CURE+ Baseline study: City of Barcelona, Spain

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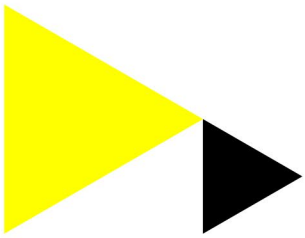

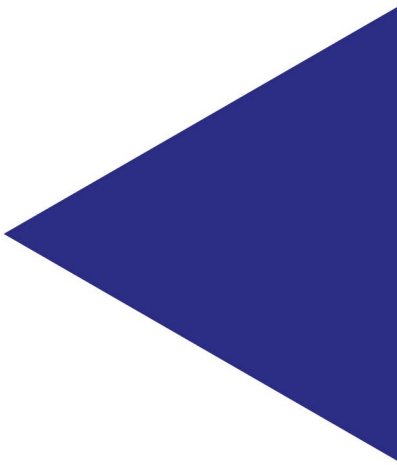

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CURE+

CENTRES FOR URBAN RESOURCES, REUSE AND REMANUFACTURE

Baseline study

City of Barcelona, Spain

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Lists of Abbreviations

CDW	Construction and Demolition Waste
CE	Circular Economy
CURE+	Centres for Urban Resources, Reuse, and Remanufacture
EUKI	European Climate Initiative
EU WFD	European Union Waste Framework Directive
GDP	Gross Domestic Product
PNIR	Plan Nacional Integrado de Residuos
II PNRCD	National Plan on Construction and Demolition Waste
URC	Urban Resource Center
WFD	Waste Framework Directive
WMP	Waste Management Plan

1. Introduction

1.1. City of Barcelona

Barcelona is the capital and largest city of Catalonia region of Spain. It is the second most populous municipality, with a population of more than 1.6 million inhabitants (Barcelona City Council, 2022). Considered as one of the “Greenest cities in Europe”, the green spaces of Barcelona make up 11% of the city, with 68 parks and other green areas. Barcelona is also home to 9 UNESCO World Heritage Sites and the city has been named as the World’s Capital of Architecture in 2026 (UNESCO, 2023).

The top five main sectors of Barcelona including its contribution to gross domestic product (GDP) based on 2021 estimates were business services (14.8%), education, healthcare and social services (14.1%), commerce (10.9%), ICT services (8.7%), and hospitality (6.1%). During the same year, the construction sector ranked 12th and contributed 3.9% to the GDP of the city (Barcelona City Council, 2022).

In terms of the Construction and Demolition Waste (CDW), the total CDWs generated in Catalonia in 2020, including the city of Barcelona, was around 5.7 million tonnes. Approximately 58.3% of these CDWs are managed through recovery process, while the remaining 41.7% goes to a control landfill facility. The GDP value of CDW in 2020 amounted to more than €10.5 billion euros (Waste Agency of Catalonia, 2020). In the past, there were around 31.34 million tonnes of CDW that are generated per year in Spain, which is equivalent to 0.74 tonnes of CDW per inhabitant per year (Miteco, 2005). Around 80% of the CDWs are produced in the demolition operations of building structures.

1.2 CURE+ Project

CDW is the most significant waste stream in the European Union (EU) in terms of mass. Around 340 million tons of CDW were generated between 2010 and 2018 in the EU (EEA, 2020). Therefore, the EU Circular Economy (CE) Action Plan (EC, 2015a) has identified CDW as a priority waste stream. The Waste Framework Directive (WFD) sets a 70% recovery target for CDW by 2020. Most member states achieved this target on time. However, the recovery rate was mainly based on backfilling or downcycling, which hampers the implementation of CE objectives (Galvez-Martos et al., 2018). Currently, most material streams from demolition and renovation works are unavailable for reuse or upcycling activities (EEA, 2020). Thus, the recovery potential of CDW in the EU is still under-exploited, with current CDW streams unsuitable for reuse or closed-loop recycling (EEA, 2020).

The CURE+ project, also known as Centres for Urban Resources, Reuse, and Remanufacture, aims to support the CE Action Plan by promoting and designing urban CE practices to track, trace, reduce, reuse, repair, remanufacture, and upcycle household related CDW. This will be done by learning from the best practices elsewhere and mapping the current waste management practices in four participating European cities, namely Riga

(Latvia), Tartu (Estonia), Kavala (Greece), and Barcelona (Spain), to develop locally tailored solutions for each city. Developing tailored-made solutions requires working with local stakeholders from cities/municipalities, private businesses, and universities while putting citizens at the forefront of this initiative. Local stakeholders will be engaged in waste prevention, upcycling wastes, and decreasing reliance on virgin raw materials. Local authorities play a crucial role in climate change mitigation through the development and execution of CE policies at the local level. Therefore, they must be provided with the necessary knowledge and tools to effectively promote and evaluate such initiatives.

The CURE+ project is funded by the European Climate Initiative (EUKI). EUKI is an initiative launched in 2017 by the German Federal Ministry for Economic Affairs and Climate Action to improve collaboration among the member states on climate action. EUKI supports organizations within the EU to implement plans related to contributing to the expansion of renewable energy, improving energy efficiency, and reducing CO_2 emissions. Furthermore, EUKI-funded projects aim "to strengthen technological advances and political dialogue, social justice in climate action as well as climate education and sustainable economy" (EUKI, 2017).

1.3 Problem statement and justification for selecting Barcelona city

The EU's transition to CE will reduce the pressure on natural resources while creating sustainable growth and jobs (EMF, 2015). Achieving the EU's 2050 climate neutrality targets is also a prerequisite. In order to contribute to this goal, the CURE+ will specifically address the following issues:

- Lack of knowledge of current CDW flows, their composition, and their characteristics to identify them as recoverable. In each partner city, there is a lack of reliable and available data and classification systems;
- Different understanding and varied accounting systems of EU-member states for waste recovery operations; as a result, there is a lack of comparable (baseline) data on how much of CDW is currently recovered, and it is difficult to measure improvements over time;
- A habit of giving preference to raw materials over secondary materials (originated from waste) for two reasons: 1. They are cheaper; 2. Warranties and standards assure their quality, giving consumers and companies a limited incentive to use recovered materials;
- Lack of knowledge and resources to rethink value chains and business models, product design, and the overall economic systems to achieve the lowest environmental impact; and
- Communicating and promoting long-term benefits from implementing circular actions in the building sector.

In sum, a common understanding, exchange, transfer of knowledge, and capacity building are crucial for the CURE+ partner municipalities to achieve the EU climate goals.

Barcelona is an important city of study for CDWs. The regions of Catalonia, in which Barcelona belongs, and the Basque Country, are considered to be leaders in CDW management (Deloitte, 2015). Therefore, other European cities can learn from both the challenges and success factors experienced by Barcelona city in terms of CDW management. In addition, there are several existing initiatives in Barcelona such as resource, upcycling, and recycling centers which integrate environmental and social aspects of sustainability in its operation. Since part of the goal of CURE+ project is to promote the management of CDW via establishment of Urban Resource Centres (URCs), Barcelona is an important learning environment for this project.

1.4 Aim of Article

The aims of this report are: (1) To highlight the unique aspects of Barcelona, including its CDW management approaches, legal and policy frameworks, city visions and strategies, innovative practices, and enablers and barriers for CDW management; and (2) To provide recommendations on how to organize URC as an innovative approach for CDW management using the baseline insights obtained from this city.

1.5 Article Roadmap

The sections of this report are structured as follows. Chapter 1 introduces the city of Barcelona, the funding body behind this project, the problem statement, and justifications for selecting this city, followed by the aim of this article. Chapter 2 presents the sources of information in this article, which include interviews and reports. Chapter 3 provides an overview of the CDW management practices based on national and local level policies and regulations and CDW stream analysis. Chapter 4 discusses the current city vision and strategies, innovative practices and experiments, and the barriers and enablers to more circular CDW management. Chapter 5 recommends how a URC, as an innovative experiment, can be organized to further manage CDW in Barcelona.

2. Methodology

The data in this report was collected using reports, interviews, site visits, and a workshop. The reports include national, regional, and city levels documents on Waste Management Plan (WMP) and policies. The majority of these reports were written in Catalan and were translated into English. The interviews, which were conducted in July 2023, consist of different stakeholders. The summary of their profiles is presented in Table 1. All interviews were conducted in person and were recorded via MS Teams. The transcripts of interviews were generated using the same platform and were analyzed by coding relevant answers to the themes of this report. Site visits of existing initiatives that focus on management of wastes including CDWs in Barcelona, were done in October 2023. The information obtained from the reports, interviews, and site visits were validated and supplemented through a workshop held among city stakeholders in Barcelona in the same month. The representatives of Barcelona city were also included in Table 1 as part of the sources of information in this report.

Table 1 Profile of the interviewees in Barcelona City (July and October 2023).

Interviewees	Type of stakeholders	Profile
1	Public-Private	General Director of CDW management company Gestora de Runes de la Construcció (GRC), with public and private holding (45% and 55% respectively)
2	Private	General director of the Recovery Union of Catalonia
3	Public	Coordinator and managers of municipally owned FabLab working with reusing waste materials. (Ateneu de la Fabrica del Sol)
4	Private	Architect in LEED Green Associate, Green Building Council Spain
5	Private	Manager at the company group Sorigué, which focuses on works in water engineering, city services, construction and materials sectors
6	Public	Manager at the Environmental Services Management, Climate Action Area – of the Provincial Deputation of Barcelona; Network of cities and towns towards sustainability
7	NGO	Studies' Director at the zero waste NGO ReZero

8	NGO	Director of a social inclusion NGO Fundación Andròmines that works with bulky and electronic waste recovery and preparation for reuse
9	Public	Head of the Prevention and Resource Efficiency Department, Circular Economy Area, in the Catalan Waste Agency
10	Private	Director of the industrial network 22@ in PobleNou that had proposed a Scrap Store project some years ago
11	Academic	PhD and professor in Mining Engineering and CDW recycling
12	Private	Manager at a Sorting and recycling plant for CDW in Sant Cugat del Vallès
13	Private	Reuse oriented maker space Transfolab BCN
14	Public	Viladecans Recycling Centre with Reuse Collection Point
15	Private	Troc shop, 2nd hand furniture and commercial leftover store

3. Construction and Demolition Waste Management practices

This section identifies the different policies and regulation frameworks in the city of Barcelona, CDW laws implemented at municipal level, and the CDW stream analysis.

3.1 Waste Management Plans (WMP)

The WMP is discussed starting from the national or state level, followed by regional, then city level.

A. National Level Royal Decree 105/2008

The currently in force Royal Decree 105/2008, in combination with various National Waste Management Plans, regulates the production and management of CDW in Spain (Spanish Government, 2008). The Royal decree specifically focuses on several measures to promote recycling and minimizing of CDW in construction and demolition projects. These regulations involved (1) requiring actors to draft a CDW report and plan in a project's design and construction phase and (2) providing an economic fee deposit that will be returned once the project ended, after the client presents all the needed documents certifying the correct management of the generated CDW.

CDW has to be separated into the following fractions (in tonnes), when an individual material exceeds the expected amount to be generated for the total construction site:

- Concrete: 80t
- Bricks, roofing, ceramics: 40t
- Metal: 2t
- Wood: 1t
- Glass 1t
- Plastic 0,5t
- Paper and cardboard: 0,5t

B. National Plan on Construction and Demolition Waste (II PNRCD)

The 2007-2015 Integrated National Plan for Waste, also known as *Plan Nacional Integrado de Residuos (PNIR)*, presents the country's plans on all national waste flows that include urban waste, hazardous waste, end of life vehicles, among others (Ministerio De Medio Ambiente, 2007). Within this plan, there is a specific national plan allocated for CDW namely the National Plan on Construction and Demolition Waste (II PNRCD). The aim of this plan is to establish objectives related to prevention, reutilization, recycling, and other forms of recovery to eliminate CDW. The II PNRCD also outlines the measures and financial methods to achieve these objectives. This plan has highlighted the current CDW management status from years 2001-2005 as well as provided the quantitative projection for CDW levels from years 2006-2012.

C. *2016-2022 State Waste Framework Plan* (*Plan Estatal Marco de Residuos or PEMAR)*

Following the Royal Decree 105/2008 that regulates CDW production and management, PEMAR 2016-2022 establishes measure that the CDW producer must include in the work execution project a waste management study. The person executing the work must present a CDW management plan. Likewise, the correct waste management must be ensured, applying the principle of hierarchy of Law 22/2011, on waste and poluted soils, thus contributing to the sustainable development of the construction sector.

The PEMAR after the adoption replaces the PNIR. It has a specific section intended for CDW. The main objectives of this plan are to outline: (1) A framework that will serve as basis for all Autonomous Communities in developing a tailor waste plan in their regions, through providing the scope and current status of CDW management in Spain; (2) A plan for demolition practices; (3) Management of CDW; (4) Providing the recycled content of CDW materials; (5) Ways to encourage recycling and reuse of CDW materials; and (6) Strength and durability of CDW.

The qualitative targets under PEMAR 2016-2020 (EC, 2015b) are:

- Reducing the amount of CDW for landfilling or backfilling;
- Including environmental costs on the price of virgin materials in favour of incentivizing and encouraging the use of recycled materials;
- Organize discussions on how to implement selective demolition and selective collection;
- Develop a framework for encouraging use of recycled aggregates in construction works.

The quantitative targets under PEMAR 2016-2020 to be achieved by 2020 are:

- 70% of non-hazardous CDW will be prepared for reuse, recycling, and other recovery options (excluding soil and stones)
- Eliminate 30% of remaining hazardous CDW to landfills
- Use 90% of soil and stones from earthworks and restoration in backfilling
- Reduce the remaining soil in landfills by 10%.

D. Regional Waste Management Plan (Autonomous Community Level)

The regional management of CDW is administered by the “Autonomous Communities” of Spain. In this case, the Generalitat de Catalunya is the expert when it comes to administration, while the Waste Agency of Catalonia (*Agencia de Residuos de Cataluña* in Spanish) has the authority when it comes to waste management (Interviewee 9). Autonomous Communities have the authority to develop specific laws based on the basic wastes’ regulations, rules, and main objectives that are formulated by the State. For example,

Catalonia has a Catalan waste law that develops things that are provided for in Spanish legislation (Interviewee 9). All “Autonomous Communities” are required to report yearly their regional statistics to the National Statistics Institute, in accordance with the European List of Waste codes, to achieve consistent and transparent figures (Deloitte, 2015).

The aim of the Regional Waste Management Plan of Catalonia is to apply and monitor on-site the criteria for the production and management of CDWs, as enumerated below (Generalitat de Catalunya, n.d.):

1. Waste minimization and prevention measures
2. Estimation of waste generation
3. Waste management operations
4. Technical specifications
5. Graphis documentation of the waste management facilities.

The various specific measures for management of CDWs are as follows: (1) CDW will have to be quantified by typology and phase of work. They shall be estimated in tonnes and cubic metres; (2) An inventory of special or hazardous waste that will be generated during the demolition, repair or renovation activities must be included; and (3) Space must be available (on-site) to carry out the selective sorting of waste, as well as the possibility of reuse and recycling (on-site).

For collected waste, what has been dumped in controlled dumps should be put in the following order: (1) reuse, (2) recycling or (3) other recovery. There must be a separation of Inert waste, non-special waste and special waste (the latter must always be separated from the rest). For reused waste, in order to define waste management operation, it will be necessary to state:

- The type of selective sorting and the number of containers depending on the possibilities of reuse, the types of waste, the space on the site, the feasibility of having a mobile crushing plant on site, etc.
- The quantity of the reused material (on-site) (m^3 after crushing) of stone waste that comes from the on-site recycling. The amount of stone waste (m^3) that has been prevented from being landfilled.
- Models of signage are used for the containers according to the type of waste they can contain.
- Data on the destination of the waste (data from the managers of the recovery, separation, transfer or controlled deposit facilities).

For recycled waste, a container leaving the site with heterogeneous waste has less chance of being recovered than a clean one loaded with homogeneous waste. Because it can be transported directly to a recycling plant if it meets the physical and chemical characteristics of waste. Any recycling or reuse operation must be subject to an initial sorting process to ensure that the raw material is uniformed, and the resulting material is of high quality.

E. City Council (Barcelona Level)

The City or the municipality is responsible for the collection and treatment of the waste, which is based on the regulations and targets set by the Generalitat [of Catalonia]. In case a municipality is very small, it may join with others with the collection of waste. Part of the collection points are managed by the metropolitan entity. In the specific case of Barcelona, the metropolitan area is the body to which, at the time, the 40 town councils of the metropolitan area delegated their powers and, subsequently, a law was passed in the Parliament of Catalonia which gave the metropolitan area its own powers. In the rest of the cases (of other autonomous communities) the local councils delegate their jurisdiction, and if there is no delegation, the supreme municipal body has no jurisdiction. In other words, the city council has to delegate its powers and can recover them whenever it wants (Interviewee 9).

The City Council may establish collaboration programmes with the different sectors of economic activity in waste management aimed at achieving the aforementioned objectives. The owners of the activities that participate in these programmes will be able to enjoy the benefits provided for in the corresponding regulations.

3.2 CDW related laws implementable at municipal level

This section discusses specific laws that are implemented at city or municipal level. It includes the management of debris, landfill fees, and dumping of bulky waste.

1. Article 67-15 Management of debris by means of containers up to 1 m³

Article 67-15 focuses on the use of containers up to 1m³ in volume when handling debris. The rubble generated from minor works and house repairs should be placed in rubble containers up to 1m^3. The service for the management of rubble may be provided by the municipality through direct (municipal service) or indirect forms of management of the general waste collection service (BOPB, 2011).

2. Article 67.3 Management of debris

Article 67.3 in general states the management of debris generated from minor works and home repairs, through municipal interventions (BOPB, 2011). This law specifically aimed to:

- Avoid the uncontrolled abandonment of rubble in unauthorized places or inappropriately carried out;
- Avoid the abandonment of rubble on the public highway, the deterioration of pavements and, in general, the generation of dirt on the public highway and in the city's public spaces.
- Guarantee the correct placement of rubble containers on the public highway and their collection when they are full.

- Encourage the recycling and reuse of by-products, materials and substances contained in waste.
- Guarantee that the operations of collection, transport, storage, recovery and disposal of debris are carried out in accordance with the demands and requirements for the protection of the environment.

In particular, the municipal administration shall encourage the disposal of rubble in the most appropriate places and in such a way as to facilitate the recovery of degraded areas. In municipal works, whether they are carried out by the administration or contracted to third parties, the City Council shall ensure that materials from the recycling of rubble are used.

3. Landfill fees

The landfill fees in Spain vary depending on the municipalities and the type of waste (Miteco, n.d.). For instance, some municipalities have a single landfill fee, with prices ranging from €1/t (Pamplona) to €25.20/t (Madrid). In general, clean inert waste has a lower landfill fee (around €2 and €10 per ton) than mixed waste (between €8 and €30 per ton). The landfill fees for inert solid waste are determined by municipalities and variation can be seen between municipalities in Spain.

4. Dumping of bulky waste

The dumping of bulky waste of any kind on the public highway, outside of the established systems, is not permitted. The separate collection of bulky waste includes both household and commercial waste, which are both specified as follow (BOPB, 2011):

A. Domestic (bulky) waste is household waste such as furniture, household goods and old junk, mattresses, bedsteads and other materials discarded by citizens in the various activities of repair or replacement of household equipment, excluding any type of commercial waste.

The collection of domestic waste will be carried out in the following three ways:

- Home collection service, for a fee, in accordance with the provisions of the public prices of the services for the provision of special cleaning and municipal waste collection services.
- Use by citizens of green points or clean points (*puntos limpios* in Spanish).
- At the door of the home and free of charge, with the frequency determined by the municipal administration.

B. *Commercial (bulky) waste* originates from commercial activity, services or other public and private establishments, and can be assimilated to municipal waste. This collection is subject to payment of the corresponding public price. Under no circumstances, the collection of industrial waste will be subject to the special bulky waste collection service.

The collection of commercial waste will be carried out in two ways:

- Home service, for a fee, in accordance with the provisions of the public prices of the services for the provision of special municipal cleaning and waste collection services.
- Use of existing green points or clean points.

3.3 CDW stream analysis

To manage CDW streams, it is important to identify the streams of waste, the actors involved, as well as the processes. Figure 1 illustrates the CDW streams based on these three factors. The types of waste are divided into (1) construction waste that includes inert wastes; non-dangerous; and dangerous; and (2) bulky wastes.

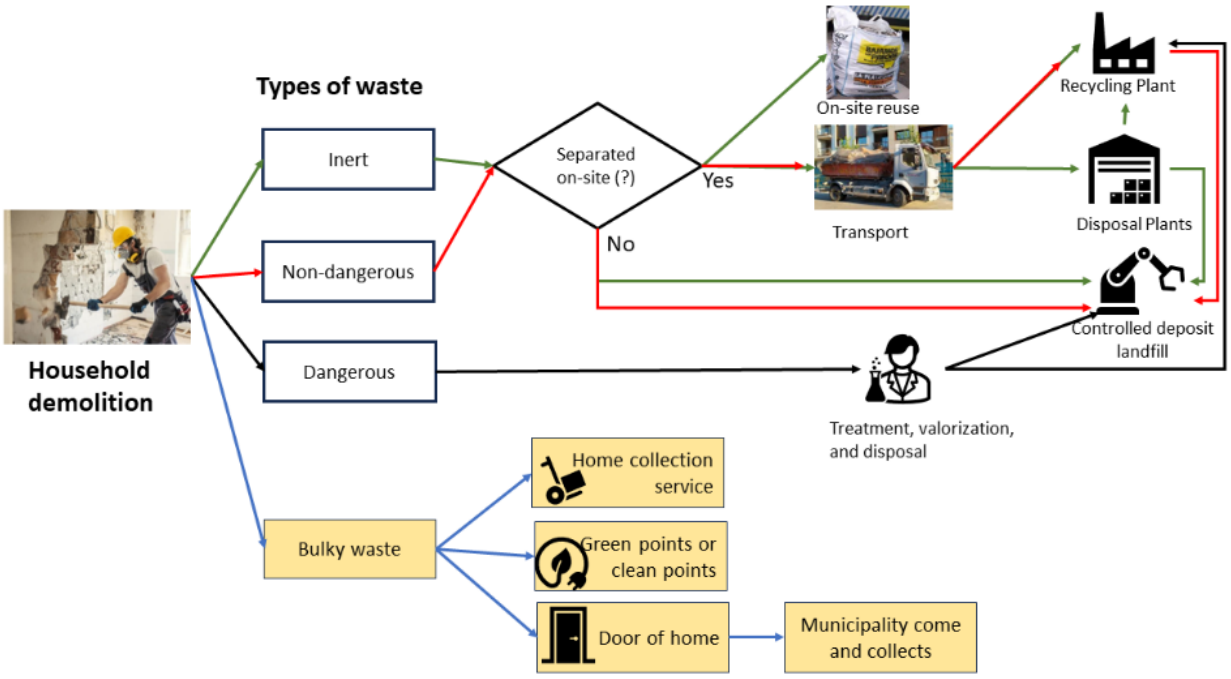

Figure 1 CDW journey based on the types of wastes, including the processes and stakeholders in Barcelona city.

Inert wastes such as bricks, old mortar, ceramics, concrete are often mixed. If these can be separated, they can be either used on-site or transported to recycling plants. Recycling is the process by which materials from CDWs are used to obtain a recoverable product that is suitable for reuse as raw material. For instance, stone materials can be reintroduced into the production cycle through crushing and screening process (Agencia de Residus de Catalunya, 2023). The main use of this material is for road filling (Interviewee 11, July 2023). Disposal plants use waste for the recovery of natural areas. The disposal of waste goes to three actors and these are (Ajuntament de Barcelona, n.d.):

1. Green points – these are centres for the selective reception of products for reuse and municipal waste for further treatment: preparation for reuse, recovery and final disposal. They are usually collected for recycling and reuse by different companies.

2. Triage plants - Their main function is to sort the waste with the option of separating the recoverable fractions and preparing them for marketing. Unseparated materials are prepared for final treatment. There are 5 working areas: the waste reception, the sorting line, the pressing and baling area, the material storage area and the offices.

3. Construction waste transfer plants - Construction waste transfer plants are created to optimize the transport to controlled depots or recycling plants. The transfer plants are linked to a nearby controlled depot.

Non-sorted inert waste can either go to disposal plants or direct to the controlled deposit landfill. Non-dangerous wastes have two possibilities –these could go straight to recycling plants or controlled deposit landfill. Dangerous wastes are first treated for valorization (upcyling or recycling) or disposal in the landfill. Finally, the bulky wastes can be collected in three ways. These include via home collection service, green or clean points, and municipality collects at the door of home.

4. Towards more circular CDW management

This section focuses on three topics: the current city vision and strategies, the current innovative practices and experiments, and the barriers and enablers in managing CDW in Barcelona city.

4.1 Current city vision and strategies

In terms of the vision and strategies, there are several initiatives and programs that the city of Barcelona participates in to align with its CE strategies. These initiatives and programs are at European, national, and city levels. Each will be discussed below.

A. European Level Strategies

The Waste Framework Directive (WFD) for CDW aims to: (1) Manage the CDW in an environmentally sound way, and (2) Reap the full potential of CDW by transitioning to CE. The 2020 target is seventy percent (70%) of CDW by weight must be recovered through reuse, recycling, and preparation of other material recovery of non-hazardous CDW (European Commission, 2008). In line with the WFD, there are also other EU level strategies that can be applied to CDW. These include the Extended Producer Responsibility and “Right to Repair”. The Extended Producer Responsibility is based on the principles of providing economic rewards to producers for designing environmentally friendly products and making producers responsible for the cost of managing the product at the end of their life cycle (European Union Law, 2024). The goal is to encourage manufacturers or producers to take into consideration the durability, reparabilitt, and end of life as part of product design via economic approach. Example applications in CDW are take-back approach, recycling incentives and disposal disincentives. The “Right to Repair” is a newly adopted EU proposal, which focus on promoting sustainable consumption via providing access to easy repair of defective goods, reducing waste, and supporting repair sector. The coverage of the new proposal is both within and beyond the legal guarantee period of a product (EC, 2023). Translating to CDW, the “Right to Repair” is useful in connecting consumers with repair platforms (both online and physical) and ensuring European quality standard for repair services of CDW materials (window frame, doors).

B. National Level Strategies

National Construction and Demolition Waste Plan (Plan Nacional de Residuos de Construcción y Demolición – PNRCD) 2007-2015

The qualitative targets set for CDW management under PNRCD (2007-2015) include:

- Creation of network and infrastructure needed to facilitate CDW management;
- Establish a standard statistic system

- Closing unathorized/non adopted landfills (or quarries)
- Controlling the collection and management of 95% of all CDW
- Selective collection and management of 95% of waste

State Waste Management Framework Plan (Plan Estatal Marco de Gestión de Residuos -PEMAR) 2016-2022

The qualitative targets under PEMAR 2016-2022 are:

- Different materials need be collected separately, guarantee the selective removal of hazardous waste from CDW, and ensure the correct management of all waste according to its nature and hazardouness.
- Promote greater use of materials from CDW management. For this purpose, actions such as increasing landfill rates can be used to discourage the deposit of valuable CDW waste and the establishment of additional responsibilities for the promoter/builder if they do not correctly separate the generated CDW at source.
- Promote the use of natural excavated materials in the construction of earthworks as well as in the restoration of degraded spaces and in conditioning or filling works; and establish environmental criteria for the use of other materials from the treatment of non-hazardous CDW in those destinations.
- Establish an greement to promote the use of recycled aggregates from CDW in construction works. Including, whenever possible, in public works construction projects of a minimum percentage of 5% of recycled aggregates. This percentage of 5% will also be applied, whenever possible, in private work.

State Waste Management Framework Plan (Plan Estatal Marco de Gestión de Residuos – PEMAR) 2023-2025

PEMAR 2023-2025 follows from the following framework (1) Royal Decree 105/2008 that regulates CDW production and management; (2) Order APM/1007/2017 that establishes the use of natural materials excavated for use in backfilling activities and works other than those in which they were generated; and (3) new Law 7/2022, on waste and contaminated soil for a circular economy's main objective, which is to reduce the generation of CDW, using the best available techniques and good environmental practices. Furthermore, to improve the effectiveness of the treatment of CDW, from July 1, 2022, non-hazardous RCD will be classified compulsorily in the following fractions: wood, mineral fractions (concrete, bricks, tiles, ceramics and stone), metals, glass, plastic and plaster. Selective demolition will be used mandatory from 2024 in order to separate these fractions.

The qualitative targets under PEMAR 2023-2025 are:

- Updating the CDW regulatory framework to adapt it to the new Law 7/2022.

- Promoting greater use of materials from the management of CDW so administrative barriers to their use are limited.
- Establish an greement to promote the use of recycled aggregates from CDW in construction works. Including, whenever possible, in public works construction projects of a minimum percentage of 5% of recycled aggregates. This percentage of 5% will also be applied, whenever possible, in private work.
- Promoting the development of guides on selective demolition and drafting of waste management studies.
- Promoting the development of guidelines to track facilities and centers with asbestos as well as the removal of asbestos from the sites.
- Promoting campaigns of surveillance and inspection of CDW treatment facilities.

The qualitative targets under PEMAR 2023-2025 are:

- Allocate 75% of non-hazardous CDW for reuse, recycling and other recovery operations, including landfilling operations (excluding clean earth and stones).

C. Regional Strategy

Prevention and Management of Waste and Resources of Catalonia in 2020 (*PRECAT20)*

PRECAT20 is a tool provided by the Generalitat de Catalunya to support long-term strategies, plans, and regulations in waste prevention and management. PRECAT20 covers a time horizon until 2020, with a perspective that in 2050, there will be significant advancements in waste management and resource use in the region (Generalitat de Catalunya & Agencia de Residus de Catalunya, n.d.). In combination with the previous waste management programmes of Catalonia, which focuses on the origin of generated waste (e.g. municipal, industrial, and construction), the new PRECAT20 is now based on the material streams of waste, or the flow of waste from its creation/source to its final disposal. The current focus of the new PRECAT20 promotes waste as a resource, provides synergies with the management of different waste streams irrespective of their origin, and overcomes the limits of traditional waste management strategies.

The general objective of PRECAT20 is divided into 10 strategic objectives, each is translated into operational objectives. There are a total of 113 quantitative and qualitative operational objectives. Some of the important objectives for 2020 which can be directly or indirectly to CDW management include a 15% reduction in generated waste compared with the year 2010; 75% recovery of CDWs, and 0% untreated waste to be incinerated or for controlled landfill (Generalitat de Catalunya & Agencia de Residus de Catalunya, n.d.).

D. City Strategy

Barcelona Zero Waste Plan 2021-2027

The Barcelona Zero Waste Plan 2021-2027 is produced by the City Council of Barcelona as a strategic instrument for addressing the challenges and goals in waste prevention and management in the coming years (Ajuntament de Barcelona, 2023). This plan is both the Barcelona Waste Prevention Plan 2012-2020 and the Zero Waste Strategy. The Zero Waste Plan incorporates three pillars such as (1) Reducing and reusing, (2) Fostering the circularlity of products and materials, and (3) Improving and increasing selective collection, with public participation and communication as cross-cutting values. This plan includes both qualitative and quantitative goals. The examples of quantitative goals which could be relevant to CDWs, based on 2019 as reference point and 2027 as the goal year, are the: (a) reduction of municipal waste from the of 1.34 kg/inhabitant/day to 1.17 kg/inhabitant/day, (b) increasing the Municipal waste destined for PfR (preparation for reuse) and reuse from 0,31% to 7%, (c) selective collection from 38.40% to 67%, and (d) a 10% increase in citizen participation (from 2,927,862 participants in 2019 to 3,220,648 participants in 2027. The qualitative goals of Zero Waste Plan include (a) Integrating the zero waste philosophy into municipal waste management; (b) Mitigating the environmental impact and that of the climate emergency, (c) Moving towards the circular economy model, (d) Reducing municipal waste generation, (e) Increasing selective collection and material recovery, and (f) Creating new job opportunities and linking them to social inclusion.

4.2 Current Innovative Practices and Experiments

Various innovative practices in the management of CDW were identified in Barcelona city based on the interviews (Personal communication, June 2023) with stakeholders found in Table 1, as well as on field visits (October 2023). These practices can be classified into four main categories, namely neighborhood greenpoints, recycling of construction materials, selective demolition (inclusion of developer in CDW management), and (Urban) Resource Centers/Reuse Centers/Prototyping hubs.

A. Neighborhood Green points

There are multiple green points in the city of Barcelona. Green points are municipal centres for the selective reception of products for reuse and municipal waste for further treatment as preparation for reuse, recovery and final disposal (BOPB, 2011). They sometimes charge a fee. Due to their limited capacity, the neighbourhood green points and mobile green points are for the exclusive use of private citizens (apart from the area green points). They accept different types of wastes such as earth, stones, rubble, and other CDWs, wood, furniture and other bulky items up to 500 kg. The special wastes that are accepted include paints, batteries, oils, solvents. Bulky waste such as furniture and household appliances are also accepted.

B. Recycling of Construction Materials

Recycling is the process by which materials from CDWs are used to obtain a recoverable product that is suitable for reuse as material. For example, stone materials are reintroduced into the production cycle through crushing and screening processes. There are also several Rubble Recycling Plants in Barcelona, which focus on recycling of materials aggregate. The recycled aggregates are used directly in the construction of civil works, foundations for roads or paths and public works by the municipality (Interviewee 1). Furthermore, the aggregate that comes out of the concrete is 100% recycled concrete aggregate (only concrete), and the demand for this pure type of aggregate is increasing. Many people recycle concrete on-site (separating it from all the other materials) and take it to a plant that makes recycled concrete aggregate exclusively. This concrete comes from factory and construction site waste. The generated aggregate tends to be of higher quality (Interviewee 5).

C. Inclusion of Developer in CDW management

According to Interviewee 2 (Personal Interview, 2023), the developer of a contruction project is currently involved in the management of construction waste at the beginning phase. In the past, the developer was not responsible for waste management. The old system has the following procedure: The developer contracts a builder, who then contracts a transporter, while the latter dumps waste uncontrollably. However, this system has changed nowadays. The developer has to go to the administration/town hall to ask for a building permit. At this point, it is compulsory to bring a signed contract from an authorised waste manager, plus to pay a deposit. The developer specifically tells the builder where to take the waste and to which waste manager (with whom the contract has been made beforehand) has to deliver it. The builder then passes on the same information to the transporter. In this way, the model manages to eradicate uncontrolled waste management.

D. Presence of many "Urban Resource Centres", Reuse centers, and Prototyping Hubs

There are a number of "URCs" sort of model in Barcelona city that have been identified during the interviews (June 2023) and that have been observed during field visit (October 2023). These URCs vary in terms of their sizes, operations, and management. In general, the URCs serve multiple purposes (being one or in combination of the following): (1) a reuse center, (2) prototyping hub, (3) working space for repairing and doing creative ideas or designs, (4) recycling center with second hand shop, and (5) inclusion of environmental and social activities in its operation. The management of the URCs can be in partnership with the municipality, an association of indvididuals, or private-led. Some of the examples are as follow:

- *Banc de Recursos (Resources Bank)* – It takes care of emptying flats and doing small repairs to prevent waste, among other things, and then they sell what they have repaired. In the Library of Things, they rent it. (Interviewee 7)"

- *Donation Room project* – It is currently not operational, but it was about the fairs and congresses in Barcelona. All the materials that were used were sent to the Nau Vila Besòs, which is where the Donation Room project was “located”, and through there they were then chanenelled. This project is run by city council. (Interviewee 7)
- *Viladecans Collection Point* – This has a large space for the preparation for reuse and for selling the materials. It’s in the metropolitan area of Barcelona and the entity that manages it is called Solidança, a social economy and social-labour management entity (Interviewee 7). In this collection point you can find the recycling center of the region where people bring waste items in containers, which are collected, sorted, processed and upcycled. This center is supported by the Catalan Waste Agency. The citizens are also active actors in this model since they get involved with repair workshops, capacity building, and education within the space of recycling centers. There are some volunteers that teach people to learn things, such as repairing. Despite being a private entity, this initiative gets the contract from the municipality, and they have the vision of repair, manufacturing and social aspects. There is also a second hand shop within the recycling center that offers products that are directly repaired or materials that are brough from recycling center. Interestingly, there are programs related to local gardening, bio cycling and the use of organic waste. Other sources of income generation are renting toys for parties, such as birthdays (Field visit, October 2023)
- *Ateneu de la Fabrica del Sol* – It is an idea generation hub for individuals, entrepreneurs, students, etc. to develop their prototype or first trial of their idea. The hub focuses on small-scale innovation to upcycle wastes materials such as plastics, boards, etc. The Fabrica del Sol works with the support from the municipality of Barcelona. It also includes social activities such as teaching kids and creating projects for social schools (Field visit, October 2023).
- *TransfoLab* – It is an initiative (with physical space) that focuses on upcycling wastes that are collected from individuals or households and that are dumped from streets. It offers space for individual members (for a fee), courses and workshops, upcycling or doing things by hand, (Field visit, October 2023)
- *Troc shop* (2nd hand store) – This store is the first European chain franchise of second hand items. The sources of the second hand item are a mixed of industrial and private sources. For individuals, workers of the store visit home to do the valuation of individuals’ items and transport them to the shop. The business model is to get 50% of the earnings for sold items in the first month. If the item is not sold during the 2nd month of stays in the shop, individuals are allowed to get them for free (Field visit, October 2023).
- *22@ (Scrap Store)* – It collects materials that are put on display for selling, while at the same time allowing citizens, schools, and individuals in general to subscribe in the store for a small fee, in order for them to buy the displayed items and use them. In addition, this store offers space for small entities related to reusing. Within the 22@, there are many entities that are interested in determining value for reuse, while the

store also wanted to offer conferences and events related to the transfer of knowledge and circular economy (Interviewee 10).

Overall, there are lots of initiatives for collecting waste, but these are not centralised yet according to Interviewee 13. There are around 70 networks of reuse centers (associated with collection points) in Catalonia. In the case of Barcelona, there is already the association of centers for the reuse of Catalonia, which was established this year. There are many entities that are working on this line, focused on different types of materials and that they want to do this kind of construction and set up a second hand shop in that area for the industry of the construction (Interviewee 4).

4.3 Barriers and Enablers

Several barriers and enablers were identified from the interviews and reports. Tables 2 and 3 summarize the lists of barriers and enablers, including the specific examples obtained from interviews and the sources of information, respectively.

Table 2 Lists of barriers for a more circular management of CDW in Barcelona city.

Barriers	**Examples according to interviews**
1. *Stringent regulation in the use of recycled aggregates limit the recycling rate of this material.*	Spain is quite restrictive in terms of the use of recycled aggregate on construction sites and has put up additional barriers to European regulations, which means that in practice, especially for civil works, only concrete waste is being used. [Interviewee 1] The minimum percentage of 5% use of recycled aggregate does not exist in any other city in Spain, but only in Catalonia. Concrete aggregate is the most regulated because, traditionally, it has been used the most and has the highest quality. However, it is the least produced. Mixed aggregate is the one that is mostly produced and is not regulated. [Interviewee 2]
2. *Illegal dumping of waste.*	There are containers where everything has been dumped on the street. This happens sometimes because there is no space on site. [Interviewee 2]
3. *Market and standards for second hand material do not exist.*	A market for second hand construction waste doesn't exist. And if it did exist, an important issue would be whether the second hand/recycled material will actually meet the necessary quality standards. [Interviewee 4]
4. *The contamination levels in CDWs are high, making the recovery and recyclability rate lower.*	Spain does not face issues with treating particular waste sources (concrete, bricks, glass, etc.) although it was generally communicated by interviewed stakeholders that despite lower record levels of generated CDW since the economic recession in

	2008, the contamination levels in incoming CDW are a main barrier for further recovery and recyclability of materials itself. [Interviewee 4]
5. *Costs of recovering wastes is high.*	The costs per tonne (of recovered material) are very high; for example, recovering 10 tonnes of plastic costs 1,000 euros. In addition, due to regulations/laws, certain processes are more expensive, i.e., the cost of leaving waste at Collection Points is more expensive than reverse logistics. [Interviewee 9] Opportunity cost is very high for start-up company that wants to recover wastes. These are usually small companies that cannot afford this cost. [Interviewee 9]
6. *There is a problem of the scale of waste to be repaired and reused.*	A waste consortium in Mataró has bought the industrial land next to the waste treatment facilities to promote what they call the circular park. The idea is that different repair and reuse companies will be located around it to create a "hub" of Circular Economy. The project is now at a standstill because archaeological remains have been found when the land was cleared. They are also having a hard time attracting companies to set up because it's about a problem of scale. [Interviewees 9]
7. *Subsidies are mostly for study and not for physical space.*	The subsidies received [for CD waste management] finance more the study and not the physical space. When the city council has been asked to collaborate in giving some space [for companies], the space that was given required renovation, and therefore investment. [Interviewee 10]

Source: Interviews July 2023

Table 3 The lists of enablers for a more circular management of CDW in Barcelona city.

Enablers	**Examples according to interviews**
1. *Presence of multiple recycling plants increases recycling rate of CDW.*	There are almost a hundred plants of different sizes that are dedicated to managing this type [CDW] of debris. [Interviewee 1]
2. *Provision of subsidies by local administrations*	Once a year, the Waste Agency issues subsidies for local administrations that use recycled aggregates on construction sites. The material, the transport and part of the work are subsidised. This saves part of the costs by using recycled aggregates while encouraging recycling at the same time. [Interviewee 2]

	The Generalitat is offering a subsidy for individuals and private individuals of 40 million euros every year. This is to help and subsidise asbestos removal since this is not well manage. [Interviewee 2]
3. *There are legislative measures promote proper management of CDWs (e.g. recycling, traceability)*	A new regulation obliges all construction works (public and private) to incorporate at least 5 % recycled aggregate of the total construction site. This forces company to improve the recycling of aggregates and use them as materials for construction. In the new regulation, the use of recycled aggregate is published, where the different types of recycled, ceramic, mixed aggregates, etc. are listed, together with the different uses that each type of aggregate can have. [Interviewee 2] There is a new law that came out, which is the law 72, 2022, which is reassessed in the European context. This law revalues, at least, seventy percent of the waste that is generated on construction sites. It requires traceability on all of this. [Interviewee 4] It is compulsory for every construction site to use 5% recycled material. [Interviewee 5]
4. *There is a fee for dumping construction waste.*	To promote recycling that began in 2010, a fee was introduced for the dumping of construction waste. There is also an additional fee on a part of the fee (charged by the manager) for all the material that goes to the dumps. This additional fee is collected by us as taxable parties, and in the administration is collected by the managers, but on a quarterly basis, we send these economic resources to the competent authority, which is the Waste Agency." [Interviewee 2]
5. *There are several platforms or softwares that could support the management of CDWs [e.g. traceability, life cycle analysis].*	"Cocircular developed their own software for traceability of the waste. This makes it much simpler, because from the worksite everything has to be done via software – from ordering the containers up to creating the report of everything that has been generated in the process. [Interviewee 4] There is already softwares and tools dedicated to analyzing the whole life cycle analysis of the materials, as well as for addressing the issue of circularity. For example, for life cycle analysis, it is possible to find all the measurements of components, materials and others. The circularity parts, however, have not been advancely incorporated yet. [Interviewee 4]
6. *There is a common methodology (called levels) of*	A European methodology based on levels is a common framework for measuring sustainability. This was developed by

construction (design and development).	the European Commission to create a standard or criteria for the construction sector. It consists of sixteen indicators that are developed and that can also be implemented at different levels. Level one is conceptual level; level two is for project development and construction; and level three is like a measurement at the level of use of construction. [Interviewee 4]
7. *There are several initiatives existing for management of CDWs*	There are people, such as independent ones and architects, who are (in the process of) creating urban resource centre (in Barcelona) including a website to communicate to wider people the function of the center. [Interviewee 7] For many years, there has been existing (resource) centers in Catalonia, such as La Bolsa de Subproductos (The by-products exchange). This has been managed jointly with the Chamber of Commerce and has now been reconverted into a website called Residuo Recurso (Waste Resource), where products that can be used to make other products are bought and sold. [Interviewee 9]

Source: Interviews July 2023

4.4 CURE+ Urban Resource Center (URC) Initiative

Design of URC in Barcelona City

Based on the outcome of interviews, field visits, and validation workshop among stakeholders in Barcelona city, there are already a number of initiatives that are synonymous to the concept of URCs. The management of these initiatives range from being publicly owned, public-private partnership, and privately owned by individuals or groups of individuals. Some operate on a small-scale while others are on a large scale, such as the Viladecans collection point at the outskirt of Barcelona city.

An opportunity for establishing a URC is via a small-scale pilot to be led by one of the project partners of CURE+, namely Elisava institute (see Figure 2). The idea is that Elisava harnesses the use of platform and creativity or innovation within the institute to connect household wastes to public as well as private companies. In terms of the platform, Elisava will make a register of the material waste that is generated from the households, which still have possible reuse. It will be distributed to different locations and labs. The platform will include information such as where the materials are generated, the location of the materials, and where people can see and access them. This material waste will be made available to the public who are interested in these kinds of materials, as well as to other companies that offer the same kind of industrial waste. The inventory management will be done by students and the location of inventory will be within the school premises. In addition, since Elisava is

known for technical designs, outputs generated via workshops and in-class projects will be made visible to public via various school events such as exhibitions and open days. This could encourage citizen engagement, while allowing public to participate in co-designing events, and to link different actors to the projects both inside and outside Elisava. Since the initiative is rooted locally, it could generate supports from local citizens.

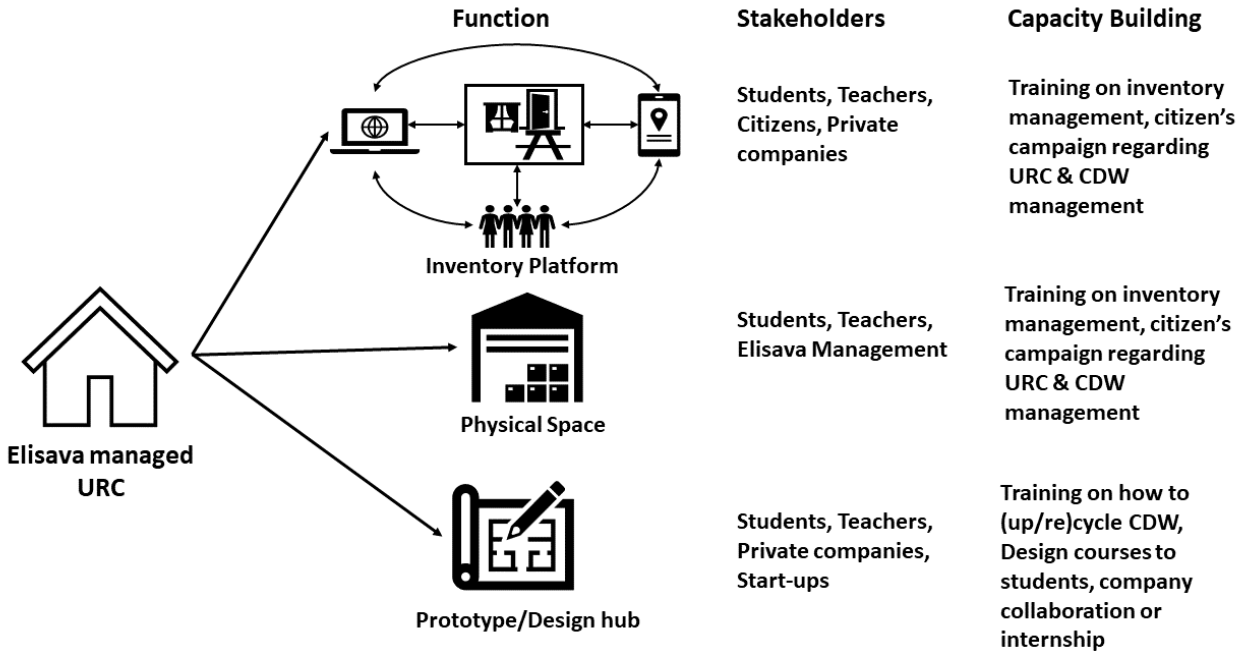

Figure 2 Possible Design of URC in Barcelona City.

Managing operations of the URC

The future URC will be privately owned and led by Elisava, with participation from the public such as students, teachers, citizens, and companies. The space for housing inventory will also be offered by Elisava. All the activities, such as inventory system management and services will be part of the labs of the school. The sources of funding for various activities could be linked to grants or projects that are generated.

Since the idea of URC is a pilot, it needs to prove first that it is working in the short-term. In order for the URC to sustain its operation in the long-term, business model(s) that will show how each stakeholder can benefit from the operation of URC should be developed. The initial ideas for possible business model, which could be adapted or modified on the actual implementation, are as follows:

(1) The operations within the URCs will be part of school activities and therefore will not require costs. For instance, inventory management could be linked to a course of school. Events that will be organized by Elisava will be free for the public.

(2) The URC activities could be linked to various grant applications that involve companies to prototype new designs and to experiment the quality of secondary materials out of CDWs and other types of household wastes. This will ensure the financing of research and development in relation to upcycling CDWs.

(3) The catalog of inventories that are initially offered to companies could become a source of income generating activity once the supply gets established. In this case, citizens must be more aware of where they can leave their CDWs as well as the other types of waste (such as bulky waste).

5. Recommendations

To make the idea of URC feasible, the following set of recommendations are formulated for capacity building of stakeholders as well as for policy makers.

In terms of capacity building:

(1) A comparative study is needed to analyze and compare the different business model(s) that could kick-off the operation of URC in Elisava. The comparative analysis will include the different possibility for reusing items, how to organize or inventorized items, how to facilitate the process, and how to operate the URC. The comparative study could be conducted by students as part of their output.
(2) Next is to provide training to students on how to do inventory management and make the inventory system operational. The training could be provided by Elisava itself, or as part of the CURE+ projects' capacity building activity, since the other three cities are also operating platforms for their selected city.

(3) Third is to organize sessions or courses that will educate students, teachers, companies, and citizens, on how to upcycle their waste.
(4) Promote awareness raising campaigns related to CDW management via school events, open days, classes, or exhibitions that are open to the public or citizens.
(5) Collaboration with companies (recycling, waste management, etc.) to research or experiment how CDWs can be better managed, recycled, and upcycled.

For policymakers, the set of recommendations are as follows:

(1) Provide a loan, subsidy, or grants for successful CDW designs or prototypes that need scaling in the institute.
(2) The municipality can give permission on designs made of CDWs that have aesthetic value, to be placed in public spaces as part of citizens exposure and creating awareness.

(3) Make it mandatory through policies and procurement of new (public) projects that both design in education and in new projects not only use recycled materials but are also recyclable by design. For example, new buildings as well as teaching of how buildings should be designed should incorporate design principles suchas modularity and and infinitely reusable materials (e.g. alliminium).

6. References

Agencia de Residus de Catalunya, n.d. Construction waste and demolition. https://residus.gencat.cat/en/ambits_dactuacio/tipus_de_residu/runes_i_altres_residus_de_la_construccio/ [accessed: 8 March 2024].

Agencia de Residus de Catalunya, 2023. Waste Documentation System – (Systema Documental de Residuos). Language in Catalan, translate to English [28 June 2023].

Ajuntament de Barcelona, n.d. Installació per a la gestió de residus a catalunya. Language in Catalan, translated to English [June 28, 2023].

Ajuntament de Barcelona, 2023. Barcelona Zero Waste Plan 2021-2027. Link: https://ajuntament.barcelona.cat/neteja-i-residus/en/presentation/waste/zero-waste-plan [Accessed date: 8 March 2024]

Barcelona City Council (Ajuntament de Barcelona), 2022. Barcelona in Figures 2021/2022 – Main Economic Indicators for Barcelona área. <Link: https://www.barcelona.cat/internationalwelcome/sites/default/files/DATA_SHEET_2022_ang_doblepag_2.pdf> [Accessed: 8 March 2024].

Bulletí Oficial de la Província de Barcelona (BOPB). 2011. Ordenança Municipal de Medi Ambient de Barcelona de 2 de maig de 2011 (TÍTOL 6. GESTIÓ DE RESIDUS. Language in Catalan, translated in English, p. 1-193. <July 2, 2023>. Doi: http://hdl.handle.net/11703/86859

European Climate Initiative (EUKI), 2017. German Federal Ministry for Economic Affairs and Climate Action. About EUKI. https://www.euki.de/en/more-about-euki/

European Commission (EC), 2015a, The European Economic and Social Committee and the Committee of the Regions — Closing the loop — An EU action plan for the Circular Economy (COM(2015) 614/2 of 2 December 2015), European Commission, Brussels, Belgium.

European Commission (EC), 2015b. Construction and Demolition Waste management in Estonia. Final report. European Union, Brussels, Belgium.

European Commission (EC), 2008. Construction and demolition waste. https://environment.ec.europa.eu/topics/waste-and-recycling/construction-and-demolition-waste_en [accessed: 21 December 2023]

European Environment Agency (EEA), 2020, Eionet Report - Construction and Demolition Waste: challenges and opportunities in a circular economy. European Topic Centre Waste and Materials in a Green Economy.

European Commission (EC), 2023. Right to repair: Commission introduces new consumer rights for easy and attractive repairs.

https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1794 [accessed: 27 March 2024]

European Union Law (EUL), 2024, Directive 2008/98 EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)Text with EEA relevance. https://eur-lex.europa.eu/eli/dir/2008/98/2024-02-18 [Accessed: 27 March 2024]

Ellen MacArthur Foundation (EMF), 2015, Towards a circular economy: business rationale for an accelerated transition, Ellen MacArthur Foundation, London, UK. Eionet Report - ETC/WMGE 2020/1 50 https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Ellen-MacArthurFoundation_26-Nov-2015.pdf [accessed 20 November]

Galvez-Martos, J.-L., Styles, D., Schoenberger, H., Zeschmar-Lahle, B., 2018. Construction and demolition waste best management practice in Europe. Resources, Conservation and Recycling Volume 136, September 2018, Pages 166-178. https://doi.org/10.1016/j.resconrec.2018.04.016

Generalitat de Catalunya & Agencia de residus de Catalunya. 2020. *General programme of prevention and management of waste and resources of Catalonia PRECAT20*. 2020 Residus Recursus.

Marquez, A. 2021. Reincarnation construction materials for a circular economy. Elisava, Barcelona Spain. Master Thesis.

Ministerio de Agricultura, Alimentación y Medio Ambiente (Ministry of Agriculture, Food and Environment). 2016. *Plan Estatal Marco de Gestión de Residuos (PEMAR) 2016-2022.* *https://www.miteco.gob.es/content/dam/miteco/es/calidad-y-evaluacion-ambiental/planes-y-estrategias/pemaraprobado6noviembrecondae_tcm30-170428.pdf*

Ministerio de Medio Ambiente (Ministry of Environment). 2007. *2007-2015 Plan Nacional Integrado De Residuos (PNIR)*. http://www.icog.es/files/PNIR3.pdf [accessed 8 April 2024].

Ministerio para la Transición Ecológica y el Reto Demográfico (Ministry for Ecological Transition and Demographic Challenge) (MITECO). CEDEX Catalogue of usable waste in construction. los-residuos-de-construccion-y-demolicion-rcd.

Ministerio para la Transición Ecológica y el Reto Demográfico (Ministry for Ecological Transition and Demographic Challenge). 2023. *Versión Inicial del Plan Estatal Marco de Gestión de Residuos (PEMAR) 2023-2035*. https://www.miteco.gob.es/content/dam/miteco/es/calidad-y-evaluacion-ambiental/participacion-publica/sgecocir/230705%20nuevo%20PEMAR_IP_Revisado.pdf

Río Merino, M. D., Izquierdo Gracia, P., & García Navarro, J. (2005). Use and recycling of construction and demolition waste in Spain (Concrete and Masonry Debris). Doi: https://oa.upm.es/47009/

Spanish Government, 2008. *Real Decreto 105/2008, de 1 de Febrero, por el que se Regula la Producción y Gestión de los Residuos de Construcción y Demolición*; (Royal Decree 105/2008, of February 1, on the Production and Management of Construction and Demolition Waste), Official state bulletin (BOE); Spanish Government: Barcelona, Spain, pp. 7724–7730. http://noticias.juridicas.com/base_datos/Admin/rd105-2008.html#a2.

UNESCO, 2023. Barcelona named UNESCO-UIA World Capital of Architecture for 2026. < https://www.unesco.org/en/articles/barcelona-named-unesco-uia-world-capital-architecture-2026> [accessed: 8 March 2024]

Waste Agency of Catalonia, 2020. Waste Statistics in Catalonia. https://residus.gencat.cat/web/.content/home/lagencia/publicacions/estadistiques/estadistiques_2020_en.pdf [Accessed: 8 March 2024].