European Commission

Background data collection for future EU end-of-waste criteria of Construction and Demolition Waste

Final Report

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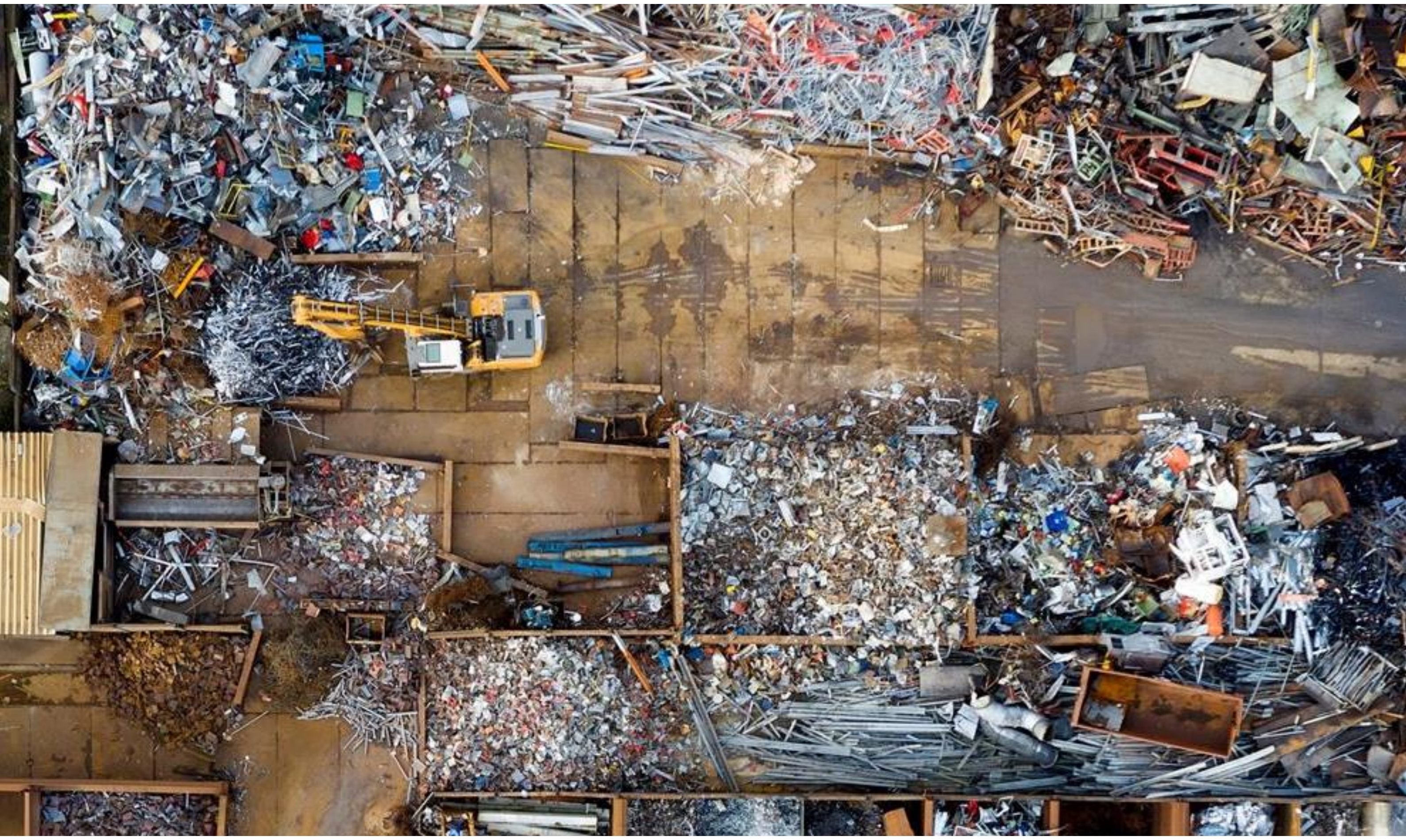

Background Data Collection for Future EU EoW Criteria of Construction and Demolition Waste – GROW/2022/OP/0015

Deliverable 3 ‘Final Report on Analysis, Conclusion and Recommendations (Task 3)’

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Abbreviations

BAU	Business-as-usual
CD	Construction and Demolition
CDW	Construction and Demolition Waste and By-Products
CRM	Critical raw materials
EFTA	European Free Trade Association
EoW	End-of-Waste
EURIMA	European Insulation Manufactures Association
FIR	Fédération Internationale du Recyclage
HLCF	High Level Construction Forum
JRC	Joint Research Centre
LCA	Life cycle assessment
P	Parameter
UEPG	European Aggregates Association (Aggregates Europe)
WFD	Waste Framework Directive

Executive Summary

This study assessed the prioritisation for the introduction of possible future European EoW criteria for a list of ten pre-selected construction and demolition waste and by-product (CDW) streams. There was a general positive acceptance and willingness among stakeholders to introduce EU-wide EoW criteria. The results showed the highest potential for possible future EU-wide EoW criteria for the waste and by-product streams of aggregates, concrete, fired clay bricks and gypsum, followed by average potential for asphalt, inert insulation, plastic foam insulation, rigid plastics and wood, and a clear outlier for the stream of building products for reuse. It is advisable to address the highest scoring waste streams first in order to achieve a higher impact.

From all the stakeholder interactions during this study, it was clear that the majority of stakeholders would be in favour of future European EoW criteria for the CDW streams investigated. The advantages of possible future EU-wide EoW criteria (clear material status, less administration, environmental benefits and improved market) outweighed the disadvantages (market disruption where local EoW criteria already exist and environmental risks). The demand for the reuse of CDW and the acceptance of a possible future EU-wide EoW was widely supported by all stakeholder groups. The existence of standards for CDW and the existence of some national and regional CDW-related EoW criteria also showed the urgency and need for EU-wide EoW criteria in the future. Some stakeholders emphasised the need for future European EoW criteria for CDW to recognise existing national and regional criteria in order to minimise or reduce bureaucratic burden. In addition, based on stakeholder input, the introduction of EU-wide EoW criteria for all CDW streams is expected to increase market potential and sales.

An important observation was that for inert waste streams there is potential for grouping, e.g. aggregates, asphalt, fired clay bricks and concrete, in future European EoW criteria. This has also been applied in national legislation in several EU Member States. It is recommended to further assess whether grouped future EU-wide EoW criteria would have a higher impact than ungrouped criteria.

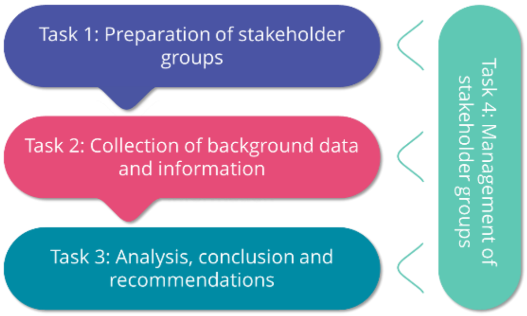
In general, the input provided a positive picture of the potential environmental and economic impacts associated with the introduction of EU-wide EoW criteria for CDW, together with a positive market attitude. The results of the environmental and human health impact regarding an increase in recycling for gypsum, fired clay bricks. In addition, it should be noted that construction and demolition is by far the largest single waste and by-product stream in the EU and therefore there would be a large potential for positive environmental impacts if recycling rates were improved.

The results of this study provided a solid background for the European Commission to plan possible further steps towards EU-wide End-of-Waste criteria for CDW.

1 Introduction

This is Deliverable 3, the final report of Task 3 'Analysis, conclusion and recommendations' of the project *Background Data Collection for Future EU End-of-Waste (EoW) Criteria of Construction and Demolition Waste (CDW) – GROW/2022/OP/0015*." The project was commissioned by the European Commission – hereafter referred to as the Commission – and started on 21 December 2022. It is scheduled to end in March 2024.

The project consists of four tasks. Tasks 1 and 4 were completed with the submission of the stakeholder group list (Deliverable 1) and the stakeholder management plan (Deliverable 4) in February 2023. The interim report for Tasks 2 and 3 was submitted on 3rd October 2023.



Task 3 was divided into the following seven subtasks: **3A**. impact estimation, **3B.** appraisal of waste streams, **3C.** interim report, **3D.** prioritisation of the list of waste streams and **3E.** final report.

The final report on Task 2 was submitted to the Commission. This report builds on the data and information collected under Task 2. It summarises the data and impact analysis done under Task 3.

2 Summary of data collection (Task 2)

The identification and **selection of ten construction and demolition waste (CDW) streams** ended in February 2023 (Task 2A). The following ten waste streams were approved by the Commission[1]: 1. aggregates[2], 2. concrete, 3. Asphalt; 4. fired clay bricks, 5. wood, 6. gypsum, 7. plastic foam insulation, 8. inert insulation, 9. building products for reuse and 10. rigid plastics (PVC for rigid plastic pipes and window frames).

Task 2 aimed to collect data on construction and demolition waste (CDW) through stakeholder involvement. The data collection took place from March to November 2023. As part of the first step, approximately 450 stakeholders were invited to the stakeholder kick-off meeting on 10 May 2023, which was attended by 157 people. During the meeting, the project was introduced, an online survey was launched at the project webpage and first data was collected in break-out sessions.
The online survey was open from 10 May to 31 August 2023 and received 116 responses, of which 103 were valid, covering information for 20 EU countries. The survey questionnaire was designed to provide 16 ranking parameters for the ten CDW streams across Europe (see Table 2-1).

[1] The streams included wastes of construction and demolition. Full definitions can be found on the project's webpage: https://eu-cdw-eow-prioritylist-tauw-group.hub.arcgis.com/pages/waste-streams.

[2] Can in some instances also be a product, this aspect is not further considered in this study.

Table 2-1: Listing and description of the 16 ranking parameters and their sub-parameters as they were used in data collection (Task 2) and data analysis (Task3; extra report).

Ranking Parameter	Sub-parameter(s)	Description	Data analysis
1. Level of support from stakeholders to develop further EU-wide EoW criteria	***P1.1 support_eow***	Parameter 1 aimed to assess the level of stakeholder support and involvement in the process of developing additional criteria for EoW.	quantitative (yes / no)
	P1.2 i_support_eow	The second sub-parameter sought to answer why stakeholders do or do not support the introduction of EU-wide EoW criteria.	qualitative
2. Current collection and material reuse / recycling rates	***P2.1 tonnes***	Parameter 2 aimed to find the most recent data available on the annual quantities (in tonnes) of waste generated by waste stream, the collection rates and the amounts of recycled and reused waste.	quantitative
	P2.2 collect_tonnes		
	P2.3 recycle_tonnes		
	P2.4 reuse_tonnes		
3. Identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors	***P3.1 reuse_into***	Parameter 3 aimed at a comprehensive understanding of the different aspects related to the recycling (*recycle_into*) and reuse (*reuse_into*) of each waste stream, including the identified uses, the types of uses (recycling versus other recovery operations) and the economic sectors affected.	qualitative
	P3.2 recycle_into		
4. Estimated EU market value	***P4 value_EU_ws***	Parameter 4 estimated the current market value (in euro) for 1 kg of the respective waste.	quantitative
5. Intra-EU shipments	***P5 ws_transp_EU***	Parameter 5 was formulated to find out if the respective waste stream is transported across national borders within the EU.	quantitative (yes / no)
6. Extra-EU shipments	***P6 ws_transp_out_EU***	Parameter 6 was formulated to find out whether the respective waste stream is transported across national borders outside of the EU.	quantitative (yes / no)
7. Purity / composition of recovered materials	***P7 reco_compos***	Parameter 7 intended to determine the quality and composition of the materials that are recovered from the waste streams.	qualitative
8. Possibility to recover critical raw materials	***P8.1 reco_ways***	Parameter 8 intended to determine if there is a possibility to recover critical raw materials from the respective waste streams.	quantitative (yes / no)
	P8.2 reco_ways_name	The second sub-parameter sought to answer *what* critical or strategic raw materials could be recovered from the respective waste streams.	qualitative
9. Evidence of demand	***P9.1 demand_recovered_ws***	Parameter 9 sought to gather evidence and data that demonstrate whether there is a market or demand for the waste materials and products that are generated as part of the waste management process.	quantitative (yes / no)
	P9.2 no_eow_demand_incr	The second sub-parameter intended to find out if the EU-wide introduction of EoW criteria would impact the volume of sales for the waste streams within the next 5 years.	qualitative
10. Existence of relevant international or national product standards	***P10 product_standard***	The goal of these parameters was to gather information on whether or not there are international or national product standards (*product_standard*) already in existence for the waste streams and/or if EoW criteria already exists in certain EU countries (*eow_criteria*). The goal of parameter 11 is to	qualitative

Ranking Parameter	Sub-parameter(s)	Description	Data analysis
11. Existence of national or regional EoW criteria	***P11 eow_criteria***	gather information on whether or not there are national or regional EoW criteria already in place for the waste streams.	quantitative (yes / no)
12. Expected environmental and human health impacts	***P12.1 eow_benefits***	The questions for parameter 12 targeted a comprehensive understanding of potential risks and benefits on environmental and human health resulting from the implementation of Eu-wide EoW criteria.	qualitative
	P12.2 eow_risks		qualitative
13. Number of recycling processes applied	***P13 recycling_process***	Parameter 13 intended to find information on the number of recycling processes applied to the respective waste streams.	quantitative
14. Estimates of market evolution	***P14 eow_demand_incr***	The question for parameter 14 was formulated to gather information on future scenarios of the market; whether or not the demand and therefore the market value and the volume of sales will increase/decrease.	qualitative
15. Challenges in technical and administrative processes	***P15 tech_chall***	The questions for parameter 15 aimed to find out about challenges in technical and administrative processes experienced by the stakeholders regarding the recycling of the waste streams.	qualitative
16. Actual problems experienced with recycling	***P16 problems***	Parameter 16 sought to find out if actual problems with recycling of the waste were experienced by the stakeholders. Note: P15 and P16 were combined during data collection (cf. chapter 3.1.1)	qualitative

An important aspect of the Task 2 methodology was to identify and address **data gaps** that remained after the survey had been conducted. A data gap was defined as less than 30% of participants responding to a particular question or parameter. Alternative data sources were then reviewed and interviews conducted with selected stakeholders to fill the gaps. Data gaps were identified for ranking parameter P2. current collection and recovery rate, P3 indirect uses of a waste stream, P4. estimated EU market value), P15. technical and administrative challenges and P16. actual recycling problems. Five waste streams had the most data gaps: wood, gypsum, plastic foam insulation, inert insulation and building products for reuse.

Following the survey, a total of 27 **interviews** were conducted to **fill the data gaps**. Stakeholders with expertise in the CDW industries and who could provide valuable insight into the waste streams and their potential for future EoW criteria were interviewed. **Desk research** was also carried out to fill further data gaps, mainly based on public sources such as Eurostat and information from industry associations. *Priority was given to data at the European level* and the methodology successfully filled most of the data gaps.

The absence of data in some cases was also considered as a significant finding as it gives an insight into the maturity and organisation of the waste streams. For P4. estimated EU market value, the desk research and interviews showed that it was difficult to compare market value data for most of the waste streams because it was unclear which value point of the value chain the data represented. A Dutch *market expert was therefore interviewed* to obtain values representing high income countries in the EU. These were used in addition to the values mentioned in the survey of where the data point was clear and comparable to the values obtained by a market expert.

The **consistency** of the numerical data was reviewed and checked for **reliability** and **accuracy** by comparing different sources and identifying any significant discrepancies. In addition, the numerical values for P3 and P4 were reviewed by a waste expert to check for accuracy and consistency between the values. This report further analyses the credibility, accuracy and consistency of the data to ensure its reliability for further analysis and decision making. Credibility focuses on the source and timeliness of the data, while accuracy examines whether the data is consistent with the scope of the study.

In summary, more than 100 survey responses and almost 30 interviews provided very satisfactory data quantity and quality and almost all data gaps have been filled. Remaining data gaps mainly concern waste generation and recycling quantities, which were filled in based on expert judgement.

All **data collected was submitted as an Excel file** with the submission of this report.

3 Methodology

The data collected came from three main sources: the survey, the interviews and the desk research. In some cases, additional expert judgement was used. Once all the data from the data collection phase had been collected and checked for consistency, reliability and accuracy, data analysis began. The data collected was thoroughly examined to draw the necessary insights and conclusions. The methodology included the following steps:

1. Scoring of the ranking parameters per waste stream
2. Weighting of the ranking parameters
3. Uncertainty analysis (data quality)
4. Sensitivity analysis
5. Impact analysis

This chapter 3 presents the methodology, while chapter 4 presents the results.

3.1 Scoring of the ranking parameters

Most of the methodology used in this project was taken from the JRC report written by Orveillon et al. (2022)[3] - hereafter referred to as the JRC report. As mentioned in the Task 2 summary (see chapter 2), sixteen **ranking parameters** were defined to rank the ten waste streams according to their **potential for possible future EoW criteria** (Table 3-1). For each ranking parameter a score of 1, 2 or 3 was applied to evaluate the data collected for each identified waste stream based on the following criteria:

- 🔴 CDW streams with lower potential were given a score of 1
- 🟠 CDW streams with average potential were given a score of 2
- 🟢 CDW streams with higher potential were given a score of 3

Parameters ① to ⑫ and their scoring rules were applied as in the JRC report. The Commission contributed the two additional parameters ⑬ and ⑭ and the project team added parameters ⑮ and ⑯. Table 3-1 shows the parameters and their respective scoring rules for assessing their potential.

Note: during the data analysis process, parameters ⑮ and ⑯ were merged into one parameter labelled as ⑮. This decision was taken because many stakeholders were unable to distinguish between (technical) challenges and (administrative) problems in recycling a waste stream.

[3] Orveillon, G., Pierri, E., Egle, L., Gerbendahl, A., Wessman, P., Garcia, J. E., Saveyn, H. G. M. (2022). Scoping possible further EU-wide end-of-waste and by-product criteria. JRC report. ISBN 978-92-76-49046-3. ISSN 1831-9424. DOI:10.2760/067213. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC128647/JRC128647_01.pdf

*Table 3-1: Ranking criteria for each parameter and their respective scoring rules. * means that the ranking parameter is additional to the JRC report.*

Ranking parameter	Lower potential (=1)	Average potential (=2)	Higher potential (=3)
① Level of support from stakeholders to develop future EU-wide EoW criteria	No industry consensus	Industry consensus but environmental associations oppose OR stream indicated as not a priority by one or more Member States	Consensus amongst stakeholders
② Current collection and material reuse/recycling rates	Lower potential to increase the current reuse and recycling rates	Average potential to increase the current reuse and recycling rates	Higher potential to increase the current reuse and recycling rates
③ Identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors	Lower impact on the economy based on the number of impacted economic sectors and uses promoting recycling over other recovery operations	Average impact on the economy based on the number of impacted economic sectors and uses promoting recycling over other recovery operations	Higher impact on the economy based on the number of impacted economic sectors and uses promoting recycling over other recycling operations
④ Estimated EU market value	Lower value (first tercile)	Average value (second tercile)	Higher value (third tercile)
⑤ Intra-EU shipments	No intra-EU shipments	Limited intra-EU shipments	Reported intra-EU shipments
⑥ Extra-EU shipments	No extra-EU shipments	Limited extra-EU shipments	Reported extra-EU shipments
⑦ Purity/composition of recovered materials	Unknown composition	Variable composition	High purity or stable composition
⑧ Possibility to recover critical raw materials (CRM)	No recovery or not relevant	Possible recovery from waste/by-product stream	
⑨ Evidence of demand	No evidence provided	Qualitative evidence provided	Quantified evidence provided
⑩ Existence of relevant international or national product standards	No standards identified	No international (EN/ISO) or equivalent standards reported but national guidance or industry standards reported	International (EN/ISO) or equivalent standards reported
⑪ Existence of national or regional EoW criteria	No criteria identified	National or regional EoW criteria identified in only one Member State or case-by-case decisions identified	National or regional EoW criteria identified in two or more Member States
⑫ Expected environmental and human health impacts	Mostly possible risks reported compared to benefits	Mostly benefits reported (but not quantified) compared to possible risks OR balanced risks and benefits reported	Mostly benefits reported (and quantified) compared to possible risks
⑬ *Number of recycling processes applied**	*No processes reported**	*One process reported**	*More than one process reported**

Ranking parameter	Lower potential (=1)	Average potential (=2)	Higher potential (=3)
⑭ *Estimates of market evolution**	*BOTH market value and sales are expected to decrease**	*Market value is expected to increase AND sales are constant or decreasing**	*BOTH market value and sales are expected to increase**
⑮ *Challenges and problems**	*No challenges reported**	*Limited challenges reported**	*Many challenges reported**

The following sub-chapters explain in more detail the parameters and the survey questions used to score the parameters.

3.1.1 Level of support from stakeholders to develop future EU-wide EoW criteria

The aim of applying this parameter was to differentiate between CDW streams based on stakeholder support for developing possible future EU-wide EoW criteria. The parameter aimed to identify CDW streams where stakeholders were in favour of implementing EU-wide EoW criteria, indicating a higher potential for the development of further EU-wide criteria. Conversely, CDW streams where stakeholders were (or could be) opposed to implementing EU-wide EoW criteria were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **6.** In general, do you support the development and implementation of EU-wide EoW criteria for the waste stream relating to construction and demolition waste?
- **6a**. Why do you support EU-wide EoW criteria for the waste stream, or why not?

Note: question 6a was used to give the respondents the opportunity to explain their position and provide additional background information.

This parameter was scored semi-automatically. If all received responses for a CDW stream were either '*Yes*' or '*No*' to survey question **6**, it was automatically scored according to the scoring rules. This was done manually if the survey question received a combination of both *'Yes'* and *'No'* responses.

The scoring rules were as follows:

- CDW streams supported by **all** stakeholders were considered to have a high potential and were assigned a score of **3**.
- CDW streams supported by industry representatives but not by environmental NGOs or member states' representatives were considered to have an average potential and were assigned a score of **2**.
- CDW streams that did not receive unanimous support from industry representatives, or where there was insufficient information on the level of support, were considered to have a lower potential and were assigned a score of **1**.

3.1.2 Current collection and material reuse/recycling rates

The aim of applying this parameter was to differentiate between CDW streams based on their potential to increase the current reuse and recycling rates. The parameter aimed to identify CDW streams with lower reuse and recycling rates, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with already high reuse and recycling rates were considered to have a lower potential for further improvement and thus for future EU-wide EoW criteria.

The survey question(s) related to this parameter were:

- **14.** Do you have any information on how much of the waste stream arises within one year in tonnes, at EU level, national or regional level?
- **14a.** Please share any sources or further information.
- **15.** Do you have any information on how much of the waste stream is being collected separately or is sorted out within one year in tonnes, at EU level, national or regional level?
- **15a.** Please share any sources or further information.
- **16.** Do you have any information on how much of the waste stream is being prepared for reuse within one year in tonnes at EU level, national or regional level?
- **16a.** Please share any sources or further information.
- **18.** Do you have any information on how much of the waste stream is being recycled within one year in tonnes at EU level, national or regional level?
- **18a.** Please share any sources or further information.

Note: questions 14a, 15a, 16a and 18a were used to give the respondents the opportunity to provide additional background information and ways for the project team to validate the data.

This parameter could not be scored automatically and the results were compiled from survey responses, interviews, desk research and expert judgement to find representative values for all CDW streams at the EU-27 level. Median values were calculated from this data and used to determine the scores.

The scoring rules were as follows:

- CDW streams with *lower* material reuse/recycling rates than the median value for all CDW streams were considered to have a higher potential and were assigned a score of **3**.
- CDW streams with *higher* material reuse/recycling rates and *lower* collection rates than the median values for all CDW streams were considered to have an average potential and were assigned a score of **2**.
- CDW streams with *higher* material reuse/recycling rates and *higher* collection rates than the median values for all CDW streams or with insufficient information were considered to have a lower potential and were assigned a score of **1**.

3.1.3 Identified uses, types of uses (material recycling versus other recovery operations) and impacted economic sectors

The aim of applying this parameter was to differentiate between CDW streams based on their impact on different economic sectors. The parameter aimed to identify CDW streams with a higher economic impact, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with lower economic impact were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **17.** What is the intended use of the waste stream that is being prepared for reuse?
- **17a.** Please share any sources or further information.
- **20.** Do you have any information on current applications for secondary or recycled [CDW stream]?
- **20a.** Please share any sources or further information.

Note: questions 17a and 20a were used to give respondents the opportunity to provide additional background information and ways for the project team to validate the data.

This parameter required expert judgement as it could not be scored automatically. The different uses of CDW were linked to the impacted economic sectors at the EU-27 level. The number of impacted economic sectors per CDW stream was divided into three categories: those within the 33rd percentile, those between the 33rd and 66th percentile and those above the 66th percentile of all CDW streams.

The scoring rules were as follows:

- CDW streams with reused materials impacting a *higher* number of economic sectors (those above the 66th percentile) were considered to have a higher potential and were assigned a score of **3**.
- CDW streams with reused materials impacting an *average* number of economic sectors (those between the 33rd and the 66th percentile) were considered to have an average potential and were assigned a score of **2**.
- CDW streams with reused materials impacting a *lower* number of economic sectors (those within the 33rd percentile) were considered to have a lower potential and were assigned a score of **1**.

3.1.4 Estimated EU market value

The aim of applying this parameter was to differentiate between CDW streams based on their expected internal market value. This market value was calculated from the total tons of waste arising, multiplied by the value per ton in Euros. The parameter aimed to identify CDW streams with a higher potential market value, indicating a higher potential for the development of future EU-wide EoW criteria.

Conversely, CDW streams with a lower expected market value were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **10.** Do you have any information on the current market value of the waste stream [waste stream]? Please indicate the value in EUR per tonne of the waste stream [waste stream].
- **10a.** Please share any sources or further information.

Note: question 10a was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter could not be scored automatically and the results were composed from survey responses, interviews, desk research and expert judgement to find representative values for all CDW streams on an EU-27 level. The total expected market value per CDW stream was divided into three categories: those within the 33rd percentile, those between the 33rd and 66th percentile and those above the 66th percentile of all CDW streams.

The scoring rules were as follows:

- CDW streams with a higher total market value (those above the 66th percentile) were considered to have a higher potential and were assigned a score of **3**.
- CDW streams with an average total market value (those between the 33rd and the 66th percentile) were considered to have an average potential and were assigned a score of **2**.
- CDW streams with a lower total market value (those within the 33rd percentile) were considered to have a lower potential and were assigned a score of **1**.

3.1.5 Intra-EU shipments

The aim of applying this parameter was to differentiate between CDW streams based on their trade and shipping activities within the EU. The parameter aimed to identify CDW streams that were being traded and shipped across borders within the EU-27, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams that were not traded across borders were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **25**. In your experience, is the waste stream [waste stream] transported across national borders within the European single market?
- **25a**. Which percentage of the waste stream [waste stream] is transported across national borders within the European single market?
- **25b**. Please share any sources or further information.

Note: question 25b was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter could not be scored automatically. The results were composed from survey responses, interviews, desk research and expert judgement.

The scoring rules were as follows:

- CDW streams *with* reported intra-EU shipments were considered to have a higher potential and were assigned a score of **3**.
- CDW streams *with limited* intra-EU shipments were considered to have an average potential and were assigned a score of **2**.
- CDW streams with *no* reported intra-EU shipments were considered to have a lower potential and were assigned a score of **1**.

3.1.6 Extra-EU shipments

The objective of applying this parameter was to differentiate between CDW streams based on their trade and shipping activities outside the EU. The parameter aimed to identify CDW streams that were being traded and shipped across borders outside the EU, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams that were not traded outside the EU were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **26**. In your experience, is the waste stream [waste stream] transported to third countries outside the European single market?
- **26a**. Which percentage of the waste stream [waste stream] is transported across national borders to third countries outside the European single market?
- **26b**. Please share any sources or further information.

Note: question 26b was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter could not be scored automatically and the results were composed from survey responses, interviews, desk research and expert judgement.

The scoring rules were as follows:

- CDW streams *with* reported extra-EU shipments were considered to have a higher potential and were assigned a score of **3**.
- CDW streams *with limited* extra-EU shipments were considered to have an average potential and were assigned a score of **2**.

- CDW streams with *no* reported extra-EU shipments were considered to have a lower potential and were assigned a score of **1**.

3.1.7 Purity/composition of recovered materials

The objective of applying this parameter was to differentiate between CDW streams based on their purity and level of contamination. The parameter aimed to identify CDW streams with a higher purity and low level of contaminants, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams of which their purity was unknown, were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **21**. Do you have any data or information on the current composition of the recovered waste stream [waste stream] compared to virgin material at EU level, national or regional level?
- **21a**. Please share any sources or further information.

Note: question 21a was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was scored semi-automatically. If most of the respondents indicated similar purities, the respective score was given, which was later validated by interviews, desk research and expert judgement.

The scoring rules were as follows:

- CDW streams with a *high* purity or with a *low* level of contaminants were considered to have a higher potential and were assigned a score of **3**.
- CDW streams with a *variable* composition were considered to have an average potential and were assigned a score of **2**.
- CDW streams with an *unknown* composition were considered to have a lower potential and were assigned a score of **1**.

3.1.8 Possibility to recover critical raw materials

The aim of applying this parameter was to differentiate between CDW streams based on the possibility of recovering critical raw materials. The parameter aimed to identify CDW streams with a possibility of recovering critical raw materials, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams for which there is no possibility of recovering critical raw materials were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **22**. Do you know of ways to recover critical raw materials (CRMs) from the waste stream [waste stream]?
- **22a**. Please name any critical raw materials which can be recovered from the waste stream [waste stream]. Please share the concentration of critical raw materials that can be recovered.
- **22b**. Please share any sources or further information.

Note: question 22b was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was automatically scored without further expert judgement.

The scoring rules were as follows:

- CDW streams for which a *possibility to recover* critical raw materials was reported were considered to have a higher potential and were assigned a score of **2**.
- CDW streams for which *no possibility to recover* critical raw materials was reported were considered to have a lower potential and were assigned a score of **1**.

3.1.9 Evidence of demand

The objective of applying this parameter was to differentiate between CDW streams based on the evidence of demand. The parameter aimed to identify CDW streams with evidence of demand, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no evidence of demand were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **11**. Is there a market demand for the waste stream [waste stream] and, if so, how high is it currently?
- **11a**. Please share any sources or further information.

Note: question 11a was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was automatically scored without further expert judgement.

The scoring rules were as follows:

- CDW streams *with quantified* evidence of demand were considered to have a higher potential and were assigned a score of **3**.
- CDW streams *with qualitative* evidence of demand were considered to have an average potential and were assigned a score of **2**.

- CDW streams with *no* evidence of demand were considered to have a lower potential and were assigned a score of **1**.

3.1.10 Existence of relevant international or national product standards

The aim of applying this parameter was to differentiate between CDW streams based on the existence of relevant product standards. The parameter aimed to identify CDW streams with relevant product standards, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no relevant product standards were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **28**. Are you aware of product standards in place for the waste stream [waste stream]?
- **28a**. Name the product standards here.
- **28b**. Please share any sources or further information.

Note: question 28b was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was scored semi-automatically. If no standards were reported, it was automatically scored accordingly. If one or more product standards were reported, the results were validated through interviews, desk research and expert judgement and scored accordingly.

The scoring rules were as follows:

- CDW streams for which one or more EN, ISO or other equivalent *international* standards were reported were considered to have a higher potential and were assigned a score of **3**.
- CDW streams for which one or more *national* or industry standards were reported were considered to have an average potential and were assigned a score of **2**.
- CDW streams for which *no* product standards were reported were considered to have a lower potential and were assigned a score of **1**.

3.1.11 Existence of national or regional EoW criteria

The objective of applying this parameter was to differentiate between CDW streams based on the existence of national or regional EoW criteria. The parameter aimed to identify CDW streams with already existing national or regional EoW criteria, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no existing national or regional EoW criteria were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **27**. Are you aware of national or sectorial EoW criteria for the waste stream [waste stream]?

- **27a**. Name the EoW criteria here.
- **27b**. Please share any sources or further information.

Note: question 27b was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was scored semi-automatically. If no EoW criteria were reported, it was automatically scored accordingly. If one or more EoW criteria were reported, the results were validated through interviews, desk research and expert judgement and scored accordingly.

The scoring rules were as follows:
- CDW streams for which *more* than one national or regional EoW criteria were reported were considered to have a higher potential and were assigned a score of **3**.
- CDW streams for which *one* national or regional EoW criteria was reported were considered to have an average potential and were assigned a score of **2**.
- CDW streams for which *no* national or regional EoW criteria were reported were considered to have a lower potential and were assigned a score of **1**.

3.1.12 Expected environmental and human health impacts

The aim of applying this parameter was to differentiate between CDW streams based on the reported risks and benefits to the environment and human health. The parameter aimed to identify CDW streams with more benefits than risks, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with more risks than benefits were considered to have a lower potential.

The survey question(s) related to this parameter were:
- **8**. What would be the benefits to human health and the environment if EU-wide EoW criteria for the waste streams [waste stream] were set? Which categories of environmental impacts do you think would improve?
- **8a**. Please share your thoughts and sources.
- **9**. What would be the risks to human health and the environment if EoW criteria for the waste stream [waste stream] were set? What environmental impacts do you think would worsen from shifting [waste stream] from the waste to the product regime?
- **9a**. Please share your thoughts and sources.

Note: questions 8a and 9a were used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was automatically scored without further expert judgement.

The scoring rules were as follows:

- CDW streams for which *more benefits* than risks were reported were considered to have a higher potential and were assigned a score of **3**.
- CDW streams for which the *same* number of benefits and risks were reported were considered to have an average potential and were assigned a score of **2**.
- CDW streams for which *more risks* than benefits were reported were considered to have a lower potential and were assigned a score of **1**.

3.1.13 Number of recycling processes applied

The objective of applying this parameter was to differentiate CDW streams based on the number of different recycling processes applied. The parameter aimed to identify CDW streams with reported recycling processes, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no reported recycling processes were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **24**. In your experience, what types of recycling processes are commonly used to recycle the waste stream [waste stream]?
- **24a**. Please share any sources or further information.

Note: question 24a was used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was scored semi-automatically. If no recycling processes were reported, it was automatically scored accordingly. If one or more recycling processes were reported, the results were assessed through interviews, desk research and expert judgement and scored accordingly.

The scoring rules were as follows:

- CDW streams for which *more* than one unique recycling process were reported were considered to have a higher potential and were assigned a score of **3**.
- CDW streams for which *one* unique recycling process was reported were considered to have an average potential and were assigned a score of **2**.
- CDW streams for which *no* unique recycling processes were reported were considered to have a lower potential and were assigned a score of **1**.

3.1.14 Estimates of market evolution

The aim of applying this parameter was to differentiate CDW streams based on the expected market evolution between 2025 and 2030. The parameter aimed to identify CDW streams with an expected increase in both market value and sales, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with an expected decrease in market value and sales were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **12**. If the EU does NOT introduce EU-wide EoW criteria for the waste stream, do you expect an increase, decrease, or no change in the volume of sales in the waste stream [waste stream] in the next 5 years?
- **12a**. If possible, please explain your assumption by stating the amount you expect it to change.
- **12b**. Please share any sources or further information.
- **13**. If the EU does introduce EU-wide EoW criteria for the waste stream [waste stream], do you expect an increase, decrease, or no change in the volume of sales in this waste stream in the next 5 years?
- **13a**. If possible, please explain your assumption by stating the amount you expect it to change.
- **13b**. Please share any sources or further information.

Note: questions 12a, 12b, 13a and 13b were used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter could not be scored automatically and the results were composed from survey responses, interviews, desk research and expert judgement to find representative values for all CDW streams at the EU-27 level.

The scoring rules were as follows:

- CDW streams with an expected *increase in both* market value and volume of sales were considered to have a higher potential and were assigned a score of **3**.
- CDW streams with an expected *increase* in market value *but* a constant or decreasing volume of sales were considered to have an average potential and were assigned a score of **2**.
- CDW streams with an expected *decrease* in both market value and volume of sales were considered to have a lower potential and were assigned a score of **1**.

3.1.15 Challenges and problems

The aim of applying this parameter was to differentiate CDW streams based on the number of reported technical and administrative challenges and problems. The parameter aimed to identify CDW streams with a higher number of reported problems, indicating a higher potential for the development of future

EU-wide EoW criteria. Conversely, CDW streams with no reported problems were considered to have a lower potential.

The survey question(s) related to this parameter were:

- **29**. Are you aware of any technical and administrative challenges in connection with the waste stream [waste stream]?
- **29a**. Please share any sources or further information.
- **30**. Are you aware of any problems in relation to the use of secondary materials derived from the waste stream [waste stream]?
- **30a**. Please share any sources or further information.

Note: questions 29a and 30a were used to give respondents the opportunity to provide additional background information and a way for the project team to validate the data.

This parameter was scored semi-automatically. If no problems were reported, it was automatically scored accordingly. If one or more problems were reported, the results were assessed through interviews, desk research and expert judgement and scored accordingly.

The scoring rule was as follows:

- CDW streams for which *more than one* unique challenge or problem was reported were considered to have a higher potential and were assigned a score of **3**.
- CDW streams for which *one* unique challenge or problem was reported were considered to have an average potential and were assigned a score of **2**.
- CDW streams for which *no* unique challenges or problems were reported were considered to have a lower potential and were assigned a score of **1**.

3.2 Weighting of the ranking parameters

To reflect the importance of each ranking parameter in the development of EU-wide EoW criteria for CDW streams, a **weighting** factor was assigned to each parameter (see JRC report, pages 13 and 14). Again, a three-level scoring rule was used:

● ranking parameters considered less important were given a weight of 1,
● ranking parameters considered of average importance were given a weight of 2 and
● ranking parameters considered more important were given a weight of 3.

Table 3-2 presents the distribution of the 15 ranking parameters across the three different weights. The 12 parameters that were included in the JRC report were distributed in the same way as in the report. The three additional parameters were evenly distributed among the weights to maintain balance in the evaluation process. This ensured that all parameters received appropriate consideration in the assessment and that there was no bias to lower or higher weights.

In the JRC report the exact argumentation on the weighting for the different parameters is not given. Argumentation for the different weighting factors is given below, as expressed by the experts in the project team. We cannot guarantee that the argumentation is the same as that used by JRC.

The higher weight is given to those parameters that are crucial factors and conditions for the development of EU-wide EoW criteria for CDW. The higher weight is given to parameter number 1 because the study gives high importance to the judgement of the consulted stakeholders on the need for EU-wide EoW criteria. Parameters 4 and 9 are given a higher weight because they relate to the extent to which the waste streams are relevant to the market and because Article 6 of the WFD includes the existence of a market or demand as a condition for waste to cease to be waste. The protection of the environment and human health, included as a factor in parameter 12, is also addressed in the conditions and is one of the main objectives for preventing or reducing the generation of waste. Parameter 13 refers to the number of recycling operations, which is a factor that is given a higher weighting because a high number of recycling operations indicates different qualities of materials, which may need more harmonisation than only one recycling operation.

The average weight is given to those parameters that are important and supportive but subject to uncertainty. For example, parameter 2 is given the average weight because it indicates the extent to which the EU-wide EoW criteria may influence an increased recycling/reuse rate. However, as current rates may depend on several factors, no higher weighting is considered for this parameter. Identified uses, which is reflected in parameter 3, reflects market relevance as in parameters 4 and 9, but does not specify to what extent it has an economic or quantitative impact on the market. Similarly, the existence of relevant product standards as well as EoW or by-product criteria, which are factors in parameters 10 and 11, are seen as a factor facilitating the introduction of EU EoW criteria, and challenges and problems, which are factors in parameter 15, influence the need for common criteria and are therefore given an average weight due to their importance but supportive nature.

The lower weight is given to those parameters that are judged to influence the relevance of the EU EoW criteria, but to a lesser extent and with a higher degree of uncertainty and/or different qualities between the waste streams. For example, intra-EU and extra-EU shipments, which are factors in parameters 5 and 6, could be considered important criteria, as the absence of cross-border shipments may indicate that the EoW criteria are better organised within each Member State. However, as it is not clear to what extent shipments take place, it cannot be excluded that the lack of common criteria is the reason for the low volume of shipments, and the desirability of cross-border shipments is debatable and varies between waste streams. In addition, the level of purity, which is a factor in parameter 7, is given a lower weighting because it is difficult to assess purity, as the same level of purity may be a problem for one waste stream but not for another. Similarly, it is difficult to predict market evolution, which is a factor in parameter 14, especially as the estimate should be based on potential criteria that have not yet been defined. For parameter 8, the possibility to recover critical raw materials, the evidence on the possibility to do so to a profitable extent is highly uncertain based on the data available for this study.

Table 3-2: Weighting factors attributed to each ranking parameter.

Lower weight (=1)	Average weight (=2)	Higher weight (=3)
⑤ Intra-EU shipments	② Current collection and material reuse/recycling rates	① Level of support from stakeholders to develop further EU-wide EoW or by-product criteria
⑥ Extra-EU shipments	③ Identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors	④ Estimated EU market value
⑦ Purity/composition of recovered materials	⑩ Existence of relevant international or national product standards	⑨ Evidence of demand
⑧ Possibility to recover critical raw materials	⑪ Existence of national or regional EoW or by-product criteria	⑫ Expected environmental and human health impacts
⑭ Estimates of market evolution	⑮ Challenges and problems	⑬ Number of recycling processes applied

Table 3-3 shows the resulting matrix of all possible scores per parameter.

Table 3-3: Values given by multiplying the scoring of potential waste streams and the importance of the ranking parameter (weighting).

↓ Scoring Weighting →	Lower weight (=1)	Average weight (=2)	Higher weight (=3)
Lower potential (=1)	1	2	3
Average potential (=2)	2	4	6
Higher potential (=3)	3	6	9

3.2.1 Ranking in groups

The waste streams will not be ranked individually, instead a division in three categories will be applied:

- High potential for EoW Criteria
- Medium potential for EoW Criteria
- Low potential for EoW Criteria

The range between the highest and lowest points result is divided into three even groups. For example, a range between 50 and 80 points would lead to the groups:

1. 70-80 points: High potential
2. 60-70 points: Medium potential
3. 50-60 points: Low potential

The reasoning behind this grouping is based on two important factors:

- Both the applied methodology (weighting factors, chosen parameters) and the variability in the given answers will leave room for discussion whether the resulting ranking properly represents the true EoW potential.
- The goal of this study is to provide sufficient background information for making proper policy decisions in the future, also regarding the most logical waste streams to create EoW criteria for. In the end, politics, market trends and simple opportunity will play a role as well in the final decision if and for which waste stream EoW criteria will be developed. It is not necessary to have a strict 1-10 ranking to base the policy decisions on.

3.3 Data quality analysis

A qualitative data quality analysis was carried out. An overview of the methodology is given in this section.

3.3.1 Quantitative Parameters

The evaluation of the data included an assessment of its credibility, accuracy and consistency. Assessing data for credibility, accuracy and consistency was essential to ensure the reliability and trustworthiness of information. **Credibility assessment** determined the trustworthiness of sources, which enabled informed decision making. **Accuracy assessment** ensured that the data represented the true situation and **consistency assessment** provided confidence in the reliability of the data by comparing multiple sources. Assessing data against these three dimensions ensured that the information as input for the scoring method was reliable, accurate and consistent, leading to more robust and effective outcomes.

Credible sources, such as the JRC, European statistical offices, European industrial organisations, national industrial organisations and national associations were considered, while individual companies and other sources were considered to have lower credibility as they only represent one small part of the value chain.

In terms of **accuracy**, data streams representing the years 2020, 2021, 2022 and 2023 were considered accurate. However, sources that partially represented the waste stream or did not fit the time span were considered to be of medium accuracy and unclear representations were considered to be less accurate.

Consistency was assessed by comparing several sources. If several sources reported the same amount or were within the same order of magnitude, the data was considered consistent. However, if there were significant differences between sources, the data was considered inconsistent. In cases where there was only one source, it was not possible to check consistency. An additional consistency check was carried out for the parameter 4 that focussed on the value of the waste stream. Consideration was given to the position in the value chain that the reported value represented. Values focused on the beginning of the waste stream were preferred to values later in the waste stream if it was unclear which point of the waste stream they represented.

Difficulties in determining the monetary value

Ideally, working with data at EU level was preferred. However, organisations representing data at EU level were unable to provide monetary values of waste streams for two reasons: First, (EU) branch organisations did not discuss this with their organisation members due to competition law restrictions. Secondly, if values were shared by individual organisations, the value of the data varied greatly from region to region. Market data therefore cannot be generalised to an EU-level. For example, regions with an abundance of natural aggregates had a different demand for recycled aggregates than regions with no natural aggregate production. In addition, the market was highly regional due to the weight of aggregates and high transport costs. In the end average prices from the survey were taken and values from TAUW’s cost register for infrastructural works in the Netherlands and researchers’ experience with material processing were used as a sanity check for the survey values.

3.3.2 Qualitative Parameters

The uncertainty of the qualitative data has been assessed through an evaluation process. The primary focus of the uncertainty assessment was on the likelihood of respondents correctly understanding the questions and providing accurate responses that fit within the scope of this report.

Any responses that did not fall within the scope of the research, such as data from regions outside Europe, were excluded from the analysis. In addition, survey responses that did not provide meaningful answers were also excluded. This increased the likelihood of using the correct data.

Measures were taken to increase the probability that respondents could understand the questions. The following measures were used: the questions were thoroughly tested by experts and non-experts. The survey was professionally proofread by a language expert and professionally translated into English, French, German, Polish and Spanish. The questions itself were also reviewed by the Commission. Despite these measures, there was always a degree of uncertainty associated with survey responses. To minimise this uncertainty, interviews were used to provide context to the responses, thus increasing the chances that the data used for the analysis represented the facts and perspectives of stakeholders in the waste stream sectors.

It is important to note that it cannot be excluded that non-experts took part in the survey. At the same time there were no reasons that suggested that the experts themselves distorted the results by deliberately or accidentally giving incorrect answers.

3.4 Impact assessment

Two scenarios were developed for the impact analysis: the **business as usual (BAU) scenario** and the **EoW scenario**. The BAU scenario assumed that the resource-waste cycles remained as they were during the time of data collection (May to November 2023, see Task 2 report), with the amount of waste being treated according to this status quo. In contrast, the EoW scenario assumed that the EoW criteria were already in place. Thus, the amount of waste would have been reduced and in some cases the waste treatment options would be different. For the EoW scenario, 10% increasing recycling rates and decreasing landfill rates were calculated. For both scenarios, the environmental and human health impacts were analysed using Life Cycle Assessment (LCA) software (SimaPro) and the EcoInvent database.

For each waste stream, the amounts of waste collected in the EU were taken from the data collection (Task 2). Potential waste treatments were added to each waste stream for both scenarios. For each waste treatment, recycling or reuse, the corresponding processes were selected from the Ecoinvent database. For the analysis, the ReCiPe16 **endpoint areas of protection** were selected: a) **damage to human health** in disability-adjusted loss of life years (unit: years), b) **damage to ecosystems** in time-integrated species loss (unit: species per year) and c) **damage to resource availability** in surplus costs (unit: Euros). In addition, the intermediate impact category **global warming** in kg CO_2-eq per kg material was analysed. Figure 3.1 provides an overview of the impact categories, their interrelationships and the pathways to endpoint area of protection.

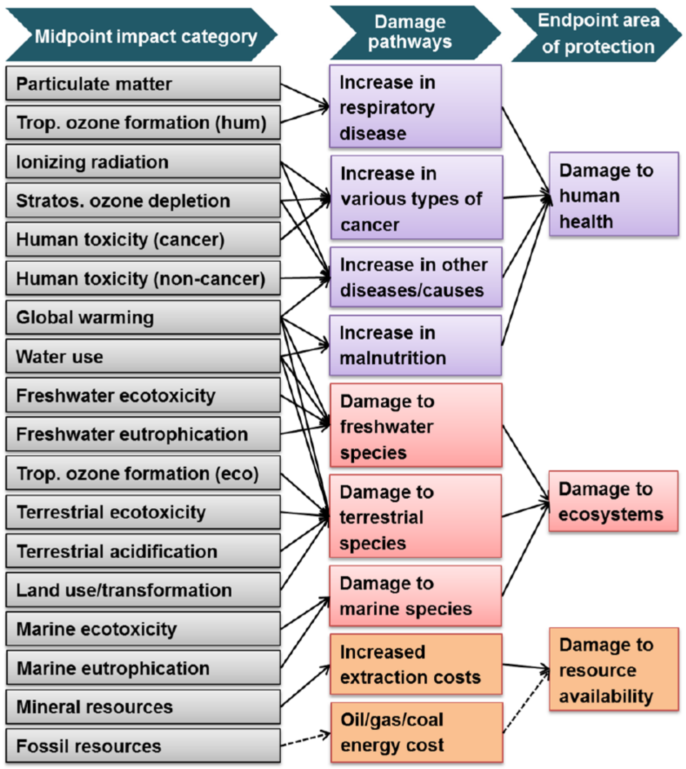


Figure 3.1: Overview of the impact categories that are covered in the ReCiPe216 methodology and their relation to the areas of protection (Source: https://pre-sustainability.com/articles/recipe/).

3.4.1 Business as usual

The impact analysis was carried out using the SimaPro Flow LCA software and the EcoInvent 3.9.1 cut-off database[4]. For each waste stream, the amount of waste collected and the amount of recycling and reuse were extracted from the data collected and used as input data for the impact (see Table 3-4). In addition, the waste treatment mixes (business as usual) and associated processes were extracted from the EcoInvent database. Where European procedures (RER) were not available in the EcoInvent database, Swiss (CH) or global (RoW or GLO) procedures were used - these were the best available and most recent LCA data.

For all input data the above mentioned ReCiPe2016 endpoint areas of protection (damage to human health, ecosystems and resource availability) and the global warming potential were calculated with SimaPro Flow. The results are presented in chapter 4.

[4] https://simapro.com/products/ecoinvent-consequential/.

Table 3-4: Input data for the impact analysis.

Waste stream	Waste collected [kton per year]	Prevention of virgin material(s)	Substitution ratio	Waste treatment category	Percentage share of waste treatment
Asphalt	54320[5]	Resource equivalent of asphalt granulate	(1:1)	Landfill	3%
				Incineration	
				Recycling	25%
				Reuse	72%
Fired clay bricks	5,000[6]	Crushed rock	(0,83:1)	Landfill	17%
				Incineration	-
				Recycling	83%
				Reuse	
Concrete	201060[7]	Gravel	(0,85:1)	Landfill	13%
				Incineration	-
				Recycling	87%
				Reuse	
Wood	43804[8]	Wood chips + energy production	(1:1)	Landfill	10%
				Incineration	41%
				Recycling	30%
				Reuse	3%
Aggregates	200000[9]	Crushed rock	(0,83:1)	Landfill	60%
				Incineration	-
				Recycling	40%
				Reuse	
Rigid plastics	840 [10]	PVC + energy production	(0,69:1)	Landfill	58%
				Incineration	12%
				Recycling	30%
				Reuse	
Gypsum	717[11]	Gypsum plasterboard	(0,88:1)	Landfill	90%
				Incineration	
				Recycling	10%
				Reuse	
Inert insulation	75 [12]	Resource equivalent glass wool production	(1:1)	Landfill	98%
				Incineration	
				Recycling	2%
				Reuse	0%
Plastic foam insulation	280[13]	EPS + energy production	(0,69:1)	Landfill	24%
				Incineration	66%
				Recycling	10%
				Reuse	-

3.4.2 With future EoW criteria

To estimate the impact of future EoW criteria on the environment and human health, the BAU input data for all waste streams were changed to a 10% increase in recycling/reuse and a 10% decrease in

[5] Source: Interview with European Asphalt Pavement Association (EAPA).

[6] Source: Joint Research Centre (JRC) and desk research data (reference: Environmental and socio-economic effects of construction and demolition waste management in the European Union, Christobal, J. et al., 2023).

[7] Source: Joint Research Centre (JRC) and desk research data (reference: Environmental and socio-economic effects of construction and demolition waste management in the European Union, Christobal, J. et al., 2023).

[8] Source: Eurostat, wood from construction.

[9] Sources: European Aggregates Association (UEPG) and survey data.

[10] Source: https://www.recovinyl.com/_files/ugd/ed9371_0c7b0ab7b8494069b31cc8cf3f4d3e50.pdf (page 44)

[11] Source: Industry association, Eurogypsum, survey data

[12] Source: EURIMA from survey data.

[13] Source: Joint Research Centre from survey data.

landfilling/incineration. This is an assumption of the change that results from introducing EU-wide EoW criteria. The 10% was assumed for lack of better data on the effects of EU-wide EoW criteria. For asphalt, the combined reuse/recycling rate was already 97%. Therefore, a shift was assumed from recycling to direct reuse. The same ReCiPe2016 endpoint areas of protection (damage to human health, ecosystems and resource availability) and global warming potential were calculated using SimaPro.

3.4.3 Impact assessment of the assumptions in the scenarios

As the 10% shift towards recycling/reuse because of EoW criteria is based on an assumption; this assumption was tested with an impact assessment. This impact assessment consists of assessing the change in the environmental and human health impacts when the percentage of increase in recycling and decrease in landfilling/ incineration in the EoW scenario was changed to 5% and 20% instead of the main assumption of 10%.

3.5 Sensitivity and uncertainty analyses

3.5.1 Influence of the weighting

A. Alternative weighting scenarios

To test the influence of the weighting on the final ranking of CDW streams in their suitability for having future Eu-wide EoW criteria, two alternatives to the weighting as presented in chapter 3.2 were assessed in this sensitivity analysis:

Alternative 1 aimed to match the relevance of the 15 ranking parameters to what is regarded as most important in current practice, i.e. by giving more weight to parameters 2 and 7. The weighting used in the first alternative is presented Table 3-5.

Alternative 2 aimed to reflect a system where there is a high circularity ambition. Parameters 2, 3, 7 and 8 were considered more important in this alternative and received a higher weight. Parameters 1, 10, 11 and 13 were considered to be less important. The weighting used in the second alternative is presented Table 3-6.

Table 3-5: Weighting factors attributed to each ranking parameter in alternative 1. Parameters that had their weighting change are shown in ***bold****.*

Lower weight (=1)	Average weight (=2)	Higher weight (=3)
⑤ Intra-EU shipments	③ Identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors	① Level of support from stakeholders to develop further EU-wide EoW or by-product criteria
⑥ Extra-EU shipments	**⑦ Purity/composition of recovered materials**	**② Current collection and material reuse/recycling rates**

Lower weight (=1)	Average weight (=2)	Higher weight (=3)
⑧ Possibility to recover critical raw materials	⑩ Existence of relevant international or national product standards	④ Estimated EU market value
⑪ Existence of national or regional EoW or by-product criteria	**⑬ Number of recycling processes applied**	⑨ Evidence of demand
⑭ Estimates of market evolution	⑮ Challenges and problems	⑫ Expected environmental and human health impacts

Table 3-6: Weighting factors attributed to each ranking parameter in alternative 2. Parameters that had their weighting change are shown in ***bold****.*

Lower weight (=1)	Average weight (=2)	Higher weight (=3)
⑤ Intra-EU shipments	**① Level of support from stakeholders to develop further EU-wide EoW or by-product criteria**	**② Current collection and material reuse/recycling rates**
⑥ Extra-EU shipments	**⑦ Purity/composition of recovered materials**	**③ Identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors**
⑩ Existence of relevant international or national product standards	**⑧ Possibility to recover critical raw materials**	④ Estimated EU market value
⑪ Existence of national or regional EoW or by-product criteria	**⑬ Number of recycling processes applied**	⑨ Evidence of demand
⑭ Estimates of market evolution	⑮ Challenges and problems	⑫ Expected environmental and human health impacts

B. Influence of weighting and scoring

To assess the influence of the weighting and scoring of the ranking parameters, they were recalculated in several ways. This gives an insight into the impact of weighting and scoring on the ranking.

The weighting of a parameter and its' score were 'tested' in five different ways for each CDW stream. The comparison was made using the default grading system (1, 2 and 3) and an amplified scoring system (1, 10 and 100 instead). This approach highlighted the most important parameters (those with higher weights) and those with better results (higher scores).

In these five tests, different combinations of weights and scores were combined as follows:

- *Default:* All parameters had default weights (1, 2 and 3) and used default scoring (1, 2 and 3)

- *Test 1:* All parameters had default weights (1, 2 and 3) and used amplified scoring (1, 10 and 100)
- *Test 2:* All parameters had no difference in weighting (1) and used default scoring (1, 2 and 3)
- *Test 3:* All parameters had no difference in weighting (1) and used amplified scoring (1, 10 and 100)
- *Test 4:* All parameters had amplified weights (1, 10 and 100) and used default scoring (1, 2 and 3)
- *Test 5:* All parameters had amplified weights (1, 10 and 100) and used amplified scoring (1, 10 and 100)

Amplified scoring highlighted those CDW streams with higher scores overall, while amplified weighting highlighted those CDW streams with higher scores for the more important parameters. The final scores resulting from these scenarios should only be considered within each test to show the differences and cannot be used to compare different tests.

3.5.2 Monte Carlo simulation

A. Default weighting

A Monte Carlo model was developed to assess the impact of variations in the input values on the final score and recommendations for the prioritisation of CDW streams for future EU-wide EoW criteria. This analysis focused on parameters 2, 3 and 4. These quantitative parameters were the most divergent for stakeholder inputs (tonnages and economic values). An analysis of the ranking of the CDW streams also showed that these parameters had the greatest influence on the differentiation of the CDW streams. The aim of the Monte Carlo analysis was to test the robustness of these parameters.

The Monte Carlo model involved the following steps:

- The base score for each CDW stream was determined by taking the total score of all parameters except parameters 2, 3 and 4.
- The determined values for parameters 2, 3 and 4 were randomly changed within two standard deviations (σ) of the original value for each CDW stream.
- Two tests were conducted with different standard deviations: one with a standard deviation of 10% of the original value and another with a standard deviation of 20% of the original value per CDW stream.
- The model was run a hundred thousand times for each test.

After each run, the final ranks of all CDW streams were recorded. Histograms were then plotted to visualise the frequency distribution of ranks across the hundred thousand runs. If the CDW streams consistently ended up in the same rank, it indicated a robust final ranking. On the other hand, if the ranks were scattered across different positions, it suggested a lack of robustness in the final ranking.

Random differentiations

For both tests, the numerical values that were used to determine the final tertile, were randomly updated to a new possible value, changing the calculation and possibly the tertile in which it falls in for one or more CDW streams. The random difference was done with the assumption that with a standard deviation (σ) of 10% and 20% of the used value per CDW stream for Test 1 and Test 2, respectively, 95% of the random values are within 2σ of the original value. The original values used in the calculations are shown in Table 3-7. The scores for the three parameters were then added to the base scores of all CDW streams. The weightings of the assessed parameters can be found in Table 3-8.

Table 3-7: Original values for nine CDW streams used in the Monte Carlo analysis.

CDW stream	Total waste arising (kton)	Total waste collected (kton)	Total waste recycled/reused (kton)	Total impacted economic sectors (n)	Value (EUR/ton)
Aggregates	450,000	200,000	180,000	2	8.50
Asphalt	56,000	54,320	54,320	1	5.50
Concrete	223,400	201,060	194,358	2	5.50
Fired clay bricks	25,800	5,000	4,350	1	-25.00
Gypsum	2,200	717	220	3	-90.00
Inert insulation	2,400	75	48	1	-115.00
Plastic foam insulation	2,800	280	280	1	-600.00
Rigid plastics	2,800	840	840	2	0.00
Wood	46,600	43,804	13,980	3	-17.50

Table 3-8: Weighting of the assessed parameters for the default scenario.

Parameter	Weighting
Parameter 2: Current collection and reuse rates	2 (average)
Parameter 3: Identified uses/impacted economic sectors	2 (average)
Parameter 4: Estimated EU market value	3 (higher)

B. Alternative weightings

The Monte Carlo model was also run for the two alternative scenarios described in Section 3.5.1. Similar to the previous runs, parameters 2, 3, and 4 were randomly updated to assess their robustness. The following factors differ between the alternatives and the base scenario:

- Base scores: Some parameters have different weights in the alternative scenarios, resulting in potentially different base scores.
- Weightings of parameters 2, 3 and 4: The weightings of these parameters differ in the default scenario and both alternatives.

Apart from these differences, all other variables remained the same.

4 Results

This chapter summarises the findings of this project. Chapter 4.1 presents the results per ranking parameter. Chapter 4.2 presents the ranking of three waste stream groups according to their potential use for possible future European EoW criteria for CDW. For the CDW stream, the environmental and human health impacts are presented in chapter 4.3. The results of the sensitivity and uncertainty analyses are shown chapter 4.4.

4.1 Scoring of the ranking parameters

4.1.1 Level of support from stakeholders to develop further EU-wide EoW criteria

The parameter aimed to identify CDW streams where stakeholders were in favour of implementing future EU-wide EoW criteria, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams where stakeholders were (or could be) opposed to implementing EU-wide EoW criteria were considered to have a lower potential. Table 4-1 presents the scoring results for this parameter.

Table 4-1: Potential of CDW streams (in alphabetical order) based on the level of support from stakeholders to develop further EU-wide EoW criteria.

CDW stream	Summary of the data collected	Score
Aggregates	Not unanimously supported by industry representatives.	1
Asphalt	Not unanimously supported by industry representatives.	1
Building products for reuse	Not unanimously supported by industry representatives.	1
Concrete	Not unanimously supported by industry representatives.	1
Fired clay bricks	Supported by all the stakeholders.	3
Gypsum	Not unanimously supported by industry representatives.	1
Inert insulation	Not unanimously supported by industry representatives.	1
Plastic foam insulation	Not unanimously supported by industry representatives.	1
Rigid plastics	Not unanimously supported by industry representatives.	1
Wood	Not unanimously supported by industry representatives.	1

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Fired clay bricks received unanimous support for possible future EU-wide EoW criteria and was given a score of 3. For the other CDW streams, there was a strong support from industry stakeholders for the introduction of possible future EU-wide EoW criteria, but at least one industry stakeholder was not in favour of possible future EU-wide EoW criteria - therefore they were given a score of 1. The industry stakeholder highlighted benefits such as increased recycling rates and a level playing field.

The fairness of giving a low score to the other CDW streams, despite overall support for the introduction of EU-wide EoW criteria, is debatable. However, the rationale of this scoring scheme is to give a high score to those waste streams for which there is unanimous support for EU-wide EoW criteria, as divergent views among industry stakeholders could lead to discussions about the introduction rather than the content of the criteria.

Specific concerns among opponents for future EU-wide EoW criteria for CDW streams related to practical challenges. Concerns included the potential undermining of existing effective national EoW criteria, administrative burdens and technical challenges related to recycling specific materials. Concern was also expressed about rigid plastics (PVC), that if they were no longer declared as waste, material containing harmful chemicals could be reintroduced into society.

The following list summarises the responses and views of stakeholders on this parameter:

- *Aggregates:* On the one hand, proponents argued, for example, that future EU-wide EoW criteria could increase the acceptance of recycled aggregates as some public authorities prioritise primary materials. On the other hand, opponents were concerned about interfering with existing national EoW criteria that work well (also see chapter 4.1.11), different standards between EU Member States (also see chapter 4.1.10) and administrative burden (also see chapter 4.1.15) .
- *Concrete:* The main benefits of future EU-wide EoW criteria were identified as creating a level playing field, facilitating cross-border trade, increasing recycling rates and reducing greenhouse gas emissions. One opponent mentioned that cross-border use of concrete was insignificant.
- *Asphalt:* Proponents of EU-wide EoW criteria argued that the lack of national guidelines in some EU Member States posed a challenge to asphalt recycling efforts. The introduction of EU-wide EoW criteria could facilitate asphalt recycling. It was also argued that the introduction of EU-wide EoW criteria would lead to less use of primary resources and lower greenhouse gas emissions. Some respondents also emphasised that the introduction of EU-wide EoW criteria would promote fair competition between companies across the EU. However, one respondent expressed concern that EU-wide EoW criteria could lead to asphalt being recycled into aggregates rather than being reused as asphalt.
- *Fired clay bricks:* All twenty-three stakeholders who provided information for this parameter on fired clay bricks agreed on the need for EU-wide EoW criteria. The main reasons given by stakeholders were the need for a level playing field and the facilitation of cross-border trade, which could increase economies of scale in the demand for and recycling of fired clay bricks.
- *Wood:* The main benefits of EU-wide EoW criteria mentioned were creating a level playing field, facilitating cross-border trade, increasing recycling rates, improving recovery methods and reducing greenhouse gas emissions. One stakeholder stated that the criteria would not bring about significant changes.

- *Gypsum:* The main benefits of EU-wide EoW criteria mentioned were the creation of a level playing field and predictability for investors, the need to increase reuse/recycling rates and that it is possible to achieve very high reuse/recycling rates. It was also mentioned that EU-wide EoW criteria could help by removing administrative barriers and changing attitudes, thus limiting the image risks for a company using recycled materials in its process. One opponent mentioned that EU-wide EoW criteria were not needed because recycling already takes place.
- *Plastic foam insulation:* The main benefits of EU-wide EoW criteria mentioned were creating a level playing field, facilitating cross-border shipments, removing legal barriers, environmental and climate benefits, increasing recycling rates and facilitating investment.
- *Inert insulation:* The main benefits of EU-wide EoW criteria mentioned were the creation of a level playing field and the predictability of a regulatory framework, which would facilitate long-term investments. One stakeholder also mentioned that it would facilitate the collection of statistics on waste volumes. Another stakeholder mentioned that EU-wide EoW criteria would be useful as there are ambiguities in the EU Waste Shipment Regulation regarding notification and procedures.
- *Building products for reuse:* Supporters argued that EU-wide EoW criteria could help overcome current legal and administrative barriers, create a level playing field and economies of scale and increase circularity for the sector across the EU. It was also argued that since materials that are directly reusable do not require any treatment or process to make them fit for use again, eliminating the waste state would shorten the (value/supply/process) chain and avoid transport and treatments that have a greater impact. Opponents argued that this waste stream has very limited reuse rates, is undefined and has a high diversity of materials and product types. Also, because this waste stream is destined for reuse and should not be considered waste in the first place, although the products being prepared for reuse should be covered by future EU-wide EoW criteria.
- *Rigid plastic (PVC for plastic pipes and window frames):* The main benefits of EU-wide EoW criteria mentioned were creating a level playing field, facilitating supply chains and intra-EU trade, improving product quality and increasing acceptance and demand for recycled products. In addition, the criteria can facilitate more closed recycling loops for certain PVC products. Opponents mentioned that older PVC products have a high content of harmful chemicals, making them harmful and technically difficult to reintroduce into the manufacturing process. On the other hand, it was also mentioned that the exclusion of harmful substances, such as lead, in new products due to EU-wide EoW criteria could be harmful to the environment, as alternative treatment methods (incineration or landfill) could lead to more pollution.

4.1.2 Current collection and material reuse/recycling rates

This parameter aimed to identify CDW streams with lower reuse and recycling rates, indicating a higher potential for the development of future EU-wide EoW criteria. CDW streams with already high reuse and recycling rates were considered to have less potential for further improvement and thus for future EU-wide EoW criteria. Table 4-2 presents the scoring results for this parameter.

Table 4-2: Potential of CDW streams (in alphabetical order) based on current collection and material reuse/recycling rates.

CDW stream	Summary of the data collected	Score
Aggregates	Material recycling and reuse rate of 40% ≥ median of 30%. Collection rate of 44% ≥ median of 33%.	1
Asphalt	Material recycling and reuse rate of 97% ≥ median of 30%. Collection rate of 97% ≥ median of 30%.	1
Building products for reuse	No data.	1
Concrete	Material recycling and reuse rate of 87% ≥ median of 30%. Collection rate of 90% ≥ median of 33%.	1
Fired clay bricks	Material recycling and reuse rate of 17% < median of 30%.	3
Gypsum	Material recycling and reuse rate of 10% < median of 30%.	3
Inert insulation	Material recycling and reuse rate of 2% < median of 30%.	3
Plastic foam insulation	Material recycling and reuse rate of 10% < median of 30%.	3
Rigid plastics	Material recycling and reuse rate of 30% ≥ median of 30%	2
Wood	Material recycling and reuse rate of 30% ≥ median of 30%. Collection rate of 94% ≥ median of 30%.	1

* The higher potential CDW streams are marked in purple (see chapter 4.2).

The lowest recycling and reuse rates were observed for fired clay bricks, gypsum, plastic foam insulation and inert insulation. These are therefore considered to have a higher potential for increasing their recycling if EU-wide EoW criteria were introduced - and were therefore given a score of **3**.

For several other CDW streams, the first data collection phase, the online survey, showed large differences between data sources, with stakeholders from industry and national or European organisations reporting significantly different volumes of waste generation, collection and recycling. For example, in the aggregates sector, one EU-level industry stakeholder reported 295 million tonnes of recycled aggregates per year in the EU, meeting 10% of the demand, while another reported 250 million tonnes.

The second phase of data collection phase, which induced desk research and expert interviews, filled data gaps could and verified the reliability and quality of the data. This resulted in more consistent collection, recycling and reuse rates, as shown in Table 4-2. Accordingly, a score of **2** was given to rigid plastics where the median recycling and reuse rate was above 30% and a score of **1** was given to the other CDW streams where both recycling and reuse and collection rates were high.

4.1.3 Identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors

The parameter aimed to identify CDW streams with a higher economic impact, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with lower economic impact were considered to have a lower potential. Table 4-3 presents the scoring results for this parameter.

Table 4-3: Potential of CDW streams (in alphabetical order) based on identified uses and impacted economic sectors.

CDW stream	Summary of the data collected	Score
Aggregates	Construction industry, cement industry	2
Concrete	Construction industry, cement industry	2
Asphalt	Construction industry	1
Fired clay bricks	Construction industry	1
Wood	Construction industry, consumer goods, packaging	3
Gypsum	Construction industry, agricultural industry, cement industry	3
Plastic foam insulation	Construction industry	1
Inert insulation	Construction industry	1
Building products for reuse	Construction industry	1
Rigid plastics	Construction industry, consumer goods	2

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Stakeholders consulted reported several types of applications for all CDW streams. Most sectors were reported for wood and gypsum, which therefore received the highest score of 3. Two economic sectors were reported for aggregates, concrete and rigid plastics and these were given a score of 2. Only the economic sector ‘construction industry’ was reported for asphalt, fired clay bricks, plastic foam insulation, inert insulation and building products for reuse - and these were given a score of 1.

4.1.4 Estimated EU market value

The parameter aimed to identify CDW streams with a higher potential market value, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with a lower expected market value were considered to have a lower potential. Table 4-4 presents the scoring results for this parameter.

Table 4-4: Potential of CDW streams (in alphabetical order) based on estimated EU market value.

CDW stream	Summary of the data collected	Score
Aggregates	Reported waste accumulation: ~450 Mt/y. Estimated value per ton: EUR 8.50. Estimated total EU market value: EUR 3.8 billion per year.	3
Asphalt	Reported waste accumulation: ~56 Mt/y. Estimated value per ton: EUR 5.50.	3

CDW stream	Summary of the data collected	Score
	Estimated total EU market value: EUR 0,3 billion per year.	
Building products for reuse	No data.	1
Concrete	Reported waste accumulation: ~223 Mt/y. Estimated value per ton: EUR 5.50. Estimated total EU market value: EUR 1.2 billion per year.	3
Fired clay bricks	Reported total EU market value: EUR 0 per year (only disposal costs reported).	1
Gypsum	Reported total EU market value: MEUR 0 per year (only disposal costs reported).	1
Inert insulation	Reported total EU market value: MEUR 0 per year (only disposal costs reported).	1
Plastic foam insulation	Reported total EU market value: MEUR 0 per year (only disposal costs reported).	1
Rigid plastics	Reported total EU market value: MEUR 0 per year.	1
Wood	Reported total EU market value: MEUR 0 per year (only disposal costs reported).	1

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Aggregates, asphalt and concrete received a score of **3** due to their significant estimated EU market values, indicating a strong economic incentive for their collection and recycling. The other CDW streams were given a score of **1**, reflecting minimal or no reported direct market value.

4.1.5 Intra-EU shipments

The parameter aimed to identify CDW streams that were being traded and shipped across borders within the EU-27, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams that were not traded across borders were considered to have a lower potential. Table 4-5 presents the scoring results for this parameter.

Table 4-5: Potential of CDW streams (in alphabetical order) based on the evidence of intra-EU shipment

Waste stream	Rationale behind the score	Score
Aggregates	For all CDW streams, several stakeholders clearly indicated that each waste stream is transported across national borders within the European internal market, thus showing that intra-EU trade takes place for all waste streams.	3
Asphalt		3
Building products for reuse		3
Concrete		3
Fired clay bricks		3
Gypsum		3
Inert insulation		3
Plastic foam insulation		3
Rigid plastics		3
Wood		3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Intra-EU shipments were reported for all CDW streams - and therefore this parameter was scored with a **3** for all CDW streams - but no precise data were provided by the stakeholders. For all waste streams except concrete, more stakeholders reported that intra-EU shipments take place than that they do not. Only a small majority of stakeholders reported that no shipments of concrete took place. However, as stakeholders also reported that concrete was shipped within the EU, concrete was also given a score of **3**.

4.1.6 Extra-EU shipments

The parameter aimed to identify CDW streams that were being traded and shipped across borders outside the EU, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams that were not traded outside the EU were considered to have a lower potential. Table 4-6 presents the scoring results for this parameter.

Table 4-6: Potential of CDW streams (in alphabetical order) based on the evidence of extra-EU shipment.

Waste stream	Rationale behind the score	Score
Aggregates	For all CDW streams, several stakeholders clearly indicated that each waste stream is transported across borders between EU Member States and third countries, thus showing that extra-EU trade takes place for all waste streams.	3
Asphalt		3
Building products for reuse		3
Concrete		3
Fired clay bricks		3
Gypsum		3
Inert insulation		3
Plastic foam insulation		3
Rigid plastics		3
Wood		3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Extra-EU shipments were reported for all CDW streams - and therefore this parameter was scored with a **3** for all CDW streams - but no precise data were provided by the stakeholders. For all waste streams except aggregates, either more or the same number of stakeholders reported that aggregates were shipped outside the EU as reported that they were not. However, as stakeholders also reported that aggregates were shipped outside the EU, concrete was also given a score of **3**.

4.1.7 Purity / composition of recovered materials

The parameter aimed to identify CDW streams with a higher purity and low level of contaminants, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams of which their purity was unknown, were considered to have a lower potential. Table 4-7 presents the scoring results for this parameter.

Table 4-7: Potential of CDW streams (in alphabetical order) based on the purity and composition of recovered materials.

Waste stream	Rationale behind the score	Score
Aggregates	For all CDW streams, several stakeholders reported low contamination levels and a high purity for all waste streams.	3
Asphalt		3
Building products for reuse		3
Concrete		3
Fired clay bricks		3
Gypsum		3
Inert insulation		3
Plastic foam insulation		3
Rigid plastics		3
Wood		3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Only a few impurities were reported for several CDW streams. This does not mean that the materials from different CDW streams could be mixed, as in the case of aggregates. However, the level of purity after recovery was reported to be adequate and therefore this parameter was scored with a **3** for all CDW streams.

4.1.8 Possibility to recover critical raw materials

The parameter aimed to identify CDW streams with a possibility of recovering critical raw materials, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams for which there is no possibility of recovering critical raw materials were considered to have a lower potential. Table 4-8 presents the scoring results for this parameter.

Table 4-8: Potential of CDW streams (in alphabetical order) based on the possibility to recover critical raw materials.

Waste stream	Rationale behind the score	Score
Aggregates	Seven stakeholders stated that it is possible to recover CRM, but 43 stated that it is not. Mentioned materials were lithium, cobalt, wolfram, silicon from quartz and feldspar.	2
Asphalt	Three stakeholders stated that it is possible to recover CRM, but 13 reported that it is not. One stakeholder stated that in a few cases it is only possible if the asphalt is made from aggregates.	2
Building products for reuse	Two stakeholders stated that it is possible to recover CRM. One material was mentioned, boron. 14 stated that it is not.	2
Concrete	Nine stakeholders stated that it is possible to recover CRM, but 26 reported that it is not, e.g. due to low concentration.	2
Fired clay bricks	Two stakeholders stated that it is possible to recover CRM, but 15 reported that it is not.	2

Waste stream	Rationale behind the score	Score
Gypsum	One stakeholder stated that it was possible to recover CRM, without further specifications and seven stated that it is not.	2
Inert insulation	Two stakeholders stated that it is possible to recover CRM. Materials mentioned were virgin boron/borax, bauxite, feldspar, fluorine, phosphate (from mineral wool) and Borates (from glass wool). Six stated that it is not.	2
Plastic foam insulation	Two stakeholders stated that it is possible to recover CRM and seven that it is not. No specifications were made.	2
Rigid plastics	All stakeholders stated that it is not possible to recover CRM.	1
Wood	All stakeholders stated that it is not possible to recover CRM.	1

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Based on the stakeholder responses, there was little evidence that it would be possible to recover critical raw materials (CRM) for any of the CDW streams. However, for seven waste streams, a few stakeholders reported such a possibility and therefore these CDW streams were given a score of **2**.

4.1.9 Evidence of demand

The parameter aimed to identify CDW streams with evidence of demand, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no evidence of demand were considered to have a lower potential. Table 4-9 presents the scoring results for this parameter.

Table 4-9: Potential of CDW streams (in alphabetical order) based on the evidence of demand.

Waste stream	Rationale behind the score	Score
Aggregates	For all CDW streams, stakeholders stated that there is quantified evidence of demand.	3
Asphalt		3
Building products for reuse		3
Concrete		3
Fired clay bricks		3
Gypsum		3
Inert insulation		3
Plastic foam insulation		3
Rigid plastics		3
Wood		3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

According to the stakeholder responses, there is a demand for recovered materials for all CDW streams - and therefore this parameter was scored as **3** for all CDW streams. Reliable data on the size of the demand was not provided, but an indication was given by the estimated EU market value (see chapter 4.1.4).

4.1.10 Existence of relevant international or national product standards

The parameter aimed to identify CDW streams with relevant product standards, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no relevant product standards were considered to have a lower potential. Table 4-10 presents the scoring results for this parameter.

Table 4-10: Potential of CDW streams (in alphabetical order) based on existing product standards.

Waste stream	Rationale behind the score	Score
Aggregates	For all CDW streams, stakeholders referred to international product standards. For all CDW streams except for inert insulation, stakeholders referred to national product standards.	3
Asphalt		3
Building products for reuse		3
Concrete		3
Fired clay bricks		3
Gypsum		3
Inert insulation		3
Plastic foam insulation		3
Rigid plastics		3
Wood		3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Relevant product standards exist for all waste streams - and therefore this parameter was scored as 3 for all CDW streams.

4.1.11 Existence of national or regional EoW or by-product criteria

The parameter aimed to identify CDW streams with already existing national or regional EoW criteria, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no existing national or regional EoW criteria were considered to have a lower potential. Table 4-11 presents the scoring results for this parameter.

Table 4-11: Potential of CDW streams (in alphabetical order) based on existing EoW or by-product criteria

Waste stream	Rationale behind the score	Score
Aggregates	There are existing EoW criteria at national level and regional level, e.g., Flanders, is working towards EoW. France, Ireland, Italy and the Netherlands have established EoW criteria for this waste stream.	3
Asphalt	No existing EoW criteria were identified in the survey. However, in Italy and The Netherlands the EoW criteria formulated for aggregates can also be applied on asphalts, if, part of the asphalt is manufactured as an aggregate.	1
Building products for reuse	No existing EoW criteria were identified.	1
Concrete	No existing EoW criteria were identified.	1

Waste stream	Rationale behind the score	Score
Fired clay bricks	No existing EoW criteria were identified.	1
Inert insulation	No existing EoW criteria were identified.	1
Gypsum	Existing EoW criteria were identified in the UK and expected criteria in Austria for closed recycle loops of gypsum boards.	2
Plastic foam insulation	No existing EoW criteria were identified.	1
Rigid plastics	No existing EoW criteria were identified.	1
Wood	No existing EoW criteria were identified.	1

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Several existing national or regional EoW or by-product criteria were identified only for aggregates, resulting in a score of **3** for aggregates. For gypsum, exiting EoW criteria were identified in the United Kingdom and therefore gypsum received a score of **2**. The other CDW streams received a score of **1** due to the lack of existing national or regional EoW criteria or the lack of single waste stream specific EoW criteria, as it was the case for asphalt.

EoW criteria | What do they contain?

As mentioned in the previous chapters, EoW criteria specifically developed for aggregates exist in many EU countries. This raises the question of when a material can be classified as an aggregate and when it still retains its original material identity. Materials such as bricks, asphalt and concrete are often recycled into recycled aggregates, which means that the EoW criteria for aggregates also affect the waste stream of concrete, bricks and asphalt. In this report we consider the EoW criteria for aggregates and for concrete, asphalt and bricks separately.

Austria

In Austria, the Recycled Building Materials Ordinance is in force (since 2016). The purpose of this ordinance is to ensure the high quality of CDW and to promote the recycling of this waste. The decree sets out requirements to be met when demolishing buildings, such as conducting a pollutant and contaminant survey and dismantling buildings in an orderly and recycling-oriented manner. The aim is to improve the suitability of the waste for the production of recycled building materials. The regulation also contains provisions on the further treatment of construction and demolition waste, quality specifications for the recycled building materials to be produced and specified areas of application for recycled building materials.

Finland

In Finland, there is the government decree on establishing criteria for the EoW classification of crushed concrete. The decree contains paragraphs on different topics such as the pre-treatment and recovery of concrete waste, sampling instructions to examine the environmental suitability of the material, use and storage instructions for the recovered material. The decree applies to manufacturers who have an environmental permit for concrete waste crushing operations or whose operations crush concrete waste pursuant to the Government Decree (858/2018).

France

France has EoW regulation for aggregates produced from construction and public works to be used in road building. Wastes that are accepted to produce aggregates are from the construction and demolition wastes category and include, among others, concrete, bricks, glass, tiles and ceramics. Those guides provide an approach to assess the environmental acceptability of alternative materials produced from CDW and industrial waste or by-products for road construction usage specifying that they must be capable of being implemented under the conditions and with the same equipment as the natural materials they replace.

Ireland

In Ireland, there is a national EoW criteria formulated for aggregates[14]. The criteria determine when recycled aggregates resulting from a recovery operation cease to be waste. The material must demonstrate compliance with all the criteria and this compliance must be documented. The criteria regulate the quality of waste inputs, the recovery processes and treatment techniques used to process the waste, the specified uses and restrictions on use. In addition, a verification sample must be taken from each batch of recycled aggregates produced and tested to ensure that the criteria have been met.

Italy

In Italy[15], there is a regulation governing on EoW status of inert construction and demolition waste and other waste aggregates of mineral origin. The EoW status for inert construction and demolition waste and other waste aggregates of mineral origin is determined on the basis of several conditions: the substance or object is commonly used for specific purposes, there is a market or demand for it, it meets technical requirements and complies with applicable legislation and standards and its use does not have a negative impact on the environment and/or human health. The objective of this regulation is the environmental benefit and the added economic value of transforming waste into a valuable resource. The regulation should contribute to reducing the consumption of raw materials and the amount of waste to be disposed of, thereby promoting a more sustainable and efficient use of resources.

[14] www.epa.ie/publications/corporate/consultations/-consultations/DRAFT-Explanatory-Note-Recycled-Aggregates.pdf

[15] Official Journal (gazzettaufficiale.it)

The Netherlands

In the Netherlands, EoW criteria have been formulated for recycled aggregates. This regulation sets out the criteria that the recycled aggregates must meet in order to be considered a product and not a waste. The requirements focus both on the waste that is accepted at the waste processing facility, such as the prohibition of tar asphalt in the recycled aggregates and on the production process of the recycled aggregates. It states that the producer must have a process control system in place. In addition, the criteria also emphasise the quality of the product by mentioning the quality standards that the recycled aggregates should meet. There are also standards mentioned that describe the quality of the material and the recycled aggregates must fulfil these standards. These EoW criteria result in reduced administrative burden for producers of recycled aggregates.

4.1.12 Expected environmental and human health impacts

The parameter aimed to identify CDW streams with more benefits than risks, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with more risks than benefits were considered to have a lower potential. Table 4-12 presents the scoring results for this parameter.

Table 4-12: Potential of CDW streams (in alphabetical order) based on the expected impacts of EU wide EoW criteria

Waste stream	Rationale behind the score	Score
Aggregates	Stakeholders consulted indicated benefits and risks to the environment and human health if EU EoW criteria are set to an equal extent. In the survey, in total, 179 benefits were chosen, compared to 39 risks. The most common benefits chosen were climate change (47), followed by abiotic depletion (32) and biodiversity (30). The most common risk chosen was water use (12). However, several national level stakeholders gave a mixed answer in interviews, including by indicating disadvantages for well-functioning national environmental criteria.	2
Asphalt	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 41 benefits were chosen, compared to 11 risks. The most common benefits chosen were climate change and abiotic depletion (11 each) and the most common risk chosen was human health (4).	3
Building products for reuse	More stakeholders consulted indicated that the risks to the environment and human health outweigh the benefits if EU EoW criteria are set. In the survey, in total, 26 benefits were chosen, compared to 14 risks. The most common benefit chosen was climate change (8) and the most common risk chosen was climate change (5).	2
Concrete	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 110 benefits were chosen, compared to 24 risks. The most common benefit chosen was climate change (33) and the most common risk chosen was climate change (8).	3

Waste stream	Rationale behind the score	Score
Fired clay bricks	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 34 benefits were chosen, compared to 13 risks. The most common benefits chosen was climate change (11) and the most common risk chosen was climate change (4).	3
Gypsum	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 18 benefits were chosen, compared to 13 risks. The most common benefit chosen was climate change (7) and the most common risk chosen was climate change (4).	3
Inert insulation	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 21 benefits were chosen, compared to 9 risks. The most common benefit chosen was climate change (5) and the most common risks chosen were biodiversity, climate change and water use (2 each).	3
Plastic foam insulation	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 9 benefits were chosen, compared to 6 risks. The most common benefit chosen was climate change (3) and the most common risk chosen was climate change (2).	3
Rigid plastics	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 19 benefits were chosen, compared to 17 risks. The most common benefit chosen was climate change (5) and the most common risks chosen were biodiversity and climate change (4 each).	3
Wood	Most stakeholders consulted indicated that the benefits to the environment and human health outweigh the risks if EU EoW criteria are set. In the survey, in total, 22 benefits were chosen, compared to 17 risks. The most common benefit chosen was climate change (7) and the most common risks chosen were biodiversity and climate change (4 each).	3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Overall, the stakeholders reported more benefits than risks if EU-wide EoW criteria were introduced – and therefore eight out of ten CDW streams received a score of 3. The most frequently mentioned benefits and risks across all CDW streams relate to climate change mitigation. For example, in the case of plastics, possible future EU-wide EoW criteria could lead to reduced use of virgin fossil materials and reduced climate change impacts through increased recycling and in the case of aggregates, climate change risks could be associated with increased transport emissions.

Only aggregates and building products for reuse received a score of 2, because several stakeholders at national level gave a mixed response in interviews, also indicating disadvantages for well-functioning national environmental criteria.

4.1.13 Number of recycling processes applied

The parameter aimed to identify CDW streams with reported recycling processes, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no reported recycling processes were considered to have a lower potential. Table 4-13 presents the scoring results for this parameter.

Table 4-13: Potential of CDW streams (in alphabetical order) based on the number of recycling processes applied

Waste stream	Rationale behind the score	Score
Aggregates	Many reuse/recycling processes were reported to be used, including screening, crushing, sorting and washing.	3
Asphalt	Several reuse/recycling processes were used for the asphalt waste stream. The main recycling process used is mechanical recycling (crushing, sorting and grinding).	3
Building products for reuse	Either for direct reuse or prior processing such as sorting, separation, cleaning and washing, as reported by stakeholders consulted.	3
Concrete	The mechanical recycling processes of sorting, washing, separating and crushing have been reported. Backfilling processes have also been reported.	3
Fired clay bricks	The mechanical recycling process of crushing, sorting and grinding were reported.	2
Gypsum	There were several mechanical recycling processes reported such as sorting, crushing, milling, shredding, mechanical separation and cleaning of improper elements including removing paper from gypsum boards.	3
Inert insulation	There were several mechanical recycling processes reported such sorting, heating and melting.	3
Plastic foam insulation	Both chemical and mechanical recycling processes were applied.	3
Rigid plastics	There were several mechanical recycling processes reported such as sorting, grinding, cryo-grinding, shredding, washing, metal separation and weldability and mechanical strength testing. There are also chemical recycling methods that are being tested.	3
Wood	Several recycling processes were reported, such as shredding, chipping and consolidating and recovery into pellets.	3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

For each CDW stream more than two recycling processes were reported by the stakeholders - and therefore nine out of ten CDW streams received a score of **3**. Only for fired clay bricks, just crushing, sorting and grinding were reported. This is considered to be a singular recycling process, so it was score as **2**.

4.1.14 Estimates of market evolution

The parameter aimed to identify CDW streams with an expected increase in both market value and sales, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with an expected decrease in market value and sales were considered to have a lower potential. Table 4-14 presents the scoring results for this parameter.

Table 4-14: Potential of CDW streams (in alphabetical order) based on the estimated market evolution.

Waste stream	Rationale behind the score	Score
Aggregates	For all CDW streams, based on stakeholder input, the introduction of EU-wide EoW criteria is expected to increase market value and sales.	3
Asphalt		3
Building products for reuse		3
Concrete		3
Fired clay bricks		3
Gypsum		3
Inert insulation		3
Plastic foam insulation		3
Rigid plastics		3
Wood		3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

The expected market development was an estimate based on the estimates of the stakeholders. The market for each CDW stream was expected to increase in both market value and sales - and therefore all CDW streams were given a score of **3** - but as this depends on many factors, the uncertainty could be high.

4.1.15 Challenges in technical and administrative processes and problems experienced with recycling

The parameter aimed to identify CDW streams with a higher number of reported problems, indicating a higher potential for the development of future EU-wide EoW criteria. Conversely, CDW streams with no reported problems were considered to have a lower potential. Table 4-15 presents the scoring results for this parameter.

Table 4-15: Potential of CDW streams (in alphabetical order) based on the number of existing challenges and problems.

Waste stream	Rationale behind the score	Score
Aggregates	Several challenges/problems were reported in relation to the aggregate waste stream. Common challenges included contaminant removal, testing and documentation requirements, material quality, traceability and high emissions from recycling and transport. Challenges/problems related to the use of secondary aggregates included lack of demand, especially from public authorities, bans on the use of secondary materials and lack of common standards and definitions.	3
Asphalt	Several challenges/problems were reported in relation to the asphalt waste stream. Challenges related to segregation of different types of asphalt, ageing of asphalt, coal tar contamination and regulations based on material composition rather than performance. These challenges were seen, e.g., in relation to the use of secondary materials, including	3

Waste stream	Rationale behind the score	Score
	permitting and national regulations prohibiting the use of recycled materials.	
Building products for reuse	The challenges and issues commonly associated with this waste stream were as follows: there were unclear regulations regarding the legal status (waste/product) of these materials and there were different interpretations of what constituted reuse, which can vary from region to region. Additionally, it was difficult to determine if a building product was contaminated with unwanted substances and if the material still meet the required standards.	3
Concrete	Several challenges/problems were reported in relation to the concrete waste stream, including those related to contamination, transport, recycling costs and lack of recycling opportunities. Challenges/problems related to the use of secondary concrete included lack of sufficient standards, permitting, regulatory barriers, transport costs, contaminant limits, lack of landfill bans and lack of demand.	3
Fired clay bricks	Challenges/problems reported in relation to this waste stream included quality and contamination from other materials such as mortar and plaster. Challenges/problems related to the use of secondary materials in this waste stream included lack of demand, that it was too cheap to landfill and gaining permission for reuse on site.	3
Gypsum	Several challenges/problems related to the gypsum stream were reported, including energy consumption of recovery operations, removal of paper and additives such as silicones and is sometimes contaminated with fire retardants and the lack of proper sorting at construction sites. Challenges/problems related to the use of secondary materials included economic disincentives due to lack of sufficient landfill fees, cheap novel materials and, in some countries, the cheap alternative of mixing the gypsum with soil rather than recycling it.	3
Inert insulation	Several challenges/problems were reported in relation to the waste stream, including contamination, legacy issues, bureaucratic costs, operational costs, recycling techniques and supply chains.	3
Plastic foam insulation	Several challenges/problems were reported in relation to the waste stream, including in relation to sorting, impurities, transport (due to the light weight), administrative barriers and the low costs for landfilling.	3
Rigid plastics	Several challenges/problems were reported in relation to the waste stream, including additives and contaminants such as lead (as special permits are required to process waste containing hazardous substances, it can be difficult for e.g. installers to return products and many substances that are now banned are part of building products that are now being replaced). Separation and traceability of substances contained in waste products were also reported as challenges. Challenges/problems related to the use of secondary materials included administrative and legal restrictions on the use of recycled materials, restrictions on the transport of waste necessary	3

Waste stream	Rationale behind the score	Score
	to close the recycling loop and difficulties in obtaining PVC waste for recycling.	
Wood	Several challenges/problems related to the concrete waste stream were reported, including contamination, traceability, inefficient recycling processes and limited quality control.	3

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Common waste treatment challenges and problems across all CDW streams included:

- Contamination from other materials such as mortar and plaster in burnt clay bricks, coal tar in asphalt and flame retardants in gypsum.
- Ensuring consistent quality of recycled materials, which affects their market acceptance and use.
- Permitting and regulatory barriers, including national regulations prohibiting the use of recycled materials and administrative barriers to recycling operations. Unclear regulations, including the legal status of materials (waste/product), affecting, for example, the market for building products for reuse.
- Lack of demand, particularly from public authorities and for secondary materials, affecting, for example, the market for recycled aggregates and concrete.
- Economic disincentives, such as inadequate landfill fees and the lower cost of virgin materials compared to recycled materials, affecting, for example, the market for recycled gypsum.
- High emissions from recycling and transport and challenges in transporting lightweight materials such as plastic foam insulation.
- Bans on the use of secondary materials, lack of common standards and difficulties in sourcing waste for recycling, such as rigid plastics.
- The lack of proper sorting at construction sites, as noted for gypsum, complicates the recycling process.
- The ability to trace the origin and content of waste materials is an issue for materials such as wood and rigid plastics.

4.2 Ranking of the CDW streams

Below is the ranking of the ten CDW streams according to the methodology applied, which included the scoring and weighting of stakeholder responses to the 15 ranking parameters.

The **higher potential CDW streams** (those within the third tertile of all CDW streams) were *aggregates, concrete, fired clay bricks* and *gypsum*[16] in alphabetical order.

The CDW streams with **average potential** (those within the second tertile) were *asphalt*, *inert insulation*, *plastic foam insulation, rigid plastics* and *wood* in alphabetical order.

The **lower potential CDW stream** (that within the first tertile) was *building products for reuse*.

4.3 Environmental impact assessment

The implementation of future EU-wide EoW criteria should result in reduced environmental impacts. It is not possible to calculate the exact impact, but a rough estimate is given in this chapter. The impact analysis assumes that the introduction of EU-wide EoW criteria would lead to an increase in recycling.

4.3.1 Business as usual (BAU)

Table 4-16 shows the environmental impacts of nine CDW streams per midpoint and endpoint indicator. The waste stream building products for reuse could not be analysed due to its heterogeneity. For the BAU scenario, the environmental impact of each CDW stream was considered including the impact of the respective waste treatment and the avoided emissions (both virgin materials and energy production). Different waste treatment mixes (landfill, incineration, recycling and reuse) were used for the waste streams. This mix was representative of the average European waste treatment.

Table 4-16: BAU per ton CDW stream.

	Global warming* [tCO_2eq/ kton]	Damage to ecosystems** [species.yr/ kton]	Damage to human health*** [DALYs/ kton]	Damage to resource availability**** [EURO/ kton]
Aggregates	8	-6.87E-05	0.03	€ 1,304
Asphalt	-3	-2.03E-04	-0.01	€ -11
Concrete	7	2.92E-05	0.04	€ 970
Fired clay bricks	9	-7.80E-07	0.03	€ 1,538
Gypsum	-3	1.38E-03	1.21	€ 980
Inert insulation	5	2.47E-05	0.02	€ 1,126

[16] Important note: As will follow when considering the sensitivity analyses, gypsum is more pronounced to changes in the ranking compared to the other 'high potential CDW streams'

	Global warming* [tCO_2eq/ kton]	Damage to ecosystems** [species.yr/ kton]	Damage to human health*** [DALYs/ kton]	Damage to resource availability**** [EURO/ kton]
Plastic foam insulation	953	2.25E-03	0.70	€ -136,921
Rigid plastics	-241	-1.32E-03	-0.52	€ -74,593
Wood	-30	-4.74E-03	0.05	€ -3,983

The higher potential CDW streams are marked in purple (see chapter 4.2).

* ‘Global warming’ is a midpoint impact category in the ReCiPe16 methodology in tonne CO2-equivalent per tonne of material.

** ‘Damage to ecosystems’ is an endpoint area of protection in the ReCiPe16 methodology (see Figure 3.1) in time-integrated species loss, briefly in species per year and per tonne of material.

*** ‘Damage to human health’ ecosystems’ is an endpoint area of protection in the ReCiPe16 methodology (see Figure 3.1) in disability-adjusted loss of life years, briefly in DALY per tonne of material.

**** ‘Damage to resource availability’ is an endpoint area of protection in the ReCiPe16 methodology (see Figure 3.1) expressing surplus costs, briefly in USD. USD 2013 were converted to EURO using the average exchange rate of 2013 (1 USD = 0,7531 EURO)

The global warming potential indicator is expressed in metric ton of CO_2eq per kton of waste stream. Plastic foam insulation had the highest score due to the high amount of CO_2eq emitted during incineration. Rigid plastics has a negative and the lowest emission value due to prevention of virgin materials and avoided energy production.

The damage to the ecosystems indicator represents the ecosystem quality. It was negative for most of the waste streams. The values are low for all waste streams. Plastic foam insulation has the highest impact and wood the lowest/ most negative.

The damage to the human health indicator showed the highest impact value for gypsum and the lowest/ most negative value for rigid plastics.

The damage to the resource availability indicator showed the highest impact values for fired clay bricks and the lowest/ most negative value for plastic foam insulation.

Table 4-16 shows the impacts to the environment and the human health for *one metric ton of CDW stream*. To get an overview of the impacts for the total amount of each waste stream generated, these values are multiplied by the total amount of waste collected in the EU (see Table 3-4) – these total impact values are shown in

Table 4-17.

Table 4-17: BAU for the total EU per CDW stream.

	Global warming [tCO_2eq]	Damage to ecosystems [species.yr]	Damage to human health [DALYs]	Damage to resource availability [EURO]
Aggregates	1,586,251	-14	6,395	€ 260,788,664
Asphalt	-149,364	-11	-766	€ -584,850
Concrete	1,444,773	6	7,250	€ 194,928,361
Fired clay bricks	46,333	0	169	€ 7,692,294
Gypsum	-1,996	1	868	€ 702,472
Inert insulation	407	0	2	€ 84,425
Plastic foam insulation	266,877	1	195	€ -38,337,953
Rigid plastics	-202,588	-1	-437	€ -62,658,410
Wood	-1,307,385	-208	1,987	€ -174,492,040
Total	**1,683,385**	-226	15,664	€ 188,112,963

* The higher potential CDW streams are marked in purple (see chapter 4.2).

In total, 1,683,385 metric tonnes of CO_2eq were estimated to be emitted in the EU from the treatment of the respective CDW streams; aggregates and concrete were the main contributors, both due to their quantity. Wood had the highest negative impact.

For ecosystem quality, the total impact was estimated to be 226 local relative species lost per year; wood was the main contributor.

For the human health impact indicator, 15,664 life years were estimated to be lost due to the processing of the nine analysed CDW streams in the EU; again with aggregates and concrete being the main contributor. The lowest/ most negative impact was asphalt.

The total extra cost of future extraction of mineral and fossil resources was estimated to be € 188,122,963 (damage to the resource availability). The main contributors were aggregates and concrete, while the lowest/ most negative impact was again for wood.

4.3.2 With future EoW criteria

Table 4-18 shows the changes after implementation of the imagined future EoW criteria. Under these future criteria, we assume that 10% more CDW material is recycled/reused instead of landfilled or incinerated. A negative percentage means a lower score and therefore a lower environmental impact. Table 4-19 shows the same changes in percentages.

Table 4-18: EoW scenario change of absolute values.

	Global warming [tCO_2eq]	Damage to ecosystems [species.yr]	Damage to human health [DALYs]	Damage to resource availability [EURO]
Aggregates	-187,277	-6.3	-355	€ -27,938,971
Asphalt	-124,003	-1.0	-293	€ -12,020,887
Concrete	-103,789	-0.7	-70	€ -20,642,598
Fired clay bricks	-5,000	-0.2	-10	€ -732,325
Gypsum	-10,853	-0.2	-122	€ -716,956
Inert insulation	-5,006	0.0	-10	€ -132,293
Plastic foam insulation	-127,273	-0.4	-159	€ -7,428,979
Rigid plastics	-135,364	-0.6	-245	€ -18,913,409
Wood	-70,701	4.0	-1,122	€ 2,343,521
Total	-769,267	-5.4	-2,384	€ -86,128,896

* The higher potential CDW streams are marked in purple (see chapter 4.2).

Table 4-19: EoW scenario percentages of reduction compared to the BAU.

	Global warming	Damage to ecosystems	Damage to human health	Damage to resource availability
Aggregates	24%	114%	14%	**32%**
Asphalt	16%	17%	12%	14%
Concrete	13%	12%	3%	24%
Fired clay bricks	1%	3%	0%	1%
Gypsum	1%	3%	5%	1%
Inert insulation	1%	0%	0%	0%
Plastic foam insulation	16%	8%	6%	8%
Rigid plastics	17%	11%	10%	22%
Wood	14%	-69%	49%	-1%

* The higher potential CDW streams are marked in purple (see chapter 4.2).

In this EoW scenario, the global warming potential, expressed in CO_2eq emissions, of nine CDW streams would decrease. Most waste streams would show a significant reduction in emissions, with aggregates at the top, mainly due to its high quantity. Fired clay bricks, gypsum and inert insulation contribute only 1% to the total reduction, mainly due to their small quantities.

The ecosystem quality indicator would show different changes compared to the changes in global warming potential. Aggregates were clearly at the top, with the highest potential reduction in ecosystem damage. Wood would be the only waste stream with a negative percentage. The other waste streams would show some improvement in the EoW scenario.

The human health indicator would follow a somewhat similar trend to ecosystem quality, but aggregates would have a lower positive impact and wood would score best for human health. Furthermore, all waste streams would improve after introduction potential EU-wide EoW criteria.

Finally, in terms of damage to resource availability, aggregates would score best again, followed by concrete and rigid plastics.

4.3.3 BAU vs EoW scenario comparison

Table 4-20 shows the difference in environmental impacts between the BAU scenario and the EoW scenario. In total, all environmental impact indicators would be lower after the implementation of future potential EoW criteria compared to the BAU scenario. The global warming potential would be reduced by 769,267 metric tonnes of CO_2eq. In terms of ecosystem quality, the total number of species lost per year would be slightly lower than in the BAU scenario. For the human health indicator 2,384 life years would be gained. For natural resources, more than € 86 million fossil and mineral resource extraction would be saved. Note that the price increase (inflation and price increase due to resource scarcity) of energy use is not included in this calculation.

Table 4-20: EoW scenario with 3 different recycling rates (absolute values).

Environmental impact	5%	EOW 10%	20%
Global warming	-386,904	**-769,266**	-1,461,337
Damage to ecosystems	-2.8	**-5.4**	-9.9
Damage to human health	-1,196	**-2,384**	-4,712
Damage to resource availability	€ -43,168,787	**€ -86,182,896**	€ -157,761,265

To test the impact of the assumption of the EoW scenario (10% more recycling), the analysis is also performed with 5% and 20% increase in recycling. In all three cases (5, 10 and 20% increase of recycling/reuse) the four environmental impact indicators would show negative values, meaning the environmental damage would be lower (compared to BAU).

Table 4-21 shows the same results, but as percentages rather than absolute values. Here, the improvement per environmental indicator would be almost half for the 5% increase in recycling compared to the 10% recycling scenario. For the 20% increase in recycling scenario, the reduction the environmental damage would almost double. The human health indicator would show the largest reduction in damage. The resource indicator would show the smallest reduction.

Table 4-21: EoW scenario with 3 different recycling rates (percentages).

Environmental impact	5%	EOW 10%	20%
Global warming	50,3%	**100%**	190,0%
Damage to ecosystems	50,2%	**100%**	185,2%
Damage to human health	53,1%	**100%**	197,6%
Damage to resource availability	50,1%	**100%**	183,1%

4.4 Sensitivity and uncertainty analyses

4.4.1 Influence of the weighting

A. Alternative weightings

In this study, two weighting alternatives were tested (see chapter 3.5.1). The influence of the changed weightings on the ranking result of the CDW streams being suitable for future EU EoW criteria for both alternatives is as follows:

Alternative 1 – current practice

The **higher potential CDW streams** were still *aggregates, concrete, fired clay bricks* and *gypsum* in alphabetical order.

The CDW streams with **average potential** were still *asphalt*, *inert insulation* and *plastic foam insulation,* but no longer *rigid plastics* and *wood* in alphabetical order.

The **lower potential CDW streams** would still include *building products for reuse* but also rigid plastics and wood.

Alternative 2 – circular economy

The **higher potential CDW streams** were still *aggregates, concrete, fired clay bricks* and *gypsum* in alphabetical order.

The CDW streams with **average potential** were still *asphalt*, *inert insulation* and *plastic foam insulation, rigid plastics* and *wood* in alphabetical order.

The **lower potential CDW stream** would still include *building products for reuse.*

B. Interrelation of weighting and scoring

Default: Default weighting and scoring

This default test shows the same results (Table 4-22**Error! Reference source not found.**) as the main list as shown in chapter 4.2. Other tests are compared to this one in the following paragraphs.

Table 4-22: Results of CDW streams for the default test. CDW streams with the same score are listed alphabetically. The possible scores range from 30 to 90, inclusive.

CDW Stream	Final Score
Gypsum	75
Aggregates	74
Concrete	73
Fired clay bricks	72
Asphalt	71
Inert insulation	69
Plastic foam insulation	69
Rigid plastics	69
Wood	69
Building products for reuse	62

The **higher potential CDW streams** (those within the third tertile of all CDW streams) in alphabetical order were *aggregates, concrete, fired clay bricks* and *gypsum*.

The CDW streams with **average potential** (those within the second tertile) in alphabetical order were *asphalt*, *inert insulation*, *plastic foam insulation, rigid plastics* and *wood*.

The **lower potential CDW stream** (that within the first tertile) was *building products for reuse*.

Test 1: Default weighting and amplified scoring

In Test 1, default weighting (1, 2 and 3) and amplified scoring (1, 10 and 100) were used. The results (Table 4-23) are, therefore, mainly influenced by the average score of the parameters. CDW streams that consistently score higher on the different parameters, end up higher on the ranking.

Table 4-23: Results of CDW streams for Test 1. CDW streams with the same score are listed alphabetically. The possible scores range from 30 to 3000, inclusive.

CDW Stream	Final Score
Gypsum	2,136
Fired clay bricks	2,046
Concrete	2,037
Asphalt	2,019

CDW Stream	Final Score
Aggregates	1,965
Inert insulation	1,920
Plastic foam insulation	1,920
Wood	1,920
Rigid plastics	1,758
Building products for reuse	1,452

The **higher potential CDW streams** (those within the third tertile of all CDW streams) in alphabetical order were *asphalt, concrete, fired clay bricks* and *gypsum*.

The CDW streams with **average potential** (those within the second tertile) in alphabetical order were *aggregates*, *inert insulation*, *plastic foam insulation, rigid plastics* and *wood*.

The **lower potential CDW stream** (that within the first tertile) was *building products for reuse*.

Test 2: No difference in weighting and default scoring

In Test 2, there was no difference in weighting between the parameters. They all had a weight of 1 attributed to them. The default scoring system (1, 2, and 3) was still applied. As the weighting of the different parameters has no influence on the results (Table 4-24) in this test, the only factor that affects the ranking is the average score of all parameters per CDW stream. This ends up meaning that most CDW streams end up with similar final scores.

Table 4-24: Results of CDW streams for Test 2. CDW streams with the same score are listed alphabetically. The possible scores range from 15 to 45, inclusive.

CDW Stream	Final Score
Gypsum	39
Aggregates	38
Concrete	37
Fired clay bricks	37
Asphalt	36
Inert insulation	36
Plastic foam insulation	36
Rigid plastics	36
Wood	36
Building products for reuse	33

The **higher potential CDW streams** (those within the third tertile of all CDW streams) in alphabetical order were *aggregates, concrete, fired clay bricks* and *gypsum*.

The CDW streams with **average potential** (those within the second tertile) in alphabetical order were *asphalt*, *inert insulation*, *plastic foam insulation, rigid plastics* and *wood*.

The **lower potential CDW stream** (that within the first tertile) was *building products for reuse*.

Test 3: No difference in weighting and amplified scoring

In Test 3, similar to Test 2, there was no difference in weighting between the parameters. They all had a weight of 1 attributed to them. In contrast to Test 2, the amplified scoring system (1, 10, and 100) was used. As the weighting of the different parameters has no influence on the results (Table 4-25) in this test, the only factor that affects the results is the average score of all parameters per CDW stream. With amplified scoring, more differentiation between CDW streams was visible.

Table 4-25: Results of CDW streams for Test 3. CDW streams with the same score are listed alphabetically. The possible scores range from 15 to 1500, inclusive.

CDW Stream	Final Score
Gypsum	1,122
Aggregates	1,032
Concrete	1,023
Fired clay bricks	1,023
Asphalt	1,014
Inert insulation	1,014
Plastic foam insulation	1,014
Wood	1,014
Rigid plastics	933
Building products for reuse	825

The **higher potential CDW streams** (those within the third tertile of all CDW streams) in alphabetical order were *aggregates, concrete, fired clay bricks* and *gypsum*.

The CDW streams with **average potential** (those within the second tertile) in alphabetical order were *asphalt*, *inert insulation*, *plastic foam insulation,* and *wood*.

The **lower potential CDW streams** (those within the first tertile) in alphabetical order were *building products for reuse* and *rigid plastics*.

Test 4: Amplified weighting and default scoring

Test 4 used amplified weighting (1, 10 and 100) and the default scoring system (1, 2, 3). This meant that the results (Table 4-26) was mainly influenced by CDW streams that had better scores for more heavily weighted parameters. Amplified weighting also led to more differentiation between the CDW streams.

Table 4-26: Results of CDW streams for Test 4. CDW streams with the same score are listed alphabetically. The possible scores range from 555 to 1665, inclusive.

CDW Stream	Final Score
Concrete	1,414
Asphalt	1,404
Fired clay bricks	1,342
Aggregates	1,334
Gypsum	1,254
Inert insulation	1,224
Plastic foam insulation	1,224
Rigid plastics	1,224
Wood	1,224
Building products for reuse	1,104

The **higher potential CDW streams** (those within the third tertile of all CDW streams) in alphabetical order were *aggregates*, *asphalt, concrete*, and *fired clay bricks*.

The CDW streams with **average potential** (those within the second tertile) in alphabetical order were *gypsum*, *inert insulation*, *plastic foam insulation, rigid plastics,* and *wood*.

The **lower potential CDW stream** (that within the first tertile) was *building products for reuse*.

Test 5: Amplified weighting and amplified scoring

Test 5 used amplified weighting (1, 10 and 100) and the amplified scoring system (1, 10, 100). This meant that the CDW streams that consistently score higher on heavier weighted parameters and end up higher in the results (Table 4-27). Amplified weighting and scoring together also led to greater differentiation between the CDW streams.

Table 4-27: Results of CDW streams for Test 5. CDW streams with the same score are listed alphabetically. The possible scores range from 555 to 55,500, inclusive.

CDW Stream	Final Score
Concrete	42,630
Asphalt	42,540
Fired clay bricks	35,421
Gypsum	34,710

CDW Stream	Final Score
Aggregates	34,620
Inert insulation	33,630
Plastic foam insulation	33,630
Wood	33,630
Rigid plastics	32,820
Building products for reuse	23,640

The **higher potential CDW streams** (those within the third tertile of all CDW streams) in alphabetical order were *asphalt, concrete*, *gypsum*, and *fired clay bricks*.

The CDW streams with **average potential** (those within the second tertile) in alphabetical order were *aggregates*, *inert insulation*, *plastic foam insulation,* and *wood*.

The **lower potential CDW stream** (those within the first tertile) in alphabetical order were *rigid plastics* and *building products for reuse*.

4.4.2 Monte Carlo simulation

Default weighting

The results of the two tests to assess the robustness of parameters 2, 3 and 4 in relation to each other are presented in this chapter. Robustness was tested by simulating a deviation within predefined boundaries one million times per test and counting the frequency that a CDW stream ended up on a certain rank. The CDW stream building products for reuse was not included in the Monte Carlo simulation, as there was insufficient qualitative data available for parameters 2 and 4 for this CDW stream. It was always assumed that it scored as lower potential for all assessed parameters.

Test 1: Standard deviation equal to 10% of the original value

Figure 4.1 presents the results of Test 1, which used a standard deviation of 10% of the original value. The analysis shows little variation in the ranking, with only two CDW streams (*rigid plastics* and *wood*) potentially having different final ranks compared to the ranking presented in chapter 4.2.

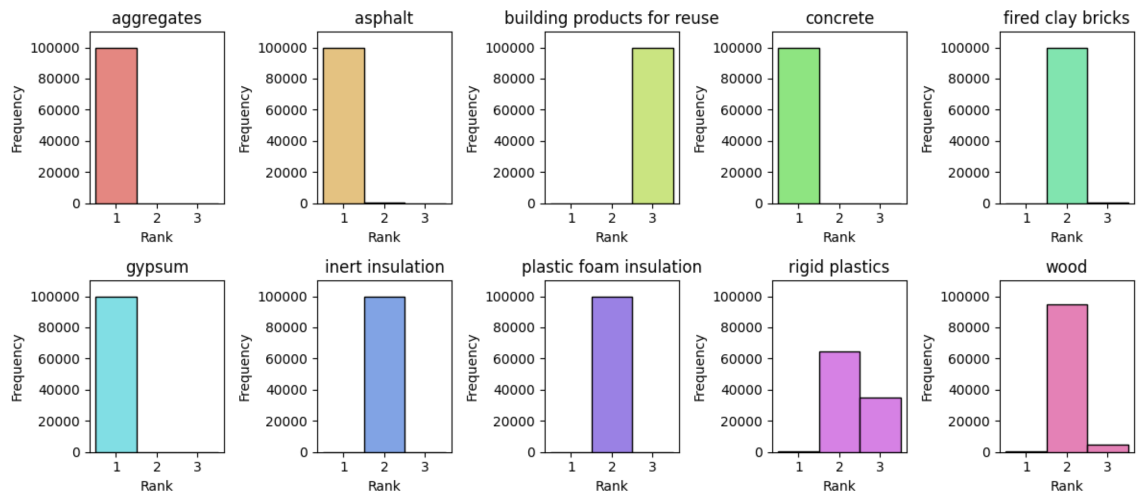


Figure 4.1: Frequency of the ranking for each CDW stream in Test 1 for the default scenario when input values for parameters 2, 3 and 4 are randomly adjusted with a standard deviation of 10% of the original value. The model was run 100,000 times.

Table 4-28 shows the absolute values. The most common rank per CDW stream is shown in bold.

Table 4-28: Absolute frequencies of potential for the ten CDW streams in Test 1 for the default scenario.

CDW Stream	Higher Potential	Average Potential	Lower Potential
Aggregates	100,000 (100%)	-	-
Asphalt	99,774 (99.77%)	226 (0.23%)	-
Concrete	100,000 (100%)	-	-
Gypsum	100,000 (100%)	-	-
Fired clay bricks	-	99,514 (99.51%)	486 (0.49%)
Inert insulation	-	100,000 (100%)	-
Plastic foam insulation	-	100,000 (100%)	-
Wood	236 (0.24%)	94,963 (94.96%)	4,801 (4.80%)
Rigid plastics	657 (0.66%)	64,382 (64.38%)	34,961 (34.96%)
Building products for reuse	-	-	100,000 (100%)

Test 2: Standard deviation equal to 20% of the original value

Figure 4.2 shows the results of Test 2. The range of ranks per CDW is greater than in Test 1, reflecting the higher uncertainty in the input figures. Still, most streams, except *asphalt*, *fired clay bricks*, *rigid plastics*, and *wood* have one clear final rank over all the simulations.

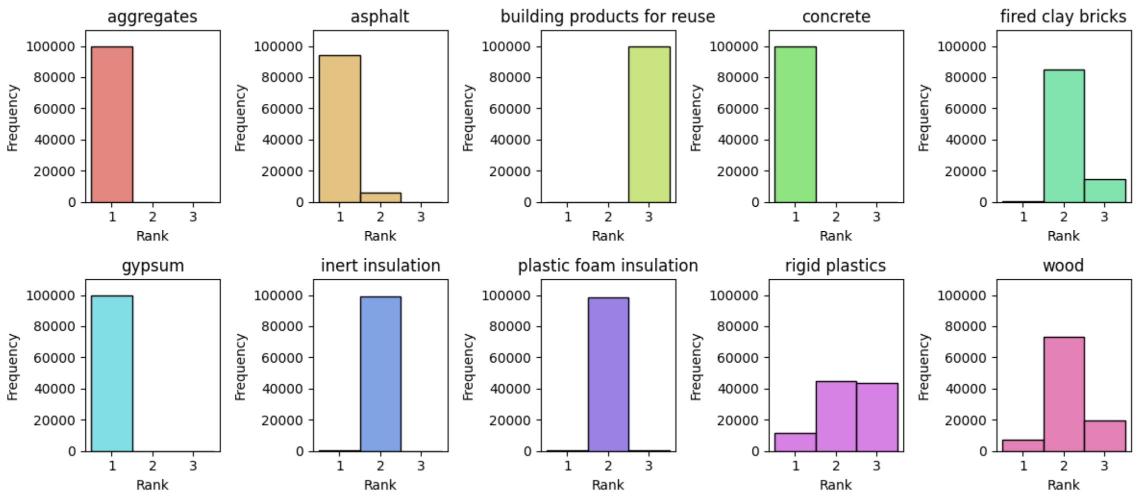


Figure 4.2: Frequency of the ranking for each CDW stream in Test 2 for the default scenario when input values for parameters 2, 3 and 4 are randomly adjusted with a standard deviation of 20% of the original value. The model was run 100,000 times.

Table 4-29 shows the absolute values. The most common rank per CDW stream is shown in bold.

Table 4-29: Absolute frequencies of potential for the ten CDW streams in Test 2 for the default scenario.

CDW Stream	Higher Potential	Average Potential	Lower Potential
Aggregates	99,993 (99.99%)	7 (0.01%)	-
Concrete	99,996 (100%)	4 (0.00%)	-
Gypsum	99,876 (99.88%)	118 (0.12%)	6 (0.01%)
Asphalt	94,094 (94.09%)	5,906 (5.91%)	-
Inert insulation	567 (0.57%)	99,350 (99.35%)	83 (0.08%)
Plastic foam insulation	566 (0.57%)	98,746 (98.75%)	688 (0.69%)
Wood	732 (7.32%)	73,178 (73.18%)	19,501 (19.50%)
Fired clay bricks	559 (0.56%)	84,892 (84.89%)	14,549 (14.55%)
Rigid plastics	11,276 (11.28%)	44,891 (44.89%)	43,833 (43.83%)
Building products for reuse	-	-	100,000 (100%)

Alternative 1 of weighting

This section covers the results of the Monte Carlo analysis performed for Alternative 1. The methodology is the same as for the default scenario, with the following changes:

- The base scores for all CDW streams are updated according to the new weightings.
- The weightings of parameters 2, 3 and 4 are changed to be equal to the values presented in Table 4-30.

Our reference R001-1288090ARS-V01-agv-NL

Table 4-30: Weighting of the assessed parameters for Alternative 1.

Parameter	Weighting
Parameter 2: Current collection and reuse rates	3 (higher)
Parameter 3: Identified uses/impacted economic sectors	2 (average)
Parameter 4: Estimated EU market value	3 (higher)

Test 1: Standard deviation equal to 10% of the original value

Figure 4.3 presents the results of Test 1 for Alternative 1, which used a standard deviation of 10% of the original value. The analysis shows that most CDW stream end up having different final ranks compared to the ranking presented in chapter 4.2. Still, the certainty of the different CDW streams ending up on the rank they do in Alternative 1 is high, with only *rigid plastics* and *wood* having possible other ranks than shown.

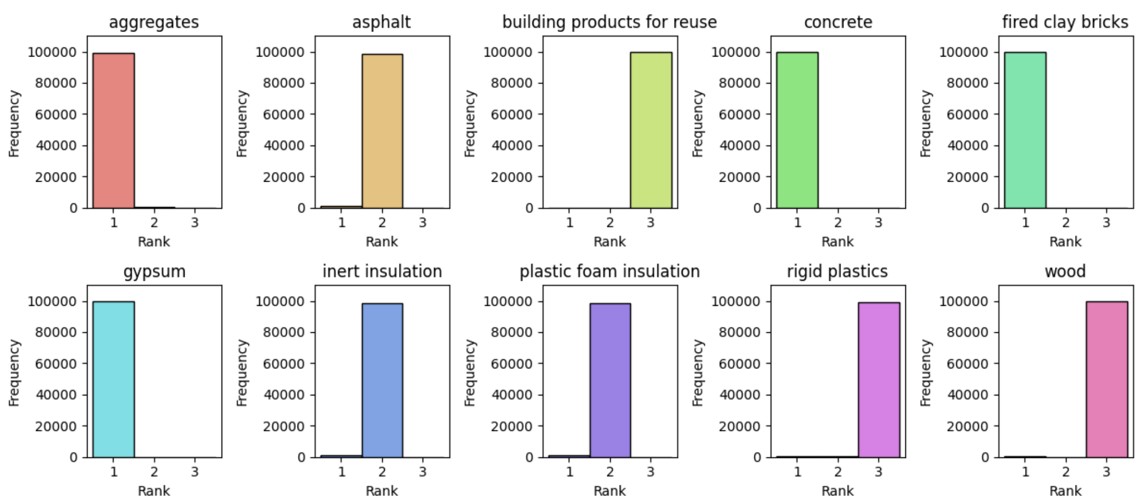


Figure 4.3: Frequency of the ranking for each CDW stream in Test 1 for Alternative 1 when input values for parameters 2, 3 and 4 are randomly adjusted with a standard deviation of 10% of the original value. The model was run 100,000 times.

Table 4-31 shows the absolute values. The most common rank per CDW stream is shown in bold.

Table 4-31: Absolute frequencies of the final ranks of the ten CDW streams in Test 1 for Alternative 1.

CDW Stream	Higher Potential	Average Potential	Lower Potential
Concrete	99,994 (99.99%)	6 (0.01%)	-
Fired clay bricks	99,974 (99.97%)	7 (0.01%)	19 (0.02%)
Gypsum	100,000 (100%)	-	-
Aggregates	99,378 (99.38%)	612 (0.61%)	10 (0.01%)
Asphalt	1245 (1.24%)	98,755 (98.76%)	-
Inert insulation	1,245 (1.24%)	98,755 (98.76%)	-

CDW Stream	Higher Potential	Average Potential	Lower Potential
Plastic foam insulation	1,245 (1.24%)	98,755 (98.76%)	-
Rigid plastics	637 (0.64%)	392 (0.39%)	98,971 (98.97%)
Building products for reuse	-	-	100,000 (100%)
Wood	214 (0.21%)	-	99,786 (99.79%)

Test 2: Standard deviation equal to 20% of the original value

Figure 4.4 presents the results of Test 2 for Alternative 1, which used a standard deviation of 20% of the original value. The analysis shows that most CDW stream end up having different final ranks compared to the ranking presented in chapter 4.2. Furthermore, the certainty of the different CDW streams ending up on the rank they do in Alternative 1 is lower, with only *building products for reuse, concrete, fired clay bricks* and *gypsum* having high certainty.

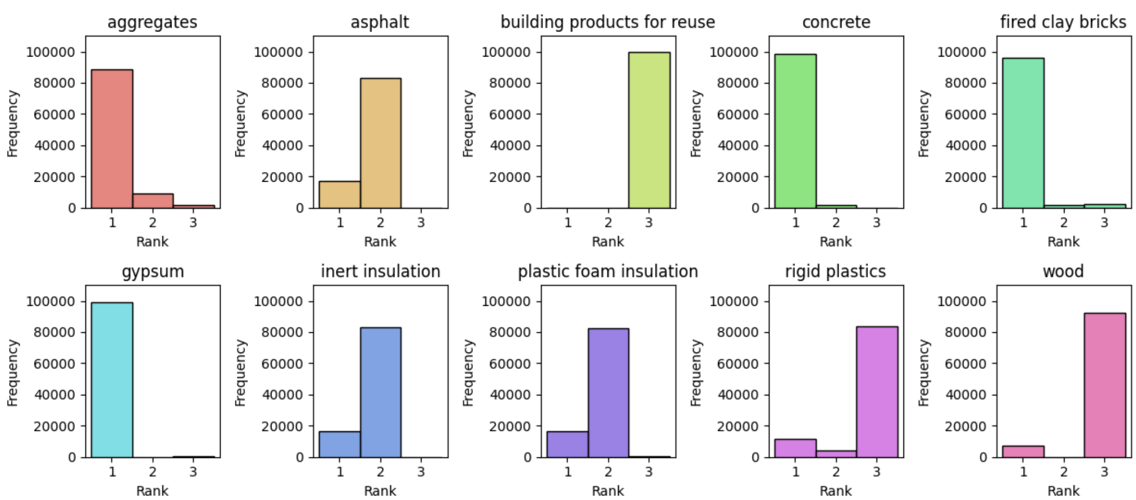


Figure 4.4: Frequency of the ranking for each CDW stream in Test 2 for Alternative 1 when input values for parameters 2, 3 and 4 are randomly adjusted with a standard deviation of 20% of the original value. The model was run 100,000 times.

Table 4-32: Absolute frequencies of the final ranks of the ten CDW streams in Test 2 for Alternative 1.shows the absolute values. The most common rank per CDW stream is shown in bold.

Table 4-32: Absolute frequencies of the final ranks of the ten CDW streams in Test 2 for Alternative 1.

CDW Stream	Higher Potential	Average Potential	Lower Potential
Gypsum	99,333 (99.33%)	89 (0.09%)	578 (0.58%)
Concrete	98,223 (98.22%)	1,777 (1.78%)	-
Fired clay bricks	95,863 (95.86%)	1,670 (1.67%)	2,467 (2.47%)
Aggregates	88,872 (88.87%)	9,151 (9.15%)	1,977 (1.98%)
Asphalt	16,793 (16.79%)	83,201 (83.20%)	6 (0.01%)

CDW Stream	Higher Potential	Average Potential	Lower Potential
Inert insulation	16,731 (16.73%)	83,262 (83.26%)	7 (0.01%)
Plastic foam insulation	16,778 (16.78%)	82,539 (82.54%)	683 (0.68%)
Rigid plastics	11,685 (11.68%)	4,397 (4.40%)	83,918 (83.92%)
Wood	7,401 (7.40%)	121 (0.12%)	92,478 (92.48%)
Building products for reuse	-	-	100,000 (100%)

Alternative 2 of weighting

This section covers the results of the Monte Carlo analysis done on Alternative 2. The methodology is the same as for the default scenario, with the following changes:

- The base scores for all CDW streams are updated according to the new weightings.
- The weightings of parameters 2, 3 and 4 are changed to be equal to the values presented in Table 4-33.

Table 4-33: Weighting of the assessed parameters for Alternative 2.

Parameter	Weighting
Parameter 2: Current collection and reuse rates	3 (higher)
Parameter 3: Identified uses/impacted economic sectors	3 (higher)
Parameter 4: Estimated EU market value	3 (higher)

Test 1: Standard deviation equal to 10% of the original value

Figure 4.5 presents the results of Test 1 of Alternative 2, which used a standard deviation of 10%. Most CDW streams show high certainty in the category where they end up.

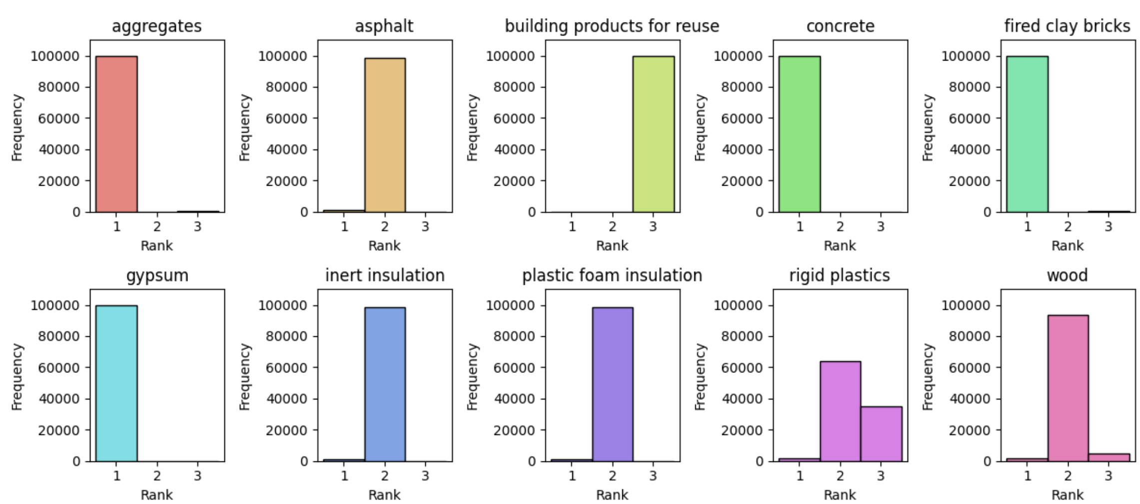


Figure 4.5: Frequency of the ranking for each CDW stream in Test 1 for Alternative 2 when input values for parameters 2, 3 and 4 are randomly adjusted with a standard deviation of 10% of the original value. The model was run 100,000 times.

Table 4-34 shows the absolute values. The most common rank per CDW stream is shown in bold.

Table 4-34: Absolute frequencies of the final ranks of the ten CDW streams in Test 1 for Alternative 2.

CDW Stream	Higher Potential	Average Potential	Lower Potential
Concrete	99,997 (100.00%)	3 (0.00%)	-
Gypsum	100,000 (100%)	-	-
Aggregates	99,421 (99.42%)	15 (0.01%)	564 (0.56%)
Fired clay bricks	99,523 (99.52%)	1 (0.00%)	476 (0.48%)
Asphalt	1,222 (1.22%)	98,778 (98.78%)	-
Inert insulation	1,222 (1.22%)	98,778 (98.78%)	-
Plastic foam insulation	1,222 (1.22%)	98,778 (98.78%)	-
Wood	1,377 (1.38%)	93,752 (93.75%)	4,871 (4.87%)
Rigid plastics	1,448 (1.45%)	63,707 (63.71%)	34,845 (34.84%)
Building products for reuse	-	-	100,000 (100%)

Test 2: Standard deviation equal to 20% of the original value

Figure 4.6 shows the results of Test 2 for Alternative 2. Uncertainty is higher than in Test 1 for this alternative. Only *building products for reuse*, *concrete* and *gypsum* have almost full certainty.

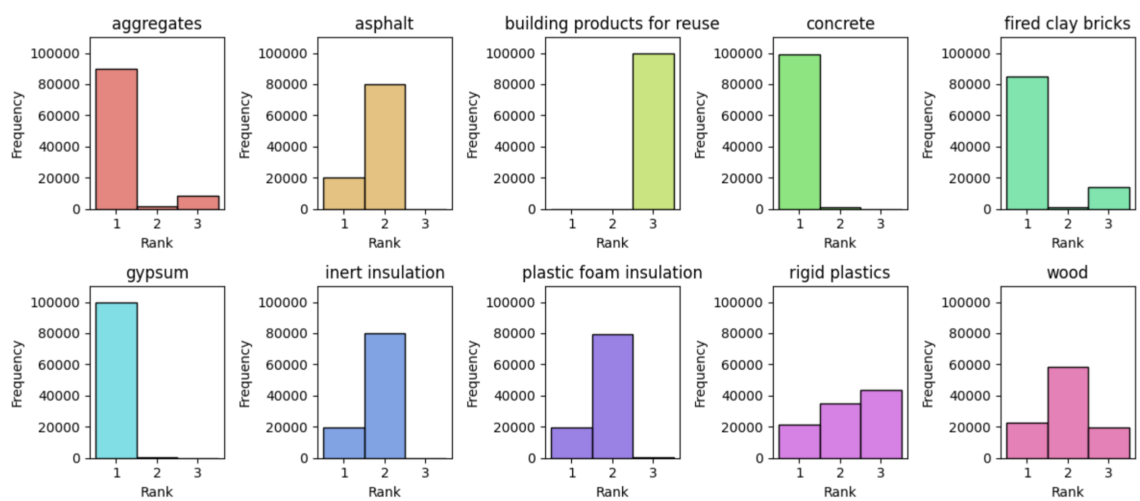


Figure 4.6: Frequency of the ranking for each CDW stream in Test 2 for Alternative 2 when input values for parameters 2, 3 and 4 are randomly adjusted with a standard deviation of 10% of the original value. The model was run 100,000 times.

Table 4-35 shows the absolute values. The most common rank per CDW stream is shown in bold.

Table 4-35: Absolute frequencies of the final ranks of the ten CDW streams in Test 2 for Alternative 2.

CDW Stream	Higher Potential	Average Potential	Lower Potential
Concrete	99,237 (99.24%)	763 (0.76%)	-
Gypsum	99,453 (99.45%)	418 (0.42%)	129 (0.13%)
Aggregates	89,934 (89.93%)	1,445 (1.44%)	8,621 (8.62%)
Fired clay bricks	84,777 (84.78%)	1,014 (1.01%)	14,209 (14.21%)
Asphalt	19,871 (19.87%)	80,129 (80.13%)	-
Inert insulation	19,807 (19.81%)	80,192 (80.19%)	1 (0.00%)
Plastic foam insulation	19,825 (19.82%)	79,489 (79.49%)	686 (0.69%)
Wood	22,369 (22.37%)	58,121 (58.12%)	19,510 (19.51%)
Rigid plastics	21,240 (21.24%)	35,157 (35.16%)	43,603 (43.60%)
Building products for reuse	-	-	100,000 (100%)

5 Discussion

5.1 Ranking results

Overall, the **priority ranking result** provides an order of the CDW streams for which possible future EU-wide EoW criteria should be developed first. The category building products for reuse scored the lowest, due to its heterogeneity and the remaining data and information gaps for all sub-materials. This result is to some extent relative; the ten waste streams had already been selected as potentially interesting for future EU-wide EoW criteria based on market input and expertise.

In this chapter, the impact of data quality, data completeness and robustness of the analysis methodology on the results as well as the evaluation of the results are discussed.

It would be useful to **group inert/mineral waste streams** to properly evaluate the results of this study. Below we grouped concrete, fired clay bricks, asphalt and aggregates as one group. We have excluded gypsum from this group (see reasons mentioned in the following paragraph). Furthermore, we evaluated the **insulation waste streams** together and the **wood and PVC waste streams** together. The reasoning is described for each ‘group’.

A first interpretation of the ranking list showed that EU-wide EoW criteria would be very beneficial for **gypsum**. This waste stream scored high on recycling potential (the current recycling rate was low). The multiple markets in which recycled gypsum was already used resulted in a higher score as well. Although the volume of gypsum is only a fraction of other inert CDW, the development of EU EoW criteria would likely lead to a significant improvement of the recycling of CDW. Increasing the recycling of gypsum could even improve the recycling rates of other CDW streams as gypsum can be a contaminant for other (inert) waste streams.

The inert waste streams **aggregates, concrete** and **fired clay bricks** scored the highest, followed by asphalt. They were physically similar waste streams and therefore for many parameters they received almost the same scoring and ranking. Thus, during the survey phase, it was already expected that there would be little difference between these waste streams. Differences resulted mainly from differences in market volume and in pricing (caused by the end-use of corresponding products). Compared to the other waste streams the tonnages of these waste streams were relatively high.

Several EU member states already had national or regional EoW criteria for one or more of these CDW streams. The heterogeneity in the different definitions and understandings of what CDW is, and what it is not and what it is used for, in particular for aggregates and concrete, was also observed when comparing the different existing EoW criteria; e.g. aggregates used in road construction (France), recycled aggregates resulting from recovery operations (Ireland), inert CDW and waste aggregates of mineral origin (Italy). Inert CDW streams were often grouped under one EoW criteria regulation, e.g. the Dutch *Regeling vaststelling van de status einde-afval van recycling granulaat*, which contained the EoW criteria for all recycled aggregates, including those from concrete, mixed concrete and masonry rubble, bricks and masonry rubble, asphalt, recycled gravel and recycled crushed stone.

Both the **inert insulation and plastic insulation** ranked similar, which fits with similar characteristics as relatively small volumes of both waste streams and low recycling rates. There were no regional EoW criteria mentioned for these materials. Although the origin of the two material streams (rock/sand and oil) was different, both materials were removed in the same way during deconstruction, and a problem of contamination with other construction materials and dust was a also common factor. And both waste streams, although they were recycled differently, faced a transport problem. The waste streams were voluminous and therefore expensive to transport. Therefore, if EoW criteria were to be considered, a grouped EoW criteria for both types of insulation would not be inconceivable.

Wood was in the lower part of the ranking in this study. It had a relatively low volume compared to the inert waste streams and a relatively high collection and recycling rate. Although recycling was already taking place to a considerable extent and was used in several sectors of society, there were no regional EoW criteria. Wood was one of the waste streams where stakeholders indicated that CRM recovery was not possible. Wood seemed to be recycled quite well without specific EoW criteria, so there is less urgency to develop EU-wide EoW criteria.

Rigid plastic also ranked relatively low. This was due to the relatively low volume of this waste stream. However, the recycling rate was relatively high, which might seem to contradict the negative value of the waste stream. However, the recycled material had a large positive value of several hundred euros per tonne. The waste stream scored low on the recovery of CRMs, resulting in the lower overall score. As there were few recycling facilities in Europe, the waste status of these rigid plastics may make it difficult to transport them across borders.

The lowest scoring CDW stream was **building products for reuse**. It contained many different sub-material streams, each with its own characteristics. It was very difficult to obtain complete and reliable data and information on the different types of building products, materials and reuse and recycling rates. This data gap was a major reason why building products for reuse scored the lowest.

5.2 Data quality

5.2.1 Data gaps and filling the gaps

Most of the data needed for the analysis was collected through the online survey (Task 2 of this project). After the survey phase, an analysis of the missing data and information was carried out. The data gaps were filled in with data from literature and interviews. Only for the CDW stream ‘building products for reuse' data gaps remained due to its' high heterogeneity, i.e. this stream contained many different sub-material streams, each with their own characteristics. The JRC methodology dealt with missing information by setting a score of 1 for a parameter if information was missing. This approach was also used in this study. The relatively low score for construction products was a consequence of this.

5.2.2 Information on quantitative parameters (volumes and prices)

The estimation of volumes and prices was challenging due to inconsistencies in the data reported by stakeholders and previous studies. However, it was considered that most of the quantitative data used was reliable and that the amounts of waste recycled and collected were in the order of magnitude expected for each CDW stream. Where it was not reliable, extra literature research was conducted. Important additional sources used for the amount of waste collected or recycled included industry associations and data from previous JRC publications.

Mainly for aggregates, there were significant differences of reported volumes waste/by-product generated and recycling rates depending on the data source. The differences were due to varying geographical coverage of the data and varying definitions of what constitutes “aggregates”, "recycling" or "collection," leading to inconsistencies in reported figures. As a solution, this study took into account the data provided by the industry associations with the most complete data set for the different EU Member States. Moreover, for the stream building products for reuse, there was not sufficient data to estimate any volumes of either waste/by-product generation, collection or recycling. Also in this case, the broad definition and differences in definitions lead to this heterogeneity.

The estimated market values differed depending on the data source as well as the quality and use of the CDW stream. Answers to the survey were the main source of data on estimated market value per waste stream. When possible, an estimated EU market value was calculated based on the estimated price per ton and volume on the market.

The methods used to fill in the gaps and interpret the data were as consistent as possible across the different CDW streams. Given the consistency of responses and the empirical judgement of the assessors, there was a reasonable degree of confidence that the quantitative values were of the right order of magnitude, in line with prior expectations. Furthermore, the methods used to fill gaps and interpret the data were consistently applied.

5.2.3 Qualitative parameters

For the large number of survey and interview responses, the results were considered trustworthy because the information came from stakeholders that are directly engaged in the processing and/or use of the respective CDW stream. Although there was a possibility of incorrect responses being given, it was considered that sufficient measures had been taken to prevent this. Language problems were avoided as far as possible by proof-reading the survey and using official translations. In addition, most of the survey responses came from experts who were familiar with the CD sector, which adds to the credibility of the results.

However, it was worth looking at the representation of respondents across Europe. Western European countries were over-represented, while Eastern European Member States were under-represented. In terms of the number of EU-level and national stakeholders, 28 EU-level stakeholders and 66 national stakeholders responded to the survey: AT (1), BE (4), BG (1), HR (2), CZ (4), DK (6), FI (4), FR (4), DE (11), EL (1), IR (4), IT (3), LV (2), LT (2), LU (3), NL (1), PL (1), PT (1), ES (9), SE (8). The number of 28 EU-level stakeholders involved in the survey, mitigated the local under-representation for most of the CDW streams.

In terms of reliability, information on CDW streams with a higher number of respondents was considered to be more reliable as there was a greater opportunity to compare and validate the responses. On the other hand, for waste streams with fewer respondents, the reliability of the results may have been lower as a single response may have biased the results.

5.2.4 Different views on materials

The streams of aggregates and building products for reuse, and to some extent insulation, were generally heterogeneous. Therefore, stakeholders may have had different compositions of these waste streams in mind when providing the data. Although European standards were reported for aggregates, industry associations had different membership bases, with varying degrees EU coverage, and may have different compositions in their operations. For building products for reuse, the data collected reflected the different building products represented by the stakeholders, resulting in different data depending on the specific product.

Despite the combination of different data collection methods (survey, desk research and interviews), some data gaps remained. This was the case for the stream building products for reuse, for parameter 2, the quantity collected and the reuse and recycling rates, and for parameter 4, the market value of the waste stream. The stream building products for reuse was too heterogeneous to collect conclusive data representing all materials in this waste stream. To fill the remaining data gaps for parameters 2 and 4, expert knowledge from interviews with sector experts was used. In general, most stakeholders found it difficult to measure this CDW stream and it was also unclear to them how large the market for reused building products was.

5.2.5 Uncertainty and sensitivity analysis

A series of tests have been applied to the results to account for uncertainties and to evaluate the impact of choices made in the methodology.

Most importantly, **two alternative scenarios** for weighting have been assessed. They were designed to assess the impact of changing the weighting of the parameters on the results. Paragraph 4.4.1 shows that for alternative 2 the outcome remains the same and for alternative 1 there is only a shift among the average and low potential waste streams. This indicates that the outcome of highest potential waste streams is robust to variations in the weighting system applied to this study.

Furthermore, various sensitivity analyses have been applied to the results, to investigate the impact of the methodology. These tests also show limited variance in the results. This leads to the conclusion that the methodology has been sufficiently robust to assess priorities for End of Waste criteria.

A Monte Carlo analysis has been applied to the results of the three weighting scenarios. It was found that with a 10% uncertainty for outcomes of parameters 2, 3 and 4, there was a high certainty for the correct priority ranking of all the waste streams. With a 20% uncertainty, there was still a range from medium to high for correct priority among all waste streams.

As a most important measure to deal with the uncertainty in provided answers and the robustness of the methodology, it has been decided to divide the waste streams into three priority groups: High, Average and Low priority, as also presented in paragraph 3.2.1.

5.3 Methodology

The overall approach for this study was considered to be multifaceted. Changing the weighting of the parameters had a limited impact. The Monte Carlo simulation also showed that up to 20% standard deviation there was a limited impact on the ranking of the waste streams. The methodology is discussed in detail in the following chapters.

5.3.1 Scoring, weighting and ranking

The scoring mainly based on the JRC report to rank the potential for future EU-wide EoW criteria for a diverse set of candidate waste and by-product streams, including plastics, textiles, electrical and electronic equipment, and mineral fractions of construction and demolition waste. In contrast, this study focused on a more homogeneous and comparable set of materials within the same sector: CDW. Moreover, the JRC report applied a scoring methodology that included 12 parameters. This study added three parameters: the number of recycling processes applied (parameter 13), estimated market evolution (parameter 14) and challenges and problems with the waste streams (parameter 15).

The advantage of having a larger number of parameters was that it covers a mix of factors to give a balanced scoring/assessment of the potential for each CDW stream considered. The disadvantage was that it did not allow for an equally thorough assessment for each parameter. However, by gathering data and perspectives from the relevant European and national stakeholders directly involved in the processing and (re)use of each CDW stream, reliable input for each parameter and waste stream was possible. For some parameters and CDW streams, the level of uncertainty of the data behind the scores was higher, as presented in the results chapter, but as the final scores and ranking results represent an aggregated reflection of all parameters, a balanced result could be achieved.

The results often showed similar scores for many of the CDW streams. This was due to similar scores for many of the parameters and may be due to the methodology's original design for a more diverse set of candidate CDW streams. The same scores across CDW streams were particularly evident for parameter 1 (stakeholder support for the development of future EU-wide EoW criteria), parameters 5 and 6 (intra- and extra-EU shipments), parameter 8 (evidence of demand), parameter 10 (existence of relevant international or national product standards), parameter 14 (estimated market evolution) and parameter 15 (challenges and problems). This was due to the methodological design, e.g. assigning a score of 1 to a CDW stream for which a single industry stakeholder opposed the development of EU-wide EoW criteria, or assigning a score of 3 to a CDW stream that was expected to have a higher market value and higher sales if EU-wide EoW criteria were to be introduced. This resulted in the differences between the CDW streams mostly being the result of differences in the scoring of parameters 2, 3 and 4.

The scores given in this research may not necessarily have reflected the exact level of, for example, stakeholder support or expected increase in market value. On the other hand, the scores were intended to indicate for which CDW streams the introduction of EU-wide EoW criteria could have the greatest impact. Therefore, the exact level of support or market development were not the only relevant parameters and therefore had an appropriate influence on the final scores.

Limitations of the scoring methodology of the following parameters:

- *Parameters 5 and 6*: Extra-EU shipment, for which the methodology gave a higher score to CDW streams for which extra-EU shipment was reported. However, the desirability of extra-EU exports was debatable and the EU-wide EoW criteria may lead to an increase in the export of valuable materials to countries where environmental standards were less stringent. In addition, long-distance intra-EU transports could also increase.
- *Parameter 8*: The possibility of recovering critical raw materials, for which the methodology gave a higher score to waste streams from which it was possible to recover critical raw materials. However, the EU EoW criteria could facilitate extra-EU exports, which could lead to a loss of these materials.
- *Parameter 7*: Purity/composition of recovered materials, where the methodology gave a higher score to waste streams with high purity or stable composition. However, the evaluation of purity was challenging. For one application, 5% impurity would not be a problem, but for other applications, 0.5% would be. Materials from different eras might contain different contaminants. The stakeholder responses for all materials resulted in a score of 3.

- *Parameter 4*: Estimated market value, where the methodology gave a higher score to CDW streams with a relatively higher market value compared to the other candidate CDW streams. However, the value of the material depended on the stage in the product cycle. The disposal of most materials was expensive. Still, they may had a (high) positive value after a fully completed recycling process. The market value indicated by the data collected was not coherently defined at which stage of the product cycle the value was attached.

Limitations of the three new parameters used for this study:

- For the number of recycling processes applied (*parameter 13*), the stakeholders reported several recycling processes applied in series under the same recycling method (e.g. sorting, crushing and screening), thus increasing the score of the waste stream. More diverse recycling processes (both mechanical and chemical recycling processes) were reported by the consulted stakeholders for the plastic waste streams.
- For the estimation of the market development (*parameter 14*), it was difficult to predict the market evolution, especially since the estimation should be based on potential criteria that have not yet been defined.
- For challenges and problems (*parameter 15*), because the parameter was initially split into two parameters that were difficult for the stakeholders consulted to distinguish: challenges in technical and administrative processes and actual problems with recycling. However, the stakeholders' answers could be interpreted and the respective scores were combined.

Lastly, in this study, we considered a total of 15 parameters. When there are several high scores on parameters of lesser importance, these scores will mask weaknesses on important parameters, even when they are subject to small changes in the weighting and scoring. Table 4-18: EoW scenario change of absolute values. provides a good example in that perspective, as it shows very low added value to the environment when introducing EoW criteria for fired clay bricks and gypsum, when compared to EoW criteria for aggregates and concrete.

The weighting scheme was taken from the JRC report, which did not provide a developed rationale for the weighting scheme. The first 12 parameters included in this study and taken from the JRC report were given the same weight as in the JRC report. Based on their distribution, this study formulated a weighting rationale and distributed the weights for the three additional parameters (13, 14 and 15) according to the same rationale.

In summary, higher weights were given to parameters that directly influenced the core objectives of the EoW criteria related to stakeholder consensus (1), market relevance (4 and 9), environmental and health protection (12) and diversity of recycling operations to promote material quality harmonisation (13). Medium weights were given to parameters that were essential but had a supporting role or were subject to uncertainties, such as the potential impact on recycling rates (2 and 3), the relevance of existing standards and criteria (10 and 11) and challenges and problems (15). Lower weights were given to factors that had an indirect impact on the applicability of the EoW criteria or were subject to greater uncertainty: intra/extra-EU shipment (5 and 6), purity (7), recovery of critical raw materials (8) and estimated market evolution of the waste stream (14).

The extent to which the weightings were fairly distributed could be discussed, taking into account the potential impact of each parameter on the potential for developing future EU-wide EoW criteria. For example, it could be discussed whether some of the parameters should be considered as knock-out criteria, such as stakeholder support, because if support is not unanimous, this could lead to an extensive debate on the need for EoW criteria rather than on the content of the criteria. Similarly, intra-EU transport could be considered as a knock-out criterion, because if no intra-EU shipments were mentioned, the EoW criteria could be better organised per Member State. However, the reasons why intra-EU shipments were given a lower rather than a higher weighting were that it cannot be excluded that the lack of common criteria was the reason for the low volume of shipments and that the desirability of transboundary shipments is uncertain and varies between waste streams.

5.3.2 Environmental and human health impact analysis

We compared BAU and a scenario according to the EU EoW criteria (10% more recycling). There were some limitations to the analysis of environmental and human health impacts. Firstly, there was a high level of uncertainty in the input figures (split between landfilling, incineration, recycling and reuse). Second, there were different types of recycling processes and different incineration processes. Thirdly, the environmental modelling was carried out with only one process for each waste treatment process. This process was chosen to be as close as possible to the average European situation. However, local situations may differ.

The shift from incineration and landfill to recycling has had huge environmental benefits. However, this benefit was based on the assumption that EU-wide EoW criteria would lead to (10%) additional recycling. The outcome would depend on the material stream and the "stringency" of the future EU-wide EoW criteria. Too strict and the material meeting the future EU-wide EoW criteria might be too expensive; too lax and the market might not accept the material because it might lead to environmental problems and unknown financial risks. Future EU-wide EoW criteria could provide an incentive for recycling and could be used to develop technical or logistical solutions.

6 Conclusion

This study assessed the prioritisation for the introduction of possible future European EoW criteria for a list of ten pre-selected construction and demolition waste and by-product (CDW) streams. There was a general positive acceptance and willingness among stakeholders to introduce EU-wide EoW criteria. The results showed the highest potential for possible future EU-wide EoW criteria for the waste and by-product streams of aggregates, concrete, fired clay bricks and gypsum, followed by average potential for asphalt, inert insulation, plastic foam insulation, rigid plastics and wood, and a clear outlier for the stream of building products for reuse. It is advisable to address the highest scoring waste streams first in order to achieve a higher impact.

From all the stakeholder interactions during this study, it was clear that the majority of stakeholders would be in favour of future European EoW criteria for the CDW streams investigated. The advantages of possible future EU-wide EoW criteria (clear material status, less administration, environmental benefits and improved market) outweighed the disadvantages (market disruption where local EoW criteria already exist and environmental risks). The demand for the reuse of CDW and the acceptance of a possible future EU-wide EoW was widely supported by all stakeholder groups. The existence of standards for CDW and the existence of some national and regional CDW-related EoW criteria also showed the urgency and need for EU-wide EoW criteria in the future. Some stakeholders emphasised the need for future European EoW criteria for CDW to recognise existing national and regional criteria in order to minimise or reduce bureaucratic burden. In addition, based on stakeholder input, the introduction of EU-wide EoW criteria for all CDW streams is expected to increase market potential and sales.

An important observation was that for inert waste streams there is potential for grouping, e.g. aggregates, asphalt, fired clay bricks and concrete, in future European EoW criteria. This has also been applied in national legislation in several EU Member States. It is recommended to further assess whether grouped future EU-wide EoW criteria would have a higher impact than ungrouped criteria.

In general, the input provided a positive picture of the potential environmental and economic impacts associated with the introduction of EU-wide EoW criteria for CDW, together with a positive market attitude. The results of the environmental and human health impact regarding an increase in recycling for gypsum, fired clay bricks. In addition, it should be noted that construction and demolition is by far the largest single waste and by-product stream in the EU and therefore there would be a large potential for positive environmental impacts if recycling rates were improved.

The results of this study provided a solid background for the European Commission to plan possible further steps towards EU-wide End-of-Waste criteria for CDW.

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