Auvergne Rhône-Alpes
Énergie Environnement

CONDEREFF activity A1.3

Analysis of the available and required C&D recycling capacity in the project territories

Methodology and data sets

23/10/2018

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Document review : (in progress)

Contributor	Date	Issue
M. Bazaud	12/10/2018	V0
M. Bazaud	19/10/2018	V1
M. Bazaud	23/10/2018	Final version

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EXECUTIVE SUMMARY

This methodology aims to guide project partners in implementing CONDEREFF activity 1.3. It presents and elaborates the thematic background and the set of procedures that project partners will use to document and investigate the existing construction and demolition recycling capacity, as well as the developments that could affect it in the future.

AURA-EE applied desk research to identify and study the thematic background of activity 1.3. More specifically, it considered statistical data, academic publications and articles, CDW reports, and legal texts. Results of this research showed that:

- Achieving zero waste and high quality of recycling in the CDW stream faces challenges of classification and data reporting. However, the composition and market demand of the CDW stream establish it as an important waste stream with the potential to achieve high recycling and recovery rates in the future.
- CDW recycling capacity varies considerably across EU countries. For recycling to work effectively in a circular economy model, it is helpful to view recycling across the whole value chain of construction and demolition activities. For this reason, the differentiation between immediate and remote or supporting recycling capacity is adopted, to increase the environmental efficiency of CDW life-cycle.
- Regarding future CDW recycling requirements, the quality of existing data makes forecasts on the issue even more uncertain. However, relevant secondary literature and statistical corrections estimate that the CDW stream will increase considerably in the future, demanding the development of improved and specific policy interventions.

DOCUMENT OUTLINE

The methodology is structured in the following way:

- Section 1 provides the context of the activity and an overview of the CONDEREFF project as a whole.
- Section 2 provides definitions of construction and demolition waste (CDW), surveys the legal and regulatory EU framework, and presents statistical data that shed light to the composition of this particular waste stream. Additionally, it outlines what counts as recycling of CDW according to the waste model proposed by the EC, as well as the main challenges it faces in its implementation.
- Section 3 introduces the core thematic background of the activity. It provides a fine-grained concept of the recycling capacity by distinguishing it in two ways: a) the direct capacity for recycling, namely the recycling infrastructure, and b) the supporting capacity for recycling, which includes elements such as policies, regulations, awareness campaigns, stakeholder initiatives, and incentives.
- Section 4 provides specifications and guidelines on data collection; it defines the research questions and methods to be used, the tools for documenting data, and a time-plan for the activity.

1 INTRODUCTION

1.1 THE CONDEREFF PROJECT

"CONDEREFF – Construction and Demolition Waste Management Policies for Improved Resource Efficiency" is a project under the INTERREG Europe programme[1] that aims to accelerate policy work on construction and demolition waste (CDW) management, improving resource efficiency in the countries of the partnership. Accordingly, CONDEREFF will assist the proliferation of infrastructures and methods for recycling and re-use of CDW materials and the introduction of green growth opportunities in the CDW stream. To achieve these goals, the project will exchange experiences and practices, as well as studies regarding CDW, on how project partner regions can move towards the adoption and further exploitation of the best practices and measures applied in the field of waste management.

1.1.1 Approach and main outputs

CONDEREFF will employ a transnational cooperation approach involving public authorities, construction and demolition enterprises, and relevant agencies and stakeholders. Its main outputs aim:

- To increase the capacity of regional administrations for effectively implementing resource efficiency policies related to CDW management.
- To explore, assess, expand, and enhance current practices in managing CDW streams generation, tracing, and processing.
- To incentivise investments and use public procurement as a driver to foster the economic potential of CDW re-use.
- To improve the implementation of resource efficiency policies, adopting proven transferable methods on C&D processes monitoring and enforcement of the regulatory framework.
- To develop Action Plans for public authorities, improving the policy instruments addressed.

1.1.2 Expected results

In the framework of CONDEREFF, the expected results are:

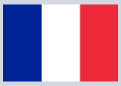
- Specifications for a prototype toolkit for the staff of territorial public authorities, to be freely used during and after the project; the purpose of the toolkit is to strengthen capacities on planning and improving C&D waste management policies and practices on the basis of collected data and generated statistics.
- A compendium of practices based on peer review reports that will produce a collection of transferable best and improved tools and resources on C&D waste management available to public authorities for future reference.
- Policy briefs, summarising the lessons learnt from the exchange of experience activities, and providing policy makers with recommendations to further promote C&D waste management.
- Enhanced collaboration of partners with existing C&D waste-relevant networks, such as the Zero Waste Municipality Network of Europe, the Circular Europe Network, the Committee of the Regions, and the Environment and Resource Efficiency Interreg Policy Learning Platform, to disseminate good practices and foster the durability of the CONDEREFF outputs.

1.1.3 The consortium

The CONDEREFF project brings together 8 partners from 7 countries:

[1] For more information, please visit www.interregeurope.eu.

TABLE 1: THE CONDEREFF CONSORTIUM

Country	Partner
	Polytechnic University of Valencia (UPV)
	Region of Thessaly (RoT)
	Auvergne-Rhône-Alpes Energy Environment Agency (AURA-EE)
	The Regional Development Agency of the Pardubice Region (RRAPK)
	Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)
	Lazio Region (Lazio)
	Styrian Provincial Government – Department 14 – Water management, Resources and Sustainability (STYRIA)
	Institute for Structural Policy and Economic Development (ISW)

1.2 ACTIVITY 1.3

1.2.1 Overview

Activity 1.3, titled "Analysis of the available and required C&D recycling capacity in the project territories", aims to survey in CONDEREFF territories: a) the existing CDW recycling capacity, and b) future CDW recycling requirements that could emerge from present construction and relevant economic activities. A1.3 will enable partners to delineate policy changes regarding regulations, infrastructure development, stakeholder involvement, and awareness-raising actions relevant to CDW recycling capacity.

Auvergne-Rhône-Alpes Energie Environnement (AURA-EE), as leader of the activity, will firstly deliver a methodology for partners to document their territorial situation and emerging trends. AURA-EE will use and analyse partners' input to prepare a report on the available and potentially required CDW recycling capacity in project territories; the conclusions of the report will also be used for capacity building in CONDEREFF workshops, events and meetings.

1.2.2 Time plan and deliverables

The activity will take place during the first two semesters of the project.

FIGURE 1: ACTIVITY TIME PLAN & DELIVERABLES

2 CONSTRUCTION & DEMOLITION WASTE: DEFINITIONS AND PRESENT SITUATION IN THE EU

2.1 OVERVIEW

Construction and demolition activities generate high volumes of left-over material. This material, for which there is no further use and there is the intent or requirement to be discarded, is classified as construction and demolition waste (CDW)[2]. There are many public and private economic activities that generate CDW. Indicatively, some of them are:

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

- Site clearance
- Excavation works
- Landscape works
- New constructions
- Repairs
- Maintenance
- Renovation
- Refurbishment
- Reconstruction
- Demolition

CDW results from construction and demolition business activities (most often activities in civil and structural engineering and earthworks), but also from minor do-it-yourself construction and demolition activities within private households. CDW materials can be:

- Aggregates
- Concrete
- Roofing construction
- Wall materials (e.g. bricks, ceramics)
- Broken asphalt
- Gypsum
- Wood
- Paving stone
- Glass
- Sand
- Pebble
- Plastics
- Metal
- Isolation materials
- Asbestos
- Railway traverse and ballast
- Excavated materials (e.g. soil, gravel)
- Stone

For environmental, management, and statistical reasons, it is important to differentiate between inert and non-inert waste. CDW that is neither chemically nor biologically reactive and will not decompose is classified as inert waste. Non-inert waste is hazardous materials which must be properly managed to avoid environmental liability. Proper management includes identification and accumulation prior to treatment or disposal.

The EU has established a classification of all waste according to the materials included in each waste stream and the liability they present for the environment in the European 'List of Waste' (LoW)[3].

- Regarding the classification of materials, the LoW contains twenty chapters (two digit codes), further divided into sub-chapters (four digit codes) and entries (six digit codes). For example, CDW is assigned the value 17, the categories of materials are assigned values from 01 to 09 (e.g. 17 04, which is 'metals and their alloys'), and the specific entries are assigned, again, values from 01 to 11 (e.g. 17 04 06, which is 'tin').
- Regarding the classification of the environmental liability of the materials, the LoW includes three entries:
    - Absolute hazardous (AH). Wastes which are assigned to AH entries are classified as hazardous and no further assessment is needed in order to decide whether the waste has to be classified as hazardous. It will still be necessary to use procedures to determine which hazardous properties are displayed by the waste in question as this information may be required for correct labelling of hazardous waste (e.g. for filling a consignment note for waste movements).
    - Absolute non-hazardous (ANH). Wastes which are assigned to ANH entries will be classified as non-hazardous and no further assessment is needed in order to decide whether the waste has to be classified as non-hazardous.
    - Two mirror entries: mirror hazardous (MH) and mirror non-hazardous (MNH). Since certain materials behave chemically differently under different circumstances or when mixed with certain other materials, mirror entries are used to determine, based on the results of investigations, whether to consider the material hazardous or not.

The main chapters that are categorised in LoW as waste from construction and demolition activities are the following[4]:

- Concrete, bricks, tiles and ceramics.
- Wood, glass and plastic.
- Bituminous mixtures, coal tar and tarred products.
- Metals and their alloys.
- Soil (including excavated soil from contaminated sites), stones and dredging spoil.
- Insulation materials and asbestos-containing construction materials.
- Gypsum-based construction material.
- Other construction and demolition wastes (e.g. CDW containing mercury, PCB, or other hazardous materials).

2.1.1 EU policy context

The main reference document for CDW is the EU Directive 2008/93/EC, usually called 'Waste Framework Directive' (WFD). It is the key legislative document on waste at the EU level, and legally binding for all Member States. The WFD sets out what waste is and how it should be managed, providing operational definitions of waste and 'end-of-waste criteria' (when waste ceases to be waste

[3] ANNEX III of WFD & https://publications.europa.eu/en/publication-detail/-/publication/239a2785-9115-4e06-adae-66c8e08a5a42.

[4] For a full list and the environmental liability of each one, please refer to https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014D0955. For a list of the LoW codes and the corresponding Eurostat ones, see European Commission 2017, Appendix A.

and becomes a secondary raw material). Additionally, it articulates a priority order for waste management (‘waste hierarchy’) along with other provisions on health, classification, polluters, and producers of waste. The Directive requires that Member States (MS) adopt waste management plans and waste prevention programmes. The recycling and recovery targets set by WFD, to be achieved by 2020, aim to boost MS efforts in effective waste management. For CDW, the target for re-use, recycling and other recovery is set at 70%.

The Circular Economy Package[5], a common and coherent EU framework to promote the circular economy is also relevant for CDW, It includes revised legislative proposals on waste as well as an ambitious Circular Economy Action Plan (CEAP) to stimulate Europe's transition towards a new economic model. The CEAP targets “closing the loop”, moving from a linear to a circular economy, and highlights the importance secondary raw materials and maintaining the value of waste at the end of life through reuse and recycling as a central part of a successful circular economy. The ultimate goal is to obtain a more resource efficient Europe, while at the same time making EU enterprises more competitive.

Part of the CEAP is the EU Construction and Demolition Waste Protocol[6]. The protocol, which includes good practices from across the EU and a checklist for policy makers and practitioners, aims to increase confidence in the Construction and Demolition waste management process and the trust in the quality of Construction and Demolition recycled materials[7].

2.1.2 Useful statistics

CDW represents the largest waste stream by volume in the EU-28 – it accounts for about one third of all waste produced, contributing 34.7 % to the total waste generated in 2014. A break-down of official statistics shows that the CDW stream:

1) It comprises mostly of mineral materials.

A lot of waste from construction and demolition (and from mining and quarrying) is classified as major mineral wastes: almost two thirds (64 % or 3.2 tonnes per inhabitant) of the total waste generated in the EU-28 in 2014 comprised major mineral wastes[8]. The available data can provide an overview of the material included in CDW (Figure 2):

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2018:150:FULL&from=EN
[6] http://ec.europa.eu/DocsRoom/documents/20509/attachments/1/translations/
[7] Policy tools relevant for CDW can be found at http://ec.europa.eu/environment/waste/construction_demolition.htm
[8] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Total_waste_generation

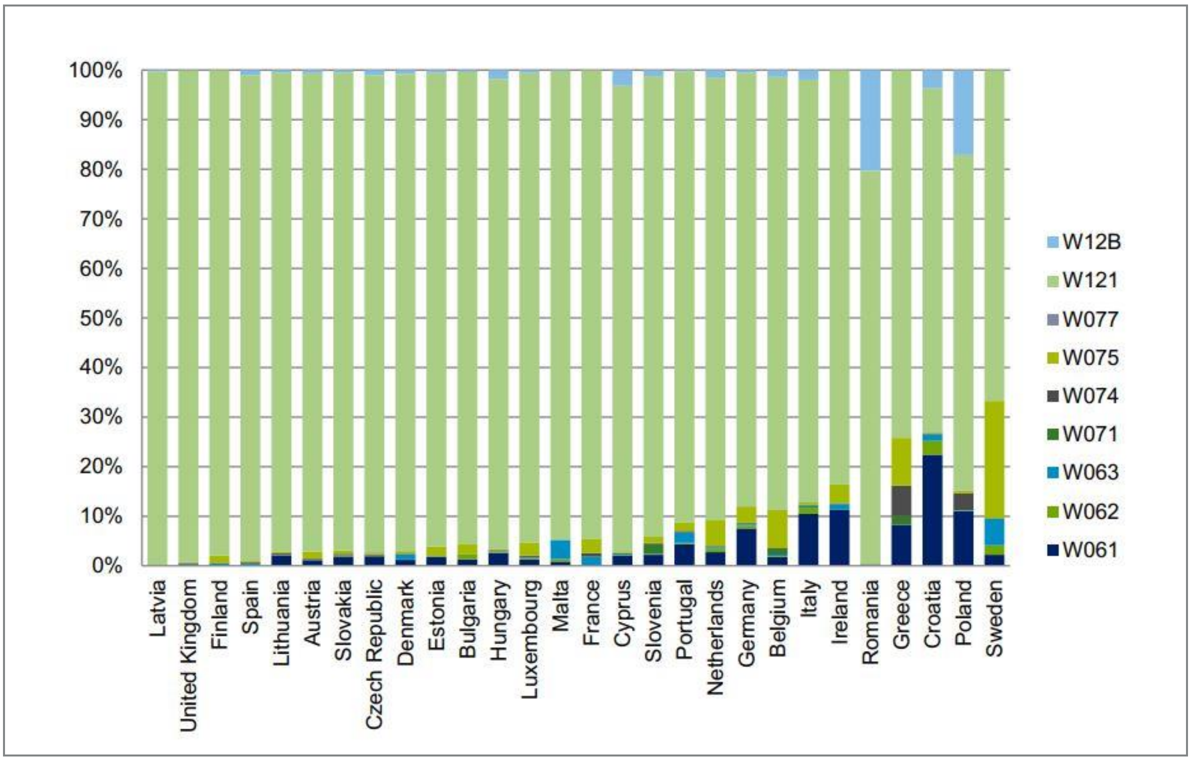


FIGURE 2: PREVALENCE OF MINERAL MATERIALS IN CDW STREAM / SOURCE: EUROPEAN COMMISSION 2017. NOTE: W061 = FERROUS METALLIC WASTE; W062 = NON-FERROUS METALLIC WASTE; W063 = MIXED FERROUS AND NON-FERROUS METALLIC WASTE; W071 = GLASS WASTE; W074 = PLASTIC WASTE; W075 = WOOD WASTE; W077 = WASTE CONTAINING PCBS; W12B = OTHER MINERAL WASTE (EXCL. C&D WASTE, COMBUSTION WASTE, SOILS, DREDGING SPOILS, WASTE FROM WASTE TREATMENT); W121 = MINERAL WASTE FROM CONSTRUCTION AND DEMOLITION

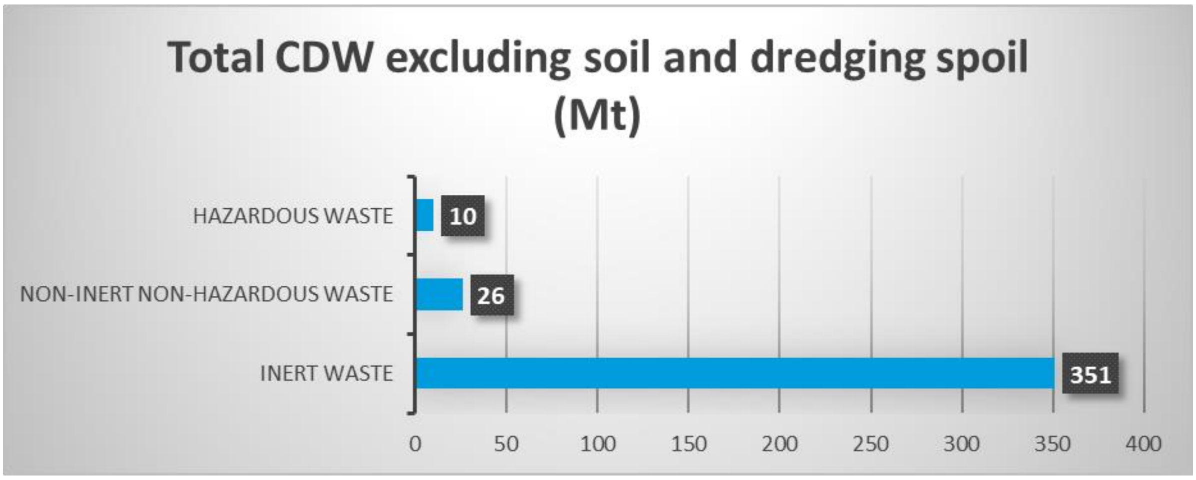
However small the percentage of non-mineral CDW, it is notable that its quantity grew at a rapid pace from 2004 to 2014 (rising by 57.2% overall)[9].

2) It is mainly inert waste.

Taking into account Eurostat statistics from 2012, the 28 Member States generated around 830 Mtonnes of CDW, including 480 Mtonnes of soil and dredging spoil. Excluding soil and dredging spoil, the 28 MS generated around 350 Mtonnes of CDW. Figure 3 below shows a breakdown by type of waste. As can be seen, inert waste represents 90% of total generated CDW.

[9] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Waste_generation,_excluding_major_mineral_wastes,_EU-28,_2004-2014_YB17.png

FIGURE 3: CDW IS MAINLY INERT WASTE / SOURCE: EUROPEAN COMMISSION 2017



3) CDW steam generates a significant amount of the total hazardous waste generated within the EU.

The small numbers of non-inert CDW should not be overlooked. Hazardous non-inert waste is a waste stream of high concern due to the potential risks it poses to human health and the environment if not managed properly. For example, CDW may contain paint and lacquer waste, wood treatment substances, toxic solvents, adhesives, coatings, lamps, mercury containing equipment. These various hazardous waste products all need specific management practices (identification, separate demolition, separate collection, proper treatment).

CDW holds a major share in generated hazardous waste amounts across several Member States (17% on average in 2012, including contaminated soils and dredging spoils)[10].

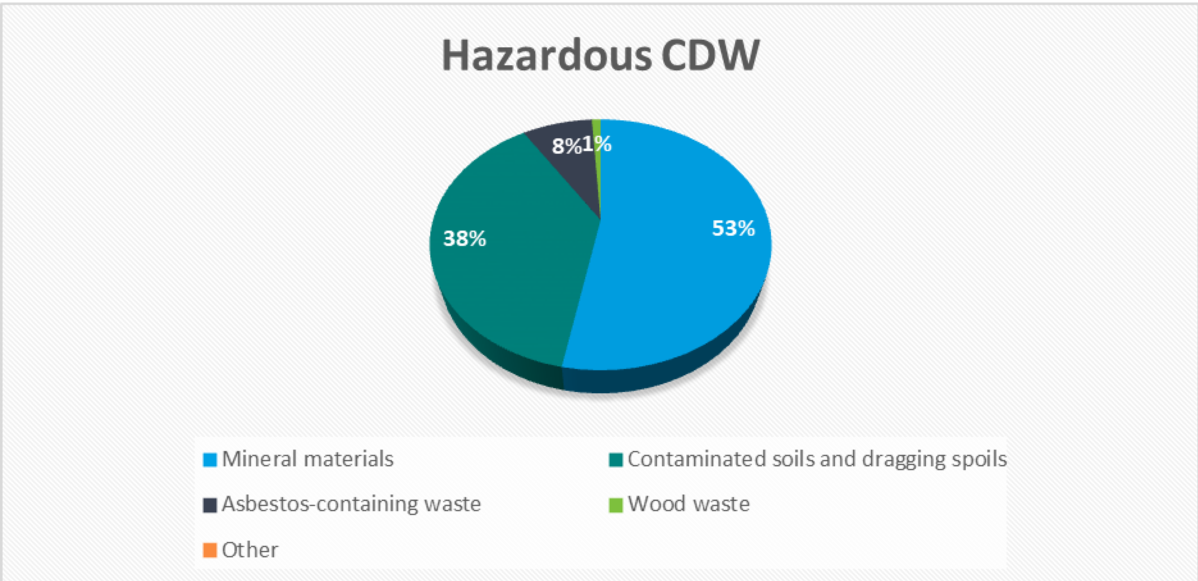


FIGURE 4: BREAKDOWN OF HAZARDOUS CDW / SOURCE: EEA 2015

Hazardous CDW includes:

- Mineral materials: concrete, bricks and gypsum containing hazardous substances, asphalt road covering containing hazardous substances, minerals containing mercury, insulation materials and other minerals;

[10] Data on hazardous CDW comes from https://cri.dk/sites/cri.dk/files/dokumenter/artikler/etc_hazardous_waste_review_in_eu-28_is._no_ch_and_tr_june2015.pdf

- Asbestos-containing waste: asbestos was commonly used as an insulating and fireproofing agent in construction materials such as cement. Since asbestos has been identified as a carcinogen product, asbestos-containing materials are no longer used. However, asbestos containing waste is a major issue as it is present in most of the renovation and demolition projects.
- Wood waste: wood sawdust, shavings, loss, particle panels and veneer containing chemicals due to painting, lacquers and fungicides.
- Other: the remaining hazardous CDW is almost insignificant in terms of quantity, however its dangerousness for both human and the environment is of paramount importance.
  - Glass waste: powder or small particles of glass containing heavy metals, such as special glazing;
  - PCB-containing waste: fillers, synthetic soil covering, double glazing, disused transformers and condensers containing PCBs are commonly found in renovation and demolition works. PCBs are also identified as potentially carcinogen substances and thus require separate collection and proper treatment.
  - Other hazardous substances: lead-based paints were commonly used before being forbidden in most countries in the late 1940's and may thus be found in renovation and demolition works.

4) It can be distinguished into demolition and construction activities, with the first producing notably more CDW regarding volume and complexity.

EU statistics do not permit a break-down of CDW by activity (e.g. construction, refurbishment, demolition) or by subsector (e.g. public works, buildings). Construction waste on one hand, and demolition waste on the other are considered as a whole, because current data does not allow a clear distinction of these two categories. However, taking into account regional data, they have quite different characteristics, both in terms of quantities, composition and potential for recovery:

- Construction waste (originating from new constructions) is usually less mixed, less contaminated, and its recovery potential is higher than demolition waste because of these characteristics. Its share in the total quantities of CDW is generally low[11].
- Demolition waste is collected after demolition of existing constructions (including those related to renovations) and includes all construction materials from a building (incl. hazardous elements). This waste stream is much larger than the construction waste stream (estimated 20-30 times more, by weight[12]), but it tends also to be more contaminated (with paintings, adhesives etc.) and more mixed due to the integration of different elements (e.g. steel and concrete for reinforced concrete).

5) CDW stream data reporting is highly inconsistent within EU.

Reporting accurate data on CDW has encountered difficulties due to various reasons. Until recently, there was a confusion on certain WFD definitions (e.g. backfilling), consequently creating complications on calculating the correct codes that actually count in fulfilling the 70% WFD objective. This was solved by the adoption of an amendment to the WFD[13]. However, the official statistical categories do not distinguish CDW per activity, and include information on CDW coming only from the construction sector (NACE code F), while many other activities are supposed to generate CDW[14]. If we add that in certain MS the lack of enforcing mechanisms results in fly tipping, then official numbers of CDW seem to be underreported.

[11] http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf, p.16.
[12] European Commission 2015, p.60-63.
[13] https://eur-lex.europa.eu/resource.html?uri=cellar:c2b5929d-999e-11e5-b3b7-01aa75ed71a1.0018.02/DOC_1&format=PDF
[14] European Commission 2011, p.9.

Additionally, many MS struggle to provide reliable data, partially explaining distortions in the official EU statistics[15]. For example, MS that appear to produce the smallest amounts of hazardous CDW relative to turnover tend to have lower data quality scores than those producing higher amounts. This might suggest that the amount of hazardous waste is under-reported in these countries[16]. Lastly, variations and distortions in statistics can be explained by differences in building tradition and materials in different regions (e.g. northern countries reporting significantly more wood than others).

2.2 RECYCLING

The high volume of CDW generated within EU today constitutes a serious problem. Today, most CDW is either directly disposed in landfills or processed in recycling plants as aggregates. Since the recycling of CDW reduces landfill and conserves natural aggregate resources, most environmental policies aim at increasing recycling. CDW has received increased attention in the past few years as it is a lens to understand the potential for resource efficiency improvement in the construction sector as a whole.

Indeed, CDW has a high potential for re-use and recycling, since some of its components have a high resource value and/or can be readily recycled. In particular, there is a market for aggregates derived from CDW in roads, drainage and other construction projects. The main industries exercising the demand for recycled aggregates are predominantly the road construction industry, concrete, cement and gypsum producers. The road construction industry in particular constitutes one of the most important buyers of recycled aggregates[17].

Recycling of CDW is of paramount importance because it reduces environmental pressure coming from CD activities. It prevents waste disposal and additionally it provides alternatives to the harmful extraction and exploitation of non-renewable raw materials. Since the construction industry makes heavy use of raw materials, it has been forecast that demand for recycled CDW will reach at least double the current levels by 2050[18].

The benefits of effective CDW recycling are economic as well. The market for recycled construction materials earned revenues of €16 billion in 2013 and it is expected to reach around €20 billion in 2020[19]. An estimated 26% rise in the volume of waste by 2020 is said to be intensifying the demand for limited landfilling, while the rising cost of landfilling CDW will lead to increased use of sustainable solutions.

2.2.1 The waste hierarchy

An important element in the WFD (Article 4) is the classification of waste management options into a hierarchy. The 'waste hierarchy', as it is called, offers wide-reaching benefits in terms of resource efficiency, sustainability, and cost savings. Although waste prevention, reuse and recycling are hierarchically higher than (energy) recovery and disposal, hence a priority, the actual choice of the waste management option differs from case to case, depending on regulatory requirements, as well as economic, environmental, technical, and public health concerns.

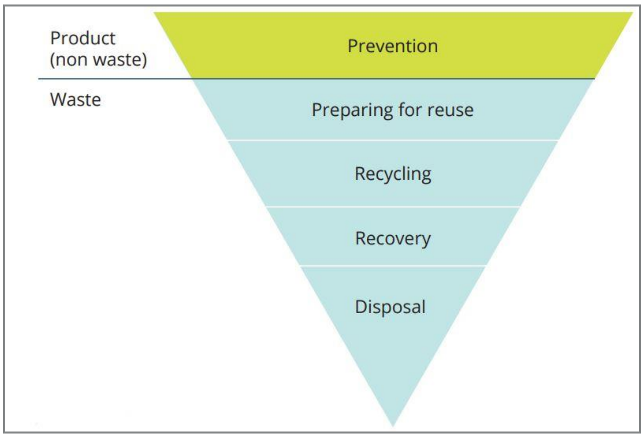


FIGURE 5: THE WASTE HIERARCHY / SOURCE: EEA REPORT NO 4/2018

[15] European Commission 2011, pp. 13-14.
[16] European Commission 2015 p. 27.
[17] European Commission 2015, p. 66.
[18] Allwood et al. 2011.
[19] Frost & Sullivan 2014.

Prevention

Waste prevention aims at reducing the amount of waste that is generated. It is the first option that should be considered as part of the WFD waste hierarchy. However, demolition waste cannot be prevented, unless a decision is made to not demolish.

Reduction of CDW seems to fit better into this step. For example, the design of construction products for immediate reuse after demolition without further processing prevents materials or products becoming a waste. Such measures will contribute to reducing waste generation figures and therefore could be considered as waste reduction.

For CDW, some elements of waste prevention may be covered within waste reuse (see next step), such as reuse of off-cut materials on site, as this is actually preventing the useful material from becoming waste.

Reuse and preparation for reuse

According to the WFD, reuse is any operation by which products acquire a second life before becoming waste: products or components are used again for the same purpose for which they were conceived. In the same hierarchical category falls the ‘preparation for reuse’ option. It refers to checking, cleaning or repairing recovery operations, by which products or components of products are prepared so that they can be reused without any other pre-processing.

There are many opportunities to reuse materials, especially at the demolition and refurbishment stages. Indicatively, practices which facilitate reuse include pre-demolition audits, on-site sorting, separate collection of materials, exchange of materials within the scope of industrial symbiosis, initial design of materials for reuse, and reuse clauses in public procurement practices.

Recycling

The WFD defines recycling as any recovery operation by which waste materials are reprocessed into products, materials or substances, whether for the original or other purposes. It includes composting and it does not include incineration. It involves the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.

This category of the waste hierarchy is the focus of this activity.

Recovery

As recovery can be defined any operation the main result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.

Disposal

Processes to dispose of waste, be it landfilling, incineration, pyrolysis, gasification and other solutions that do not involve any of the operations described in the steps above, fall into this waste hierarchy category.

2.2.2 Recycling statistics

The WFD includes in Article 11(2) a specific target for the reuse, recycling and other material recovery of CDW:

“by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight.”

There is currently no reliable data on recovery and recycling rates of CDW in the EU. Data on CDW treatment suffers from the same gaps and inconsistencies as generation data (see section 4.1.2)[20]. For example, most reports on the matter cite that the definition of recycling itself is not yet homogeneous between MS and great divergences in what counts towards estimating recycling rates[21]. For example, some MS include excavated material while some others do not (e.g. Germany), others include waste from public works while some others do not (e.g. France)[22].

However, there have been efforts to partially correct data biases through additional data collection and adjustments. These efforts should be considered with a note of caution. However, they seem to be the most reliable on the matter. Here two corrections of official data are presented and discussed[23]. The first is based on 2009 data, while the second on 2010-2012 data. For matters of convenience the first is labelled Effort A and the other Effort B.

Effort A (Figure 6) provides an estimation (with a high uncertainty) an average of 46% recycling rate for EU-27. However, this rate seems plausible, since it is within the 30%-60% range of estimates proposed by experts and literature[24]. Concerning individual MS rates, the following were indicated by the corrections:

- 6 countries report recycling rates that already fulfil the WFD target (Denmark, Estonia, Germany, Ireland, the UK, and the Netherlands)
- 3 countries report recycling rates between 60% and 70% (Austria, Belgium, and Lithuania)
- 4 countries (France, Latvia, Luxembourg, and Slovenia) report recycling rates between 40% and 60%
- 8 countries report recycling rates lower than 40% (Cyprus, Czech Republic, Finland, Greece, Hungary, Poland, Portugal, and Spain)
- 6 countries data estimates were unavailable for calculating the recycling rates (Bulgaria, Italy, Malta, Romania, Slovakia, and Sweden)

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[20] As a WFD obligation, MS provide data on the state of preparation for reuse, recycling and material recovery of the respective waste stream. The available data as of 2018 under this reporting obligation covers the reference period from 2010 to 2012.
[21] European Commission 2017, p. 22.
[22] European Commission 2011, p. 19
[23] First effort come from European Commission 2011, pp. 21-22, and the second comes from European Commission 2017, pp. 23-25.
[24] European Commission 2011, p. 22.

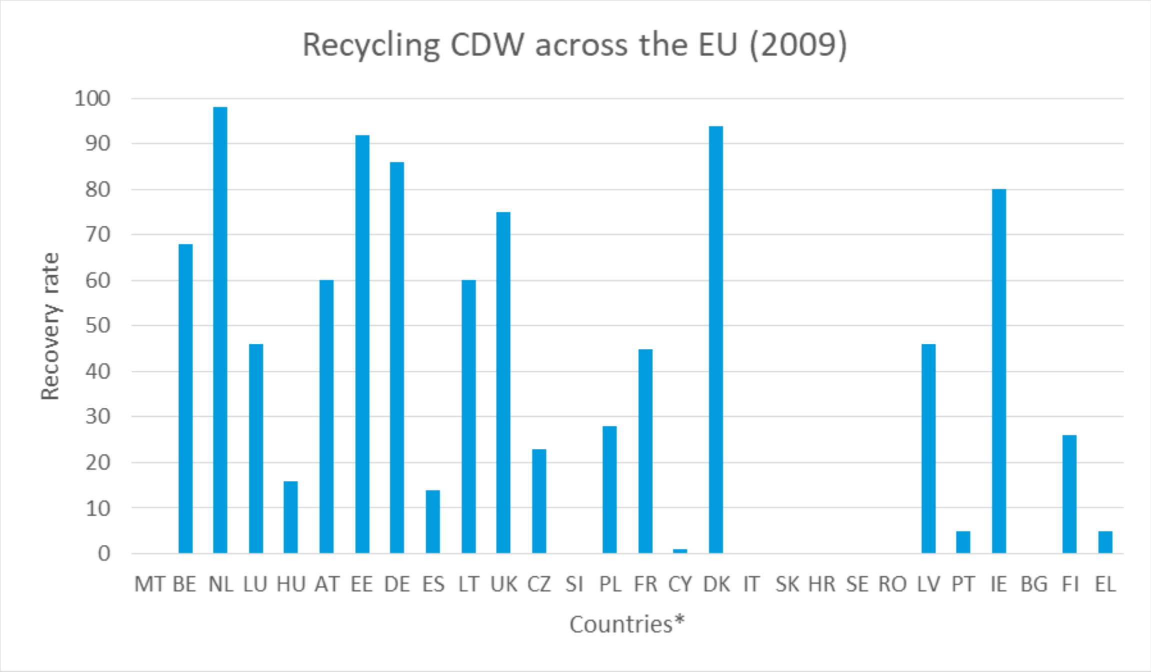


FIGURE 6: RECYCLING ACROSS THE EU / SOURCE: EUROPEAN COMMISSION 2011, P. 21-22.

***RECYCLING RATES COULD NOT BE CALCULATED WITH ACCURACY FOR SOME COUNTRIES, HENCE THE ZERO PERCENTAGES.**

Effort B (Figure 7) is based on data collected within the WFD. It refines the CDW recycling rates by standardising waste recovery definitions, including the latest guidelines of Eurostat for the term ‘backfilling’[25] and by taking into account national statistics, which mostly follow different reporting mechanisms. Thus, it aims to adjust recycling rates by applying normalised and more accurate definitions of what processes count towards estimating the recycling rate. This is important for countries that are relying to a large extent on backfilling of CDW to meet the EU recovery target, an amendment of the backfilling definition can have a major impact.

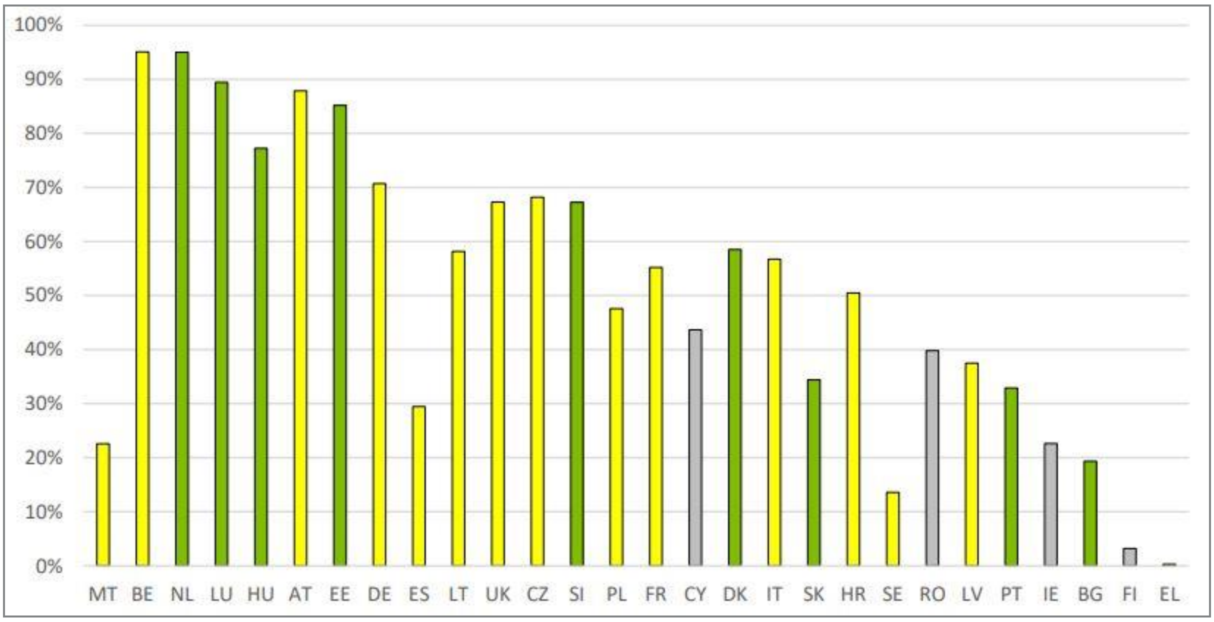
Additionally, Effort B assessed the quality of data reporting mechanisms in each MS in order to highlight the importance of data quality when taking into account CDW statistics. For this reason, data quality was categorised in three confidence levels: a) green shows high data quality, b) yellow indicates medium confidence, and c) grey signifies low confidence on data quality.

The following results were obtained:

- 7 countries meet the EU recovery target (Belgium, the Netherlands, Luxembourg, Hungary, Austria, Estonia, and Germany). However, only 4 of them score high data confidence levels.
- 3 are close to the target (the UK, Czech Republic, Slovenia), with recovery rates between 60%-70%, with only 1 having high quality data reporting mechanisms.
- 8 countries report lower rates, between 40-60% (Lithuania, Poland, France, Cyprus, Denmark, Italy, Croatia, and Romania), with 5 of them having medium quality data.
- 10 fall below 40% recycling rates (Malta, Spain, Slovakia, Sweden, Latvia, Portugal, Ireland, Bulgaria, Finland, and Greece).

[25] https://ec.europa.eu/eurostat/documents/342366/4953052/Guidance-on-Backfilling.pdf/c18d330c-97f2-4f8c-badd-ba446491b47e

FIGURE 7: CDW RECOVERY RATES EXCLUDING BACKFILLING / SOURCE: EUROPEAN COMMISSION 2017, P.22.



2.2.3 Challenges

Three utility levels of recycled CDW can be distinguished[26]:

- Low utility, used for example in earthworks.
- Intermediate utility, with use as building and road foundation materials (but excluding use in concrete).
- High utility, with, for example, use as natural aggregate substitute in concrete, for clinker production or as part of structural road construction layers.

However, even the use of recycled aggregate in cement is mostly a down-cycling, as impurities such as mortar lead to different mechanical properties and a reduced durability, in particular in aggressive environments[27].

In general, most CD materials are down-cycled. High quality recycling is much more demanding and requires, apart from advanced demolition techniques, strong industry leadership and more effective policies across the EU. Zero-waste goals and circular economy frameworks demand an approach that specifically tackles the prevalence of down-cycling and aims to boost high-quality CDW recycling.

The down-cycling of materials is less than ideal from the ecological and economic perspectives. Although less costly than high-quality recycling, it entails the consumption of new materials in the recycling process and continues structural inefficiencies in the construction market, such as the dominance of primary raw materials over recycled ones. Due to the prevalence of down-cycling, all countries are far from attaining the ideal of a closed-loop system where there is virtually no waste, all material is reused, and no new material or resources are introduced[28]. However, down-cycling is still a positive step compared with typical (wasteful) processes for CDW, such as disposal. A benefit of down-cycling is that recycled materials are substituted and therefore natural aggregate resources are conserved.

The demolition technique used, however, can largely determine the quality of the demolition waste generated, which is strongly site and project specific. Conventional demolition techniques (using heavy equipment to demolish buildings), usually result in a more mixed CDW stream. When selective

[26] Winter and Henderson 2003.
[27] Martin-Morales et al. 2011.
[28] Hiete et al. 2011.

demolition techniques are applied (employees deconstructing elements of buildings individually so that CDW can be sorted better), inert materials can be separated more efficiently from other non-mineral fractions and typically result in a higher quality waste stream[29].

Another type of challenge that CDW recycling faces comes from CD market structure. The market price of recycled material is tied with virgin material prices, reducing the profit margin for the industry. Therefore, all the costs involved in each processing stage of CDW recycling have an a priori limit due to the strategic pricing behaviour of the sellers based on the characteristics that define demand.

There are two additional factors that seriously hinder the market for CDW. A defining factor that shapes the mineral C&D market is transport costs. Since mineral waste is often heavy and bulky, the costs of transporting it from the site to a stationary recycling plant. In turn, for the exchange of recycled aggregates to be profitable the distance between buyer and seller has to be close. This characteristic makes the markets for mineral CDW local/regional. The average distance that recycled aggregates could maximum travel based on interactions with stakeholders is about 30 kilometres[30].

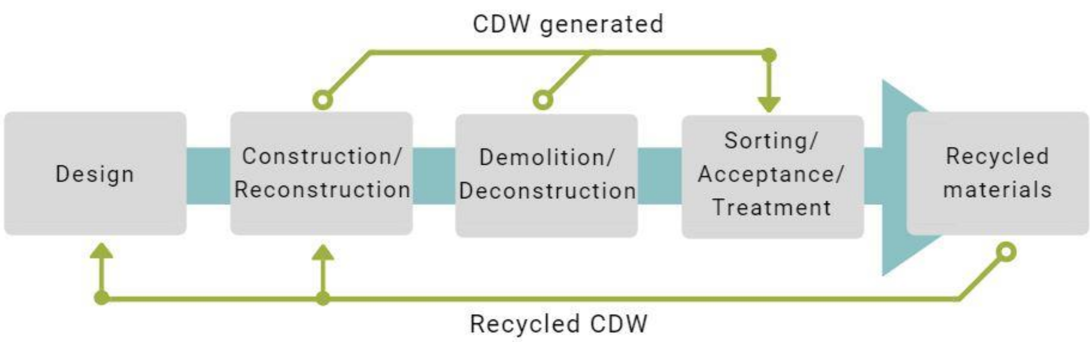
[29] European Commission 2015, p. 68.
[30] European Commission 2015, p. 68.

3 RECYCLING CAPACITY: TYPES AND EMERGING REQUIREMENTS

CDW has been identified by the EU as a priority stream because of the large amounts that are generated and the high potential for recycling embodied in these materials. A proper management would lead to an effective and efficient use of natural resources and the mitigation of the environmental impacts to the planet.

For recycling to be effective in a circular economy model, it should be understood horizontally, addressing the flow of waste in across the CD value chain. Identifying the life-cycle of CDW aims to close the loop of CDW stream and increase environmental efficiency. The CDW value chain includes the following phases (Figure 8): the design of materials for construction, the construction, repair, maintenance and other reparatory activities, the demolition or deconstruction phase, and then sorting, acceptance of materials, treatment, certification, and the final recyclable product.

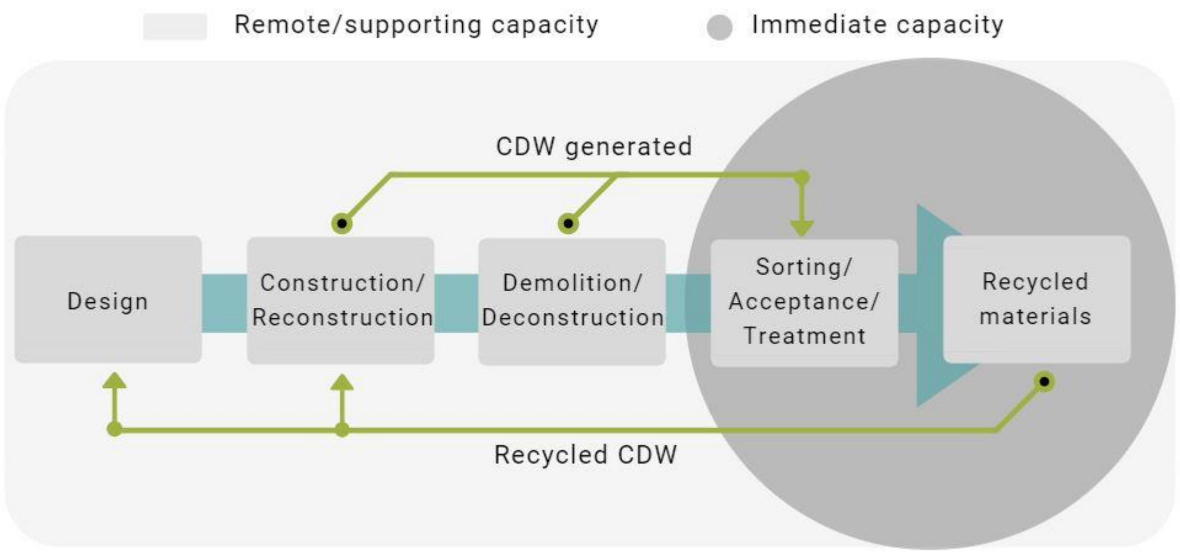
FIGURE 8: CDW STREAM ACROSS THE VALUE CHAIN / SOURCE: EUROPEAN COMMISSION 2018 (MODIFIED).



The definition of capacity for CDW recycling should be applied to cover the whole CDW life-cycle. Therefore, in this case recycling capacity can be subdivided into two definitions of capacity:

- **Immediate** capacity concerns the infrastructural capacity of a region for treating and recycling CDW. This includes, for example, the number of recycling plants available in a region and the volume of CD processed and treated.
- **Remote (or supporting) capacity** includes all the other non-infrastructural elements that influence and mediate the immediate capacity yet are not directly involved with the practical operations of CDW recycling. It comprises relevant policies and regulations, incentives, initiatives, and awareness campaigns.

FIGURE 9: RECYCLING CAPACITY COVERAGE OF THE CDW VALUE CHAIN



3.1 IMMEDIATE CAPACITY

Immediate capacity is defined as the recycling infrastructure that accepts, sorts, and treats CDW materials. It concerns all the operations that revolve around waste recycling plants. Such plants aim to separate the mixed waste (e.g. remove steel from aggregates) to streamline recycling and remove contaminants through industrial processes (e.g. crushing, grinding) to achieve marketable products.

CDW management plants can be mobile, semi-mobile, and stationary. The selection of different recycling methods affects the achievable type, quantity and quality of recycled aggregate materials and thus the recycling rate. In general, stationary plants produce higher-quality aggregates, but have to incorporate transport costs. If recycled aggregate materials can also be used on site, transport of both CDW and recycled aggregate materials can be avoided. However, avoided transport comes at the expense of a lower sorting performance, so that application of (semi-)mobile plants is best for rather homogenous and 'clean' CD waste, for example concrete waste[31].

3.2 REMOTE/SUPPORTING CAPACITY

There are five elements that constitute the remote CDW recycling capacity: a) waste recycling policies and regulations affecting CDW, b) incentives to increase CDW recycling, c) stakeholder initiatives, and d) awareness campaigns that promote CDW recycling. All five elements are enabling and supporting the CDW recycling infrastructure.

- Waste policies and regulations are binding documents that set the framework for managing waste, or in our case, CDW. These can be:
    - Waste framework policies
    - Circular economy policies
    - CDW regulations
    - Landfill legislation
    - Secondary raw material legislation and standards
    - CD sites legislation and standards
    - Construction standards
    - Pre-demolition standards
- Incentives that touch on CDW recycling could be:
    - Landfill taxes on CDW materials
    - Financial support to improving or/and increasing CDW recycling plants

[31] Hiete 2013, p. 58.

- Initiatives of stakeholders are a great bottom-up approach to increase the CDW recycling with industry efforts. Such efforts could take the form of coalitions, partnerships, and collaborations.
- Awareness campaigns that aim, for example, to increase the involvement of stakeholders in CDW recycling can improve regional recycling rates. Public environmental awareness is also important, since it contributes to the conscious changes in CD market, and increases the pressure for policy changes.

3.3 FUTURE REQUIREMENTS & CDW RECYCLING

Research on trends that could impact the CDW could reveal several important developments (e.g. expected volume to increase) which in turn policy-makers and stakeholders can take into account when planning for the future. Considering the significance of the CDW stream in volume and quality, the identification of future trends could mitigate the risk coming from waste while enhancing waste management efforts.

Recycling of CDW is best understood and controlled at the regional level. Recycling rates are limited by CDW composition, the available techniques in recycling plants, the use options for recycled products and the overall demand generated by projects that can absorb these materials.

Regarding the purposes of this activity, a trend is an assumed development in the future that will have an effect (usually long-term and lasting) on and change the CDW recycling. Specifically, the focus will be on current CDW developments, internal or external to the CDW stream, that affect the immediate capacity of CDW recycling (as this has been defined in section 5.1 above). After extensive desk research, the following current developments have been identified as indicative of potential change in CDW recycling requirements:

Increase in CDW volume & supply

The forecast that the CDW will increase the next years up to 2050 is a common result of multiple future scenarios in the relevant literature[32]. Due to the aging population in the EU, it is expected that demolition activities will increase in the near future. For example, if the population decline projected for Germany for 2050 affects demolition rates[33], then CDW supply may triple (in comparison to 2011 rates) in some forecast scenarios. Another report estimates that the quantities of CDW will keep increasing, at least as fast as the economy. It provides the example of Flanders, which indicates a negative decoupling, meaning that the amounts of CDW could grow faster than the economy[34].

However, this may result in a situation where supply exceeds demand, and therefore CDW will be increasingly being landfilled. Matching supply and demand is crucial for maintaining a balance in the CDW recycling market, due to its regional structure and economic transport costs. In the past, in most EU countries demand considerably surpasses supply. In the future this may change completely. Increasing the acceptance and finally demand of (high-quality) recycling products, such as the use of recycling aggregates in concrete, may be a lever to cope with expected future increases of CDW[35]. Landfill bans, tax incentives, and stricter legislation (e.g. requiring a certain percentage of recycled materials in new construction) could also improve recycling demand in the future.

Recycling in the circular economy

European environmental and waste legislation has become stricter over the past decade, demanding more efficient waste treatment and increased recycling rates. The recent European Commission communication[36] establishes a monitoring framework for the circular economy, and sets the objective

[32] Hiete et al. 2011 & European Commission 2011, pp. 28-30.
[33] Deilmann et al. 2009.
[34] European Commission 2011, p. 28.
[35] Hiete et al. 2011.
[36] http://ec.europa.eu/environment/circular-economy/pdf/monitoring-framework.pdf

for a zero waste economy. This is expected to enrich waste chain management with more efficient processes and technologies[37] and enhance synergies and technology transfer among waste industries

For example, within the circular economy efforts, the analysis on the potential of industrial symbiosis can be further explored. This prospect is further substantiated by taking into account characteristics of industrial networks involving the exchange mineral CDW – many materials can be recycled and find new purpose in other industries through that way (e.g. plasterboard etc.)[38].

Increased public awareness

In light of growing public concerns over environmental problems and climate change, it is expected that raised public awareness on the environment will spill over to calls for more effective zero waste policies and waste management efforts. Considering that CDW materials have a high recycling potential, public perceptions are going to direct additional pressure to better the recycling processes of the CDW stream.

Additionally, increased corporate responsibility will come along with the emergence of a more conscious public. As a result, firms will aim to increasing their self-generated waste recycling efforts, as well as being more vocal about sustainability in general. Greenwashing is getting increasingly difficult to manage, as people are more vigilant and ready to pounce on illegitimate sustainability efforts. Besides, there are upsides to businesses becoming more sustainable, such as increased supply line efficiency and reductions in waste. We can expect to see increased corporate responsibility as well-informed consumers continue to demand that the companies they buy their products from be more socially responsible and environmentally-conscious.

Shift in construction methods

Although they do not hold a large share of construction activities, modular and green construction are more efficient in construction terms and, more importantly, they can streamline the CDW stream. By modular construction, building activity takes place almost 80% off-site without any compromise in quality, thus reducing the required construction time by approximately 65 times[39]. This development will make the management of CDW waste much more effective and will boost the volume and quality of recycled CDW significantly. In combination with certified green construction projects, a growing market within the construction industry, a shift in construction methods will have a significant effect in the management and treatment of CDW.

Introduction of technological innovations

The waste and recycling industry is beginning to embrace technological innovation as a driver for future success. Critical infrastructure improvements will be made possible through advanced robotics and machine learning, enabling virtual waste assessments and better sorting at recycling facilities. Technology can also play a role in creating more efficient route models, eliminating unnecessary pickups and ultimately employing autonomous vehicle technology. This could greatly impact CDW market, since one of its main challenges is transportation costs.

Applications of robotics to demolition processes are an example of how CDW recycling could change in the future. The 2013 International Design Excellence Award from the Industrial Designers Society of America was for ERO – a robot that can actually recycle buildings made out of concrete and rebar. While only a conceptual project at this point, the fact that an entire concrete building can be theoretically recycled is a ground-breaking achievement of design. It is expected that similar innovative applications will continue to evolve at a faster rate.

Automation in the recycling industry is heavily linked to the technological progress of Artificial Intelligence. Unlike an automotive line, robots cannot simply repeat the same task over and over again at a recycling facility. They need to learn the difference between materials, shapes and contamination.

[37] VTT 2012.
[38] European Commission 2015.
[39] https://geniebelt.com/blog/top-8-trends-for-construction-in-2018.

An impressive example of new technology is being implemented in the UK through Green Recycling with a Max-AI Autonomous Quality Control robotic sorter. The Max-AI sorter essentially learns from past experiences thanks to its artificial neural network technology, so it can quickly and easily identify recyclables and place them into the appropriate chutes[40].

[40] http://www.max-ai.com/

4 DATA COLLECTION GUIDELINES AND TOOLS

Based on the purposes and the thematic background of the activity, as these have been defined in sections 3.2, 4, and 5, this study seeks to address the following questions:

- What are the existing structures and frameworks that enable and support CDW recycling capacity in project partners' regions?
- Extrapolating on existing trends, what are future requirements that could arise for the CDW recycling capacity in partners' territories?

4.1 RESEARCH APPROACH

This activity will make use of two research methods for data collection: a) desk research and b) survey to cover adequately the activity's thematic scope.

Desk research will be used a) for collecting data on the regional immediate and supporting capacity and b) for identifying future developments and requirements in CDW recycling their territories. The tool for desk research is an input documentation form. It is addressed and it is expected to be completed by the project partners, since they have the proper institutional standing and capacity to gather information on these two issues.

The survey will be used for complementing the findings of desk research. It aims to document the current developments in CONDEREFF territories relevant to CDW and assess the likelihood of their impact on the territorial recycling capacity. The tool for the survey is a questionnaire, to be distributed and completed to the relevant stakeholders of each partners' region.

In this way, AURA-EE will have additional data material on the topic of future CDW recycling, which is a difficult topic due to its future-oriented character. The assistance of stakeholders is crucial, because the uncertainty inherent in identifying future requirements for an issue is mitigated by including multiple perceptions and interpretations.

4.2 DESK RESEARCH

Desk research will be the method that project partners will use to identify the a) immediate, and b) remote/supporting CDW recycling capacity in their regions.

Desk research data is data collected by someone else and within other studies (i.e. primary research – for example surveys, interviews, case studies) or it is a literature review. There are many sources for this type of data, notably government agencies, educational institutions, companies, non-profit institutions, libraries, and the Internet. This method was chosen for its efficiency and cost-effectiveness, capitalising on already existing knowledge without requiring primary data collection. It can help project partners' data collection efforts by offering already analysed and validated data. Desk research can be divided into two categories according to their source: external or internal.

Internal desk research refers to the collection of data by members an organisation within their own organisation. The accessibility of this kind of data is the reason CONDEREFF project partners should consider internal desk research as one of the starting points of their research. Internal desk research starts with internal documents (e.g. statistical reports, studies, memos, and others). Considering the nature of information required for this activity (e.g. CDW stream materials and recycling rates), there is a high possibility that CONDEREFF project partners have already available CDW data and/or may have participated in projects concerned with waste management and recycling.

Indicatively, during internal desk research CONDEREFF partners should focus on deriving data from the following categories of their internal documents:

- Internal reports on waste management/CDW stream
- Studies on CDW recycling
- Waste monitoring results

- Feasibility analyses of CDW recycling infrastructure
- Proposals or communications on CDW stream
- Emails, memoranda, letters with CD stakeholders

External desk research draws from documents produced outside the organisation, i.e. documents that are publicly available either online or in libraries, delivered by other organisations other than CONDEREFF partners. In external desk research, project partners need to read and examine various texts/documents that contain data congruent with the purposes of activity 1.3. The data will be collected from relevant secondary sources of information. Indicatively, possible sources of information can be:

1. Statistical databases:
    a. Eurostat: https://ec.europa.eu/eurostat/web/waste/overview

2. Journals and other academic sources:
    a. Resources, Conservation and Recycling (https://www.sciencedirect.com/journal/resources-conservation-and-recycling)
    b. Waste Management (https://www.sciencedirect.com/journal/waste-management)
    c. Journal of Industrial Ecology (https://onlinelibrary.wiley.com/journal/15309290)
    d. Building Research & Information (https://www.tandfonline.com/loi/rbri20)
    e. Construction Management & Economics (https://www.tandfonline.com/loi/rcme20)
    f. Waste Management & Research (https://www.sciencedirect.com/journal/waste-management-and-research)
    g. Key Engineering Materials (https://www.scientific.net/KEM)
    h. Journal of Construction Engineering and Management (https://ascelibrary.org/journal/jcemd4)
    i. Construction and Building Materials (https://www.sciencedirect.com/journal/construction-and-building-materials)

3. CDW research reports:
    a. JRC-IES – Supporting Environmentally Sound Decisions for Construction and Demolition (C&D) Waste Management (http://eplca.jrc.ec.europa.eu/uploads/waste-Guide-to-LCTLCA-for-C-D-waste-management-Final-ONLINE.pdf)
    b. European Commission – Management of Construction and Demolition Waste (http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf)
    c. European Commission - Resource efficient use of mixed wastes improving management of construction and demolition waste (https://publications.europa.eu/en/publication-detail/-/publication/78e42e6c-d8a6-11e7-a506-01aa75ed71a1/language-en/format-PDF/source-76637999)
    d. European Commission – Development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure (https://publications.europa.eu/en/publication-detail/-/publication/3637d9db-1c3e-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-76637999)
    e. European Commission - Analysis of certain waste streams and the potential of industrial symbiosis to promote waste as a resource for EU industry (https://publications.europa.eu/en/publication-detail/-/publication/d659518c-78d3-45a1-ad2e-d112c80e1614/language-en/format-PDF/source-76638069)
    f. VTT - Directions of Future developments in waste recycling (https://www.vtt.fi/inf/pdf/technology/2012/T60.pdf)
    g. VTT - Reuse of recycled aggregates and other C&D wastes (https://www.vtt.fi/inf/julkaisut/muut/2012/VTT-R-05984-12.pdf)

4.2.1 Input documentation form

To guarantee that all results are documented in a consistent and clearly structured manner, the methodology prescribes a common approach for reporting results. For the desk research, a case documentation form, presented in ANNEX A, provides a tool for data collection.

The tool has three sections (A, B, and C):

- **Section A** aims to gather territorial information on the CDW immediate recycling capacity of project partners. It includes questions on the volume, composition, and recycling rate of the CDW stream, as well as information pertaining to the recycling plants.
- **Section B** demands information on the remote/supporting territorial CDW recycling capacity, and asks project partners to document the relevant waste policies and regulations, incentives that may be in place, awareness campaigns, and stakeholder initiatives that promote CDW recycling.
- **Section C** inquires about the future CDW recycling requirements that could appear in CONDEREFF territories. It includes questions on future volume, increase/decrease rate, and materials affected in the CDW stream. Also, it asks project partners to identify construction and demolition trends that perceive as likely to occur in their territories, and, based on them, to assess their existing capacity.

The suitable personnel to conduct the desk research and fill-in the input documentation forms are members or staff of the organisations represented in the project consortium, or relevant experts.

4.3 SURVEY

The second research method for data collection is a survey (presented in ANNEX B). The general objective of the survey is to further investigate the future CDW trends and recycling requirements that could appear in the future in partners' territories.

The sample population of the survey is the stakeholders of each CONDEREFF partner that are relevant to the CDW recycling and have adequate knowledge of waste management practices in the CDW stream. The indicative list of stakeholders includes:

- Construction, repair, demolition company
- Recycling organisation / association
- CDW Recycling plant
- R&D centre (e.g. universities, institutions) specialised in waste management
- Engineering company
- Environmental company
- NGO relevant to CDW management
- Quality certification bodies for buildings and infrastructure
- Clients of CDW recycled materials

The survey tool is a structured questionnaire which will be distributed to stakeholders. To ensure consistency, the questionnaire is developed, communicated and completed in English. Where feasible, and in cases where communication can only be established in national language(s), project partners may translate both the questionnaire and responses (in case of additional comments, communication, etc.). Direct communication (by e-mail or phone) with survey respondents could take place so as to establish an initial contact, allowing to ask for additional evidence or clarifications.

4.3.1 Questionnaire

The questionnaire includes a question that aims to document the perceptions of stakeholders on current developments that could set new requirements for CDW recycling capacity. It proposes a list of possible and current developments relevant to CDW and asks stakeholders to pick and rate those that they think could affect the CDW recycling capacity in their territories.

4.3.2 KPIs & sampling

To ensure the validity of the survey, the following KPIs have been identified. The methodology suggests three scenarios for the number of questionnaires to be collected: a moderate, a good, and a best scenario. In the moderate scenario, the desirable number of completed questionnaire is 100; the good scenario foresees 140 completed questionnaires, and the best scenario aims for 180 completed questionnaires[41]. The distribution of targets among project partners takes into account two factors: a) the research capacity and their expertise on CDW recycling, and b) the official recovery rates for each country[42].

TABLE 2: CALCULATING THE KPIS

#	Partner	Research capacity & expertise	Country	Recovery rates for CDW
1	UPV	High	Spain	79%
2	RoT	Medium	Greece	0%
3	AURA-EE	High	France	72%
4	RRAPK	Medium	Czech Republic	90%
5	ENEA	High	Italy	98%
6	Lazio	Medium		
7	STYRIA	Medium	Austria	94%
8	ISW	High	Germany	94%

[41] Regarding the total numbers of minimum and maximum completed questionnaires, since this is not defined in the Application Form, these correspond to established practices from past experience and implementation of stakeholder surveys in the literature.
[42] Data source is Eurostat cei_wm040, calculating the recovery rate of construction and demolition waste. Here the latest available data is presented for each country.

Taking into consideration the above factors, and the fact that two partners share the same NUTS 2 region[43], an indicative target number of completed questionnaires per consortium country and project partner is presented in the following table:

TABLE 3: TARGET FOR EACH PROJECT PARTNER

#	Partner	Moderate scenario	Good scenario	Best scenario
1	UPV	20	25	30
2	RoT	5	10	15
3	AURA-EE	20	25	30
4	RRAPK	10	15	20
5	ENEA	10	15	20
6	Lazio	5	10	15
7	STYRIA	10	15	20
8	ISW	20	25	30
-	**Total**	100	140	180

4.4 ROADMAP FOR DATA COLLECTION

After project partners have received the methodology, feedback is expected by **October the 19th**. Any comments and feedback will be incorporated into the final methodology report.

The deadline for CONDEREFF partners to provide territorial data (by filling-in the 'input documentation form') is one month after the methodology has been received by all partners (i.e., **November the 23rd**). The same deadline applies for the questionnaire: partners should distribute and collect the completed questionnaires by **November the 23rd**. AURA-EE will review the collected evidence and a final round of fine-tuning will take place during the last week of November (if necessary). All responses should be gathered and delivered following the provided format (Excel).

Finally, the data gathered will be analysed and used for drafting the final report, which is to be delivered by AURA-EE in the second semester.

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[43] Since ENEA and Lazio share the same NUTS2 region, one target is split among them so as to reflect each one's institutional capacities.

5 REFERENCES

Allwood, J., Ashby, M., Gutowski, T., and Worrell E (2011). 'Material efficiency: A white paper '. *Resources, Conservation and Recycling* 55: 362 – 381.

European Commission (2017). *Resource Efficient Use of Mixed Wastes Improving Management of Construction and Demolition Waste*. Luxembourg: Publications Office of the European Union.

European Commission (2015). *Analysis of Certain Waste Streams and the Potential of Industrial Symbiosis to Promote Waste as a Resource for EU Industry*. Luxembourg: Publications Office of the European Union.

European Commission (2011). *Service Contract on Management of Construction and Demolition Waste – SR1*. http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

Frost & Sullivan (2014). European Construction and Demolition Recycling Services Market: Legislation Drives Recycling Target Toward Multibillion Dollar Market by 2020. Frost & Sullivan.

Hiete, M. (2013). Waste management plants and technology for recycling construction and demolition (C&D) waste: state- of-the- art and future challenges. In F. Pacheco-Torgal, V. W. Y. Tam, J. A. Labrincha, Y. Ding and J. de Brito, *Handbook of recycled concrete and demolition waste*. Oxford: Woodhead Publishing, 53-75.

Hiete, M., Stengel, J., Ludwig, J. and Schultmann F. (2011). 'Matching construction and demolition waste supply to recycling demand: a regional management chain model'. *Building Research & Information* 39(4): 333-351.

European Environmental Agency (2018). *Waste prevention in Europe — policies, status and trends in reuse in 2017*. EEA Report No 4/2018

European Environmental Agency (2015). *Hazardous waste review in the EU-28, Iceland, Norway, Switzerland and Turkey: Generation and treatment*. Luxembourg: Publications Office of the European Union.

VTT (2012). *Directions of Future Developments in Waste Recycling*. VTT TECHNOLOGY 60.