guidelines for Waste Demolition Audits. With the Construction 2020 the EC supports the change of the economy towards circularity. Still, the key actors driving this transition forward are the regional players and other local stakeholders. The EC is looking for ways to support in particular regions that are lagging behind in CDW recycling. Ms. Hamdouch pointed out that this study helps to understand the business models of CDW recycling facilities and provides some suggestions on how the lagging regions could be supported. The workshop will provide validation of the study results and allow for further feedback from the industry and other key players. She encouraged the participants to actively contribute to the discussions. CDW recycling business is a competing with other ways of waste management like for example landfilling. In addition, it requires upfront investment. Therefore, the EC wants to create a regulatory environment that promotes investments and development in the area of CDW recycling.

Vincent Basuyau (DG GROW, Unit C.1) welcomed the participants and presented the agenda of the meeting. He encouraged the participants to provide feedback, in order to further refine the business cases and thus support the development of CDW infrastructure throughout the European Union.

4.2 The study and business cases

Valentijn Bilsen (IDEA Consult) introduced the main outcome of the study, namely the five key business cases, with an underlying quantitative Excel tool each including about 50 parameters. The business type methodology was elaborated based on 48 interviews in 10 countries of which 39 with entrepreneurs and business representatives and nine with investors and financial specialists. The selected business cases represent most successful cases for upscaling the CDW recycling. Mr. Bilsen added that many business opportunities exist in this area.

Joris Van Ostaeyen (Van Ostaeyen Consulting) presented the qualitative business model typology framework. Business models are part of the business context including four aspects: regulatory/legislative, market/economic, technological and social. Essential characteristics of each business model include: value propositions; customers (downstream/upstream) and key partners; revenue mechanism(s); material streams processed; typical investment; main technologies and processes, main risks. Mr Van Ostaeyen explained that a SWOT analysis has been conducted, followed by a multi-criteria analysis, in order to select the top five business models for business case development. Based on that, the following five business cases were selected and further elaborated:

1) Gypsum processor;

2) Bricks processor;

3) Stationary mixed CDW;

4) Mobile mixed CDW;

5) Selective deconstruction.

Subsequently, the gypsum processor pilot business cases were validated by the European Commission, entrepreneurs and financial stakeholders. The four remaining business cases were developed taking into account the validation input. Finally, entrepreneurs validated the parameters of the four remaining business cases.

Mr. Van Ostaeyen presented the key success factors of each of the five business models. The key success factors for the gypsum processor business case include: the gate fee per tonne; enough supply of recyclable gypsum and material recovery rate. In case of the bricks processor business case, the key success factors include brick content and price of the input; price per recycled brick, enough market for high end bricks, as well as labour costs. The key success factors for the stationary mixed CDW business case include: the price per ton of mixed granulate and broken concrete; gate fee per ton of stony fractions and total number of tons processed. The key success factors for the mobile mixed CDW are different. In this case they include the crushing fee per tonne of output material; average tonnes per project; total number of tonnes processed and specifically during the first years ("production ramp -up"). Finally, the success of the selective demolition business case depends on accurate building inventory and project estimation; optimal trade-off of deconstruction and disposal; enough large projects to be able to utilise the capacity of the equipment, as well as metal revenue.

After presenting each of the business case studies, Mr. Van Ostaeyen listed the key findings of the study. First, niche models (bricks and gypsum) can be more profitable but also more variable than mixed CDW models (stationary and mobile). Second, a different dynamic is at play in project-based businesses (mobile mixed CDW and selective deconstruction) in comparison to pure material-based businesses (bricks, gypsum, stationary mixed). Third, often the viability is determined by regulatory aspects in the business context (e.g. gate fee in comparison to landfill costs). Fourth, CDW recycling businesses often have a relatively long payback period (5-10 years) and a modest ROI (1-7% annually). Finally, niche models and the selective deconstruction all depend to some extent on the willingness to pay extra for a more environmentally sound practice versus the no-recycling option.

4.2.1 Q&A

Jose Blanco (European Demolition Association) said that the basic statements of the study are wrong and that main barriers of recycling (like for example the need for transfer facilities in cities) were not taken into account. He pointed out that the main assumption of the study is that everything will be demolished, but this is wrong, because 60% of demolition companies are taking some materials out, so they can be reused. Thus, not everything is being demolished. Therefore, the main assumption of the study that the owner pays for everything is wrong.

Mr. Basuyau replied that a lot of quantitative and qualitative information was included in the study and that due to time and scope limitations it was not possible to look at more aspects/materials. Furthermore the Excel tools allow entering alternative values for a wide set of parameters without compromising the logic and validity of the business case and of the simulation exercise.

Christine Marlet (Eurogypsum) appreciated the study results and the calculation sheets saying that they can be very useful. She added that that most of the conclusions of the study are in line with Eurogypsum study results. It is valid what was said about gypsum. However, the quality of the recycling material, the quality of the recycled company and trust of the recycles towards the demolition is missing and should be added. Traceability, quality control of the selective demolition process and the recycled materials is vital.

Mr. Basuyau replied that these issues were addressed in the CDW Protocol. Moreover, it is difficult to depict this in numbers and is not the specific object of this study.

Vagner Maringolo (CEMBUREAU, the European Cement Association), asked which of the business cases includes cement.

Mr. Van Ostaeyen answered that in case of cement especially relevant is the mobile mixed CDW processors and stationary mixed CDW processor business case.

Phillipe Van Velde (OVAM) pointed out that there is a significant cost of quality control and asked if it was included.

Mr. Van Ostaeyen answered that it was included as certification costs.

Ms. Hamdouch (DG GROW) asked if the study team looked into synergies between business models (clustering)?

Mr. Van Ostaeyen answered that mobile and stationary plants are often combined.

Toine Janssen (PolyStryreneLoop BV) asked where to find polluted incinerator materials?

Mr. Van Ostaeyen answered that they are in the 11 business model, which can be found in the factsheet.

Jean-Pierre Pigeolet (Knauf Insulation) pointed out that the business model typology chart is misleading, because other materials like wood, metal, insulation materials are missing.

Mr. Van Ostaeyen answered that the figure is only mapping companies involved in this study. Other types of materials could be added.

Martin Policar (European Plastics Converters) asked if hazardous plastics was included.

Mr. Van Ostaeyen answered that hazardous plastic is described in the business model 11 factsheet.

Mr. Basuyau highlighted that this study should support the facilities lagging behind dealing with the main streams of waste. The focus of the study lies on the biggest waste streams, in order to support the reaching of the 70% target.

Christian Schempp (European Investment Bank) mentioned that in EIB assessments for example CO2 savings are used. He asked if this is also the case in this study. Mr Schempp also asked if pre-tax or after tax was used?

Mr. Van Ostaeyen confirmed that CO2 savings have been included. Calculations were based on after tax values but by setting the corporate tax rate at 0% the pre-tax numbers can be calculated.

Mr. Schempp commented that using pre-tax would be more useful.

Roumiana Zaharieva (University of Architecture, Civil Engineering and Geodesy (UACEG)) asked if the option of buying secondary hand equipment was included. She added that the prices in Bulgaria are very different than the numbers included in the study.

Mr. Van Ostaeyen answered that the model can be adjusted. The model is flexible enough to also include the assumption that the equipment was rented.

4.3 Testimonials

Mark Tomlinson (Lafarge Holcim) presented the circular economy ambitions from Lafarge Holcim. The company has a strategy that aims among others at multiplying by 4 the total amount of recycled aggregates towards 2030. Mr Tomlinson pointed out that the size of a city (the bigger the better) and enforcement of regulations are two key aspects promoting sustainable solutions. In this context, the example of London Olympics was mentioned, where due to green public procurement rules a substantial amount of recycled constructions materials was used. It was added that CDW recycling needs to take place locally. Mr Tomlinson highlighted that there is mistrust in the quality of the recycled aggregates on the market. In this context, a deconstruction and renovation pilot project in Paris was mentioned. A company offered a full circular economy solution by taking back, sorting and recycling 4,000 tonnes of demolition waste and by producing recycled aggregates from those demolition waste in a dedicated and local platform, including 720 tonnes to make new concrete for the renovation project in a local concrete plant. Still, the building owner feared that the aggregates could not deliver the required quality. Thereby, the price for this procedure is the same as using virgin materials.

Claus Juul Nielsen (Gamle Mursten) presented his company that is upcycling bricks. It currently employs 35 employees, has a turnover of € 3 million and processed about 3 million bricks per year. The company realises an annual growth of 41%. Mr Nielsen said that bricks that were produced some years ago are of a better quality and thus it is easier to reuse them. The potential for reclaimed bricks in Denmark is 47 million bricks per year of which

3% is reused. The valorisation of these would generate 440 jobs and create an additional turnover of € 44 million, as well as save 22,000 tonnes of CO2. The market is there to support this type of industry, because the demand is higher at the moment than the supply. Quality certificates (ETA, EPD and CE) are part of the upcycling process. Thereby, it is important to remove the hazardous materials before the demolition, in order to ensure that clean materials will be provided. When asked how to ensure that these upcycled bricks can be used again in the future, Mr Nielsen answered that the design for deconstruction is important. Upcycling of bricks can be done through available technologies. Separation and cleaning of bricks is done by vibration, they are selected by hand and stocked by machines (this could also be done by hand). Bricks of poor quality cannot be reused. The CE marking is relevant in this context, because the standard applies across the EU and allows for partner-based expansion into the rest of the EU.

Gene Maertens (Top-mix) presented his company. Top-Mix is part of the family-owned Group Verhelst. It started in 2006, Bruges Belgium. Top-Mix works closely together with the demolition and infrastructure department of the Group Verhelst; as such 20% of turnover is in-house business and 80% are for other clients. Three additional CDW processing sites have been set-up. Between 2006 and 2016 annual turnover rose from approximately € 5 million to more than € 20 million. Employment rose from five employees to more than 30.

The Top-Mix business model is a one stop-shop for all recycled materials (main stream includes bricks/stones, soil, concrete etc.). The company is also preparing ecological solutions for any type of CDW problem. They are the first certified centre in Europe dealing with asphalt containing tar (certified by COPRO). All recycled materials are certified at the plant. Mr. Maertens pointed out that regulations need to be in place and they need to be enforced. Traceability of the whole process is also very important. Mr. Maertens said that the plant is highly profitable. In order to put such a plant in place it is necessary to have a surface of minimum 4 ha; legislation and enforcement need to be in place; Use of recycled CDW should be prescribed in specifications for construction works; ecology premiums. Seven years ago, the Top-mix plant required an investment of about 1.7 Mio. Euro in order to be built.

4.4 Interactive break-out sessions

4.4.1 Breakout session 1 "niche business models"

- **Gypsum processor**

Mr. Bilsen explained the structure of the business case sheet. Interpretation of the business model, what it incorporates and what not. It was stressed that the Excel sheet is a tool where the essentials of the business case are modelled in order to be able to use it as an instrument for further assessment by entrepreneurs and investors alike. Evidently the case has borders. Not everything is in the hands of the entrepreneurs, financers and investors. On average the business cases contain 50+ variables which can be altered to help to assess the viability of the envisioned business case in a particular business environment. Entrepreneurs and financers can use the tool to assess whether the exogenous conditions perceived allow them to set up a profitable business, and within which period the investment will be paid back.

Mr. Blanco asked what the definition of the "gate fee" is.

Ms. Marlet explained that the gate fee is paid by the house owner/demolition company to the reprocessing company. She added that 15-20.000 tonnes are needed per year for making gypsum recycling a business worth the investment. She pointed out that production, as well as construction waste is used.

Mr. Blanco said that there is no business case for gypsum now, because there is lack of transfer facilities in cities based in 15-20 km radius of the demolition site.

Mr. Schempp said that this business case is less relevant for scarcely populated areas. In case of less populated areas transfer facilities could help generating the minimum scale and influx of gypsum material needed.

Mr. Bilsen specified that the business model presented incorporates the gypsum production residuals from the plasterboard manufacturers which is a relatively pure fraction, and asked who in Mr. Blanco's view should organise the transfer facilities.

Mr. Blanco suggested that the state authorities should facilitate such transfer facilities.

Mr. Bilsen inquired why the businesses could not self-organise these facilities, upon which Mr. Blanco indicated that in his view they were not profitable enough warranting private investment, and therefore EU – funding would be needed.

Mr. Janssen indicated that for such facilities with pure business motive no EU funding would be available and that other solutions are possible referring to the PolyStyreneLoop which is currently co-financed with the EU's LIFE project.

Ms. Marlet pointed out that the deconstruction/demolition phase is missing in the model, because it relates to the landfill cost. She added that the gate fee of 28€ is much too low and that it needs to be checked with gypsum recyclers. In addition, it is important to have landfill bans and have them enforced by the Member States. If the landfill cost is high then the material will be recycled. Selective demolition is a precondition for avoiding gypsum in stony fractions.

Mr. Pigeolet indicated that a minimum gate fee would be rather around 35€

Mr. Blanco said that the gate fee in Germany is 10€. If the gate fee is 35€ recycling of CDW will not work.

Mr. Schempp commented that such a high gate fee makes the ROI very high [*after simulation*]. He pointed out that the workshop participants should look for a variable in the calculation sheet that needs to be adjusted.

Ms. Marlet said that Eurogypsum is analysing the waste flows, however currently it is not possible to define the stock of gypsum available. The IDEA study assumes that the market is there, but the market is not there yet. She added that, in some Member States gypsum recycling does not exist, but there are also countries were gypsum recycling is taking place. Therefore, a differentiation should be made.

- **Bricks processor**

Due to time constraints, it was agreed that the exchange on this business case will take place on a bilateral basis.

4.4.2 *Breakout session 2 "mixed CDW processor"*

Figure 1: Notes from the discussion during break-out session 2

Source: Kretz, D. 2017

- **Mobile mixed CDW processor:**

Mr. Van Ostaeyen opens by indicating that the aim of the session is to look at the key success factors of those models, particularly also to think about what happens if this model is applied in other members states where there is a lower recycling rate, the so-called "lagging member states".

- Summary of the main discussion points:

1) Crushing fee:
   - It was indicated that there are differences between concrete and stony fraction with regards to the crushing fee
   - *Mr. Tomlinson* indicates that the crushing fee would be double in London compared to the average and could largely fluctuate taking into account the different economies of the Member States, e.g.
     - 2€ in Warsaw, and 8€ in London is not unthinkable (huge range)
     - 3€ per tonne in Flanders
   - *Mr. Tomlinson* indicates that most of the time the material is reused on site
   - It is discussed that per tonne generated CDW, 100% cannot be recycled
     - Assumptions on the recycling rate made as a part of the business case can be found in the business case excel file in one of the sheets in % (ca. 70% is assumed here)
     - Only about half of the 1% waste generated from stony fractions goes to disposal, there is still an economic value for most of these materials
   - It is indicated that sometimes crushed materials are sold to other customers close by the crushing site. There is an opportunity for symbiosis of demolition/construction sites.
   - *Mike Van Acoleyen (Arcadis)* asks: would it be possible to mirror the crushing fee to the gate fee of a landfill? E.g. cost for transport, disposal

12

- It is discussed that this depends on landfill and gate fee, if it's cheaper to dump, they will be dumped or illegally dumped Calculation is based on cost of disposal + logistics cost of getting it there, e.g. if 50-100km to nearest landfill, and cost is high, it would be linked to cost of processing, i.e. that would be linked to what they charge the customer
- It is added that alternative options per tonne also plays an important role (e.g. how much cheaper is the alternative such as landfilling)

– *Mr. Tomlinson* indicates that these point discussed above are the main drivers of mixed CDW processing, only regulation is the other main driver
  - He adds that the more you can use on site, the better
– It is mentioned that there are very low barriers to market entry for a mobile crusher
  - A risk remains: that a low crushing fee would be too low to encourage the recycling activity
– It is added about the composition of the crushing fee: Customer usually pays per tonne of crushed material treated
– It is clarified that a crushing fee for a mobile installation is comparable to a gate fee for a stationary installation

2) Size of projects / urban vs. rural context
– *Mr. Tomlinson* indicates that this model (the rural model) doesn't work in rural areas unless a motorway is being built. In this model the risk remains:
  - Have to remove materials a long way if you cannot use them in the site itself
  - And the natural availability of virgin material is higher (competition)
– The is a call for a need to bring in public procurement
– It is mentioned that recycling of materials works best when you demolish and build again a new building as you can recycle the material e.g. in the foundations
– An important factor is mentioned: if the availability of raw materials cheap, i.e. if there is a lot of primary aggregate, people would not buy recycled. However when a gate fee/crushing fee is higher you can sell your materials cheaper

3) Other aspects mentioned
– It is indicated there is a mechanism missing in project processes or project specifications to include recycled materials. There should be a step in which this idea is foreseen.
– It is indicated that a dominant issue with recycled materials is certification
– A further problem is mentioned: the problem of enforcement of regulation
– It is indicated that there is a challenge of quality vs. perception of quality
– It is mentioned that a general issue in CDW recycling is lack of ambition: companies hesitate to put their name on the recycled materials due to liability concerns
– A general issue is mentioned: Liability. There is a reluctance to give the "all clear" to the structure when it is built with recycled materials
– A further challenge is mentioned which is sand (by-product of crushing)
– *Susana Lopes (LIPOR)* asks whether we considering open / closed recycling?
  - Open recycling is downcycling, concrete to concrete is same value (closed loop, real circular economy)
– *Ms. Lopes* adds that the Joint Research Centre is currently working on Best Environment Management Practices (BEMPs) mostly on municipal waste management, could be interesting to show best practices for CDW recycling to improve this.

4) Examples:
– *Roumiana Zaharieva (University of Architecture, Civil Engineering and Geodesy (UACEG))* indicated that they use more recycled aggregate in bridge building, it is feasible but it not permitted.

- *Eunan Kelly (CDE Global)* presents the example of the building of a new stadium in Glasgow had green public procurement in which it was indicated that there needed to be at least 25% recycled materials. Quickest to way volume was ground, not recycling on windows and doors, but with ground recycling. Need to recognise the role of green public procurement
- *Mr. Tomlinson* adds that in some locations prices of secondary granulates are higher than those of primary granulates, e.g. in Zürich where there is regulation that stipulates a minimum percentage of secondary material to be used in construction projects.
- *Ms. Lopes* indicates that according to reporting alone they have achieved targets however they do so by backfilling. The Commission indicates that the Regulation is being revised. Portugal is exploring a green dot package EPR for the whole value chain on CDW. Consultants indicate that so far EPR in CDW only exists for some materials (for example photovoltaic cells). Applying EPR for construction materials with a lifespan of up to 100 years or more is a challenge.. In the Netherlands, they are the most advanced in EPR for CDW.
- *Ms. Zaharieva* adds that in Bulgaria, mobile crushers don't get permission, because of the environmental considerations are decided & regulated at regional level.

- **Stationary mixed CDW processor:**

Mr Van Ostaeyen asks what whether the mobile or the stationary model would be more suitable for implementation in eastern EU.

- Summary of key points from the discussion:
  - Due to transport levies per kilometre being implemented through regulation, this favours scenarios in which less materials have to be transported (e.g. mobile crusher)
  - The environmental regulation and cost are high, not always applied to mobile crushing. It's difficult to track for inspection whereas a fixed site faces the environmental parts with more scrutiny because it is more inspected. However, in some countries the regulations do not allow mobile plants to operate.

4.5 Findings from the breakout sessions

- Summary of the key points from the breakout session 1 on "niche business models":
  - Market: uncertainty of access to the material – the stock of available gypsum cannot be defined;
  - Price of landfilling is important – if the price is too low it, is more challenging to recycle;
  - Link with demolition industry should be stronger in the business model;
  - Transfer facilities are important, especially in context of bulky waste;
  - Gate fee of 28€ is too low, it should be at least 35€. Still, this fee is not feasible in all Member States;
  - Model can only be used in very urban/densely populated areas;
  - What is the minimum size of the plant to make it feasible?

- Summary of the key points from the breakout session 2 on "mixed CDW processor":

The breakout session analysed what could make the business models work. Apart from many other elements following issues where stressed:

- Quality issues – lack of trust in the secondary construction and demolition materials – certification can help to overcome this challenge;
- Price of and competition with virgin material have an impact on the viability of business models;
- Fuel prices and e.g. kilometre levies are also important to define the costs;
- Distances between users and producers play a role – CDW recycling needs to take place locally;
- Impact through dust and noise are elements having impact on the acceptability of business models;
- Legislation and enforcement is vital;
- Policy impact on prices of the secondary materials can create the context within which a business case can flourish; support on green procurement and the application of green public procurement are key;

- Possibility of on-site use of CDW should be considered;
- The industrial symbiosis concept is relevant in the context of CDW recycling, in case on-site use by the waste producer is not feasible but the material can be useful for neighbouring companies or projects;
- It is discussed (without giving the answer) whether extended producer responsibility schemes are relevant to support the business cases;
- Size of projects is important to make them viable or not viable.

4.6 Financial session

Jonas Byström (European Investment Bank) indicates that this study provides good templates and the EIB is enthusiastic about the results. They believe it will be useful for assessing a potential company for financing.

- Summary of the key points from the presentation by the European Investment Bank:
  - About EIB:
    - Have very little margin for profit. 3,000 staff based in Luxembourg. 84 billion lent last year, mainly in EU ranging over many investments in environment, infrastructure, innovation, with a large share to SMEs
  - Lending: Two types:
    - Direct financing, e.g. big highways, towers, waste treatments plants. Also lend to smaller companies with typically large tickets. It is generally a more complex procedure to lend
    - Intermediated: More risk with cross equity, more return. This is available for smaller financing. There is typically another intermediary, someone closer to project that has a quicker reaction time. This can also include guarantees
  - Direct:
    - InnovFIN with an innovation focus up to 3000 FTE include technical and business model innovation, can be of relevance in CDW size > 7.5 million direct loan
    - EFSI strategic investment, guarantee under Juncker plan, enable taking more risk. At least 50 million, lend 25 million, cover up to 50%, but in some instances they go above
    - 350 engineers doing appraisals and due diligence, sector issues and advising. Christian Schempp is a full time circular economy advisor. In house expertise helping promoters with technical aspects. By doing appraisal and due diligence it is a quality standard, and leverage through their involvement to get other investors in the project
  - Indirect
    - Towards / through a bank. They don't due to the due diligence, agree rather on sector, criteria, product type for the area. They extend the credit line, agree use, and monitor use of it
      - E.g. Benelux: Rabobank, lending with an impact (environmental) (social) interesting projects result (SMEs and Midcaps III)
      - E.g. Belfius: smart cities, climate and circular economy EUR 200m. they go out and bring the projects to them, otherwise they are monitoring them
    - On the homepage, there is a list of banks with whom they have operations, in the country you operate you can find this out. This extends benefits of the cheap loan. One could also look at ways to do this for intermediary lending through National promotional banks (NPBs).
    - EFSI can be extended to an NPB to create platforms, to extend money and take certain risk through the platform.
  - EFSI

- Wide scope, but among these target sectors environmental and natural resources are mentioned
- Mature, be structured to mobilise private capital,
- Idea it to leverage private capital and by leverage de-risk
- R&D and innovation
  - OPEX
  - CAPEX
  - First of a kind, advanced and KETs
  - Mid cap is up to 3000 employees (these companies are well within this limit)
  - Innovation or fast-growing employees has to be at a 10% per year basis

- EIB:
  - Created in 1958 to try to promote implementation of EU policy. They try to do what they can to support implementation. The Commission is really trying to promote circular economy. In the last 5 years 2.6 billion to CE project, but to his knowledge 0 in the construction sector. They are really keen to work with us to get this number up and have a wide range of products that can be applied. If the products don't meet the needs, then they would be ready to try to adjust or develop new ones. Not just looking at loans, but advising promoters looking at business models, looking at improving bankability.
- EIB & CE
  - Their instruments might be able to bridge such gaps. Suggest downloading the flyer. They are mainly working in EU and around the world, they are building experience and expertise, by engaging in projects, they ask questions, and push to think further and differently
- CDW
  - There is still a lot to do, to do more and do better, to get better quality, better quantity. They also try to target the multi materials, sanitary materials and find ways of targeting these. There are new technologies and risks. Feedstock and offtake side are also needed. As the EIB they are the promoters. Key success factors are knowledge of markets & competitors, business plans assessment, ensure that they have an equity stake in the project and that they are doing their best to ensure this. Credit metric could be adjusted to be beyond what they normally do.
- Risk in CE projects:
  - Limited collateral
  - Few assets as security
  - Technologies also have some commercial risks
  - Market studies and public awareness challenge include customers and industry. Need to raise insight in what is possible and what are the real benefits of using these materials
- EIB benefits from having
  - Good portfolio projects. They are not used to taking risks. Their credit rating is very good; therefore they can borrow and lend well. They are also very careful in selection
- Eligibility:
  - Need long term projects
  - Priority sectors:
    - Transport, energy, urban development, environmental protection, resource efficiency
  - Don't refinance
  - Mature

16

- Sound
- Credible
- Robust technologies should be robust, mature and have a track record,
- Cost revenue prediction, up & downstream and sensitivity to this
- Can you find the volumes and reach the ones you want to offtake?
- Viability
- Technical analysis
- Predictive cash flows
- Sensitise and stress looking ability to repay.

- Circular economy advisory hub:
  - European Investment Advisory Hub. Consists of financial advisors. All requests are channelled through this hub

4.6.1 Q&A

Mr. Bilsen asks Mr. Byström to indicate the instruments focussed on the circular economy.

Mr. Byström refers to the Belfius bank example, where they agreed on 200,000 €. In this case Belfius do the promotional material and they pick up the portfolio, and they look at whether or not those projects meet the criteria. There is also an example of a promotional Italian bank (NPB) working with them. There are also cases of more dedicated funds for the circular bio-economy, which is a first one that is still on a very early discussion stage. Like the Belfius and Italian case the EIB are open and interested in seeing what could be the means bundle projects, e.g. 1, 2, 3 million are small and could work for an intermediary loan, but if you could find another way to bundle, with NPB and EIB focussing on circular economy on CDW specifically, this could also be possible. Key aspects to answer include: (i) what are their needs and (ii) what the projects and (iii) look at how we can aggregate and (iv) bank them. Framework loans are also done with cities, they city have an investment programme, they list what kinds of projects they want to do, and agree on allocations, and as well for larger cities and loans. They could limit it to circular economy with a certain volume - that would be an interesting focus for them.

Someone asks: how does the advisory office work in practice? Does it also address the NPB?

Mr. Byström replies that the advisory office also has an office in EIB. They work with NPB but not in detail and not in a formal extended way. NPBs are partners of the EIB, so they are already involved. There are many ways to approach the bank, not just using the online platform, but also each has country offices in each member state. In those country offices, you will also find receptors that can also forward a project proposal, where an advisory component is involved. The hub is an entry point, but they do not provide the advice. That is done by advisors.

Mr. Basuyau asks: for InnovFIN, where lending is typically 7.5 – 25 million, and regular EFSI, which is generally >25 million, what can be done with these instruments given that CDW recycling typically deals with less than 10 million€ investments?

Mr. Byström responds that if you have an SME with one plant, then EIB cannot do a direct loan. It has to be an intermediary, or an aggregation. However, a waste management company that does 50 investments of a certain or related kind can look at the bulk, where many small facilities are considered e.g. 3 year programmes at a bank for CDW or circular economy also for companies and municipalities. Bulking in a singular company is also possible.

Ms. Marlet indicates that in the search for a loan or other investment it is sometimes already difficult to find 2 million €, e.g. intermediary banks, what can be foreseen in this case?

Mr. Byström replies that they also invest in funds. Funds can relate to smaller companies. In the Netherlands, circular economy received also 2 or 3 million € investments specifically for CDW. With regards to intermediary banks, it is agreed what they can and cannot do, with smaller or larger amounts, using equity and senior loans.

4.7 Panel discussion

Mr. Bilsen poses the question to Steen Lohse: Can you please say what your motivation in investing in Gamle Mursten was? And what are you views on the EIB presented funds?

Steen Lohse (Den Social Kapital Fond) replies that in Denmark there are currently 450,000 persons out of the labour market. Social capital fund is investing in the social friendly projects. In the case of Gamle Mursten, a few people working in the plant has psychological issues. They have a focus on social integration, saving cultural heritage and positive environmental impact. In term of finance they started with a private loan and converted it to equity. They are on the verge of next big leap for the company. In addition, they are establishing a foundation for circular economy in Denmark to create companies and do research and this foundation will be part owner of the processing plants, and with better processing plants, the more financially sound the foundation will be. The Foundation will do political work and will be able to invest in new areas of circular economy. They imagine creating 500 jobs for disadvantaged people. Social capital fund is an impact oriented investor. In our foundation and in our work, we have 40 million euros under management that the future of investment market is investing in companies like this. We expect that the future generation will look at more positive impact projects.

Mr. Bilsen poses the question to Claus Juul Nielsen: How would you see the exporting of your business model to other member states and what would be the financial implications or demand for that?

Claus Juul Nielsen (Gamle Mursten) replies that the mobile sorting unit bring the bricks into plants, and they sell them in Hamburg or elsewhere. A key issue for them is the CE certification. Certain locations have a high availability of bricks and those are areas that they will target including Eastern Germany, East EU, the UK, Hungary. Brick recycling is a very old practice which has been dated back 384 years.

Mr. Bilsen follows up to Claus Juul Nielsen: The heritage link: is that particularly important in your business model?

Mr. Nielsen replies that they are able to allow municipalities, e.g. a school wants to have their bricks back into their new school. Through their work new markets become aware that it would be possible to reclaim their own material. There is a need to raise awareness because the market doesn't have that information at present. There is also a need to bring the technology out to areas where bricks are in the EU. Technology needs to be developed and the new market will be developed, this is valid for many materials in EU. It's from these companies that we are able to create new markets.

Mr. Bilsen poses the next question to Gene Maertens: You have a one stop shop. How would you see the exporting of your business model to other member states and what would be the financial implications or demand for that?

Gene Maertens (Top-Mix) indicates that there are problems of legislation in other countries. It's possible but two conditions need to be met: firstly, it should be allowed to use recycled materials in roadworks and the second factor is price. We can always compete with natural products because we have a gate fee. Whether you make money at the gate or make it when you sell it, it makes no difference. They had a large work of 850,000 tonnes and sand was for free. This was possible, and it depends on the gate fee, you can even give money to reuse the material if needed. The problem is landfills: when you raise the taxes, people will be searching for and finding solutions such as illegal dumping.

Mr. Bilsen follows up to Gene Maertens asking: which countries would be easier, which would be more difficult?

Mr. Maertens indicates that this depends on legislation. It is easier to search for products for landfill, and in certain countries you can't reuse materials the way you can here. There is also an issue of trust in recycled products. For quality, it is difficult to compete with natural products, but for price there is typically not an issue.

Mr. Bilsen poses a question to Christian Schempp: what can the EIB do to help the lagging Member States improving their CDW recycling record?

Christian Schempp (European Investment Bank) recommend blending of EU structural funds with EIB funds. Romania receives massive EU structural funds for SME support and other sectors. Many funds will be unused because of lack of capacity in national authority etc. The idea would be to use those funds as a guarantee for dedicated financial instruments to finance SMEs e.g. very dedicated to circular economy. There are certain funds that are managed by European Investment Fund for support of SME competitiveness. They can lend money at lower cost to promoters which has the banking experience, e.g. a bank could set up for countries lagging behind. However, this will not solve problems of regulation, where landfilling does not cost much it will be difficult to establish technically and economically sound projects and commercially viable projects. They can increase offer of financial instruments, but also need to work on policy and that is the responsibility of the member states. As long as landfilling is cheap in Romania it will be difficult. Enforcement is also a greater problem. There is a need for a systemic approach is needed to tackle this all, with funding financing, both structural and EIB, regulation and promoting participatory approach, involving all stakeholder involved in the process. As indicated by Mr. Lohse, the millennium generation will also change habits. Until them, a lot of awareness raising is needed and education to teach to consumer of the consequences of their consumption habits.

Mr. Bilsen follows up to Christian Schempp: Innovation finance is that something applicable to CDW?

Mr. Schempp indicates that the innovation aspect needs to be proven in order to be accepted. For EFSI it is not entirely correct to say it is above 25 million, but they need the projects to look into in order to assess their eligibility on a case by case basis. If there is a project that is worth looking into and advisory services might be required, please approach. Advisory services are available also at reduced cost. For the cost of advisory service: Public promoters are 100% free of charge. Private promoters there is a few charged beyond a certain basic and limited advisory volume. For SMEs, there is a rebate. If there is an innovation component, then the advisory is also free of charge for them. It should be noted that innovative business models can also qualify.

Mr. Bilsen poses a question to Jef Bergmans: which technologies are most promising for CDW recycling and what is the innovation potential?

Jef Bergmans (VITO) replied that emerging technologies on CDW recycling are mostly focused on a more high-grade recycling (e.g. the use of concrete aggregates in high-strength concrete) and on the recycling of certain smaller problem fractions. To reach the target of 70% recycled material from C&DW, the current technologies should suffice if other (e.g. legal) conditions are met.

4.8 Closing remarks

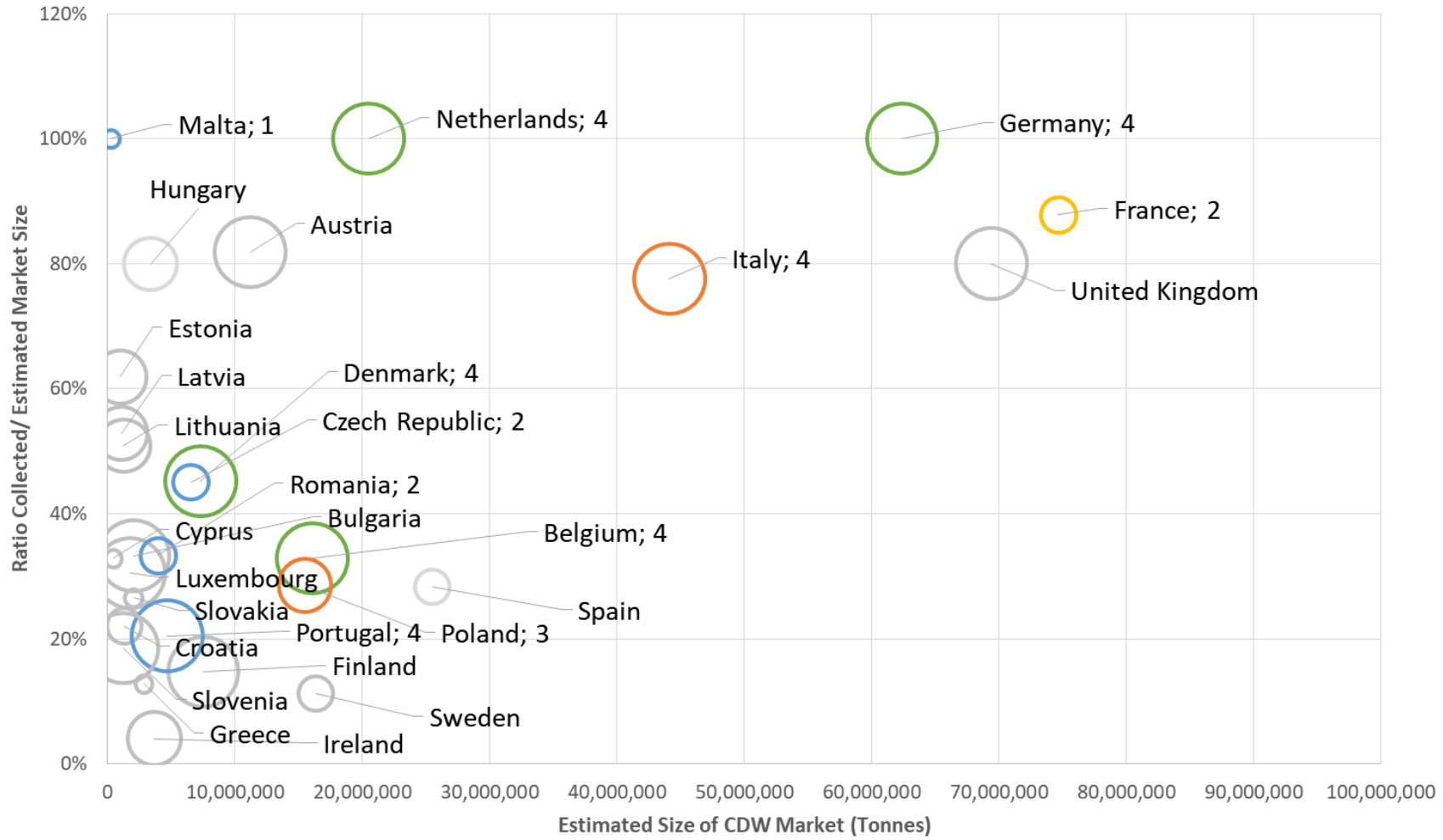
Vincent Basuyau (DG GROW, Unit C.1) summarises that technology is there, finance is there and the legislation is written, so everything is all there. He indicates that there is a novelty to this approach, looking at technical and management angles, asking how we can overcome the barriers for marketing CDW is aim of DG Grow. Dg Grow is also looking to support the WFD 2008, together with DG Environment, but know that asking Member States to reach the target of 70% recycled ('recovered' according to DG Environment) requires: (i) implementation, (ii) enforcement (iii) the availability of technical tools and (iv) entrepreneurship and a matter of development of these businesses, where some of them have been developed with success. He adds that in this workshop testimonials

have been presented with strong faith in the truth and the validity of the business models are at the core of success. The business models and cases presented here have not covered all materials and all business models in CDW recycling. This is a new approach and we cannot cover everything within the limited time available. This is a new approach. He indicates that there will be an assessment of this event in the coming days. In addition, this work will feed into thematic group 3: natural resources in the construction sector. CDW recycling is a difficult business, which is not highly profitable and the stability, elasticity, small conditions can affect the viability. These are critical criteria for MS, regional areas, and when we imagine developing this kind of business this is a part of the strategy. The aim is to improve confidence in product and stability in CDW recycling. The Commission wants to ensure that all tools at EU level can be used for implementing these businesses.

Antonio Paparella (DG GROW, Unit C.1) indicates that there was a challenge to initiate this project as it was a novel approach. It was initiated in the investment platform Europe, whereby they were asked to make a proposal for an initiative to be put into place. At this moment, recycling infrastructure was a subject of interest. There continues to be a need to convince a financer and build common views. Business cases were subject to a lot of discussion, to have an understanding of influencing variables and a wish for explaining business models and the business case. This work has merit for giving a push forward.

20

9/ Annex 9: Estimated amount of CDW generated related with CDW collection ratio (all Member States)



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