

From Demolition to Construction: a comparative review of pioneering Urban Resource Centers

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Abstract

Construction and demolition waste (CDW) is the most important waste stream in the EU in terms of mass, with around 340 million tonnes between 2010 and 2018 (EEA, 2020). Most member states achieved a recovery target of 70% for this fraction, however, it is mainly based on backfilling or downcycling. Materials coming from demolition and renovation work are not often available for reuse or recycling activities, with some noticeable exceptions in the case of some pioneering Urban Resource Centres (URCs). URCs are physical centres that promote the circular economy at local level prioritizing reuse, preparation for reuse, upcycling and remanufacturing activities over material recycling. This is an emerging concept throughout Europe, that has received much policy attention given its potential to help achieve Circular Economy goals set by the European Commission. So far there have been few systematic analyses of URCs, their operation and their impact. The goal of this paper is twofold: 1) to understand how frontrunning URCs currently operate and 2) to derive conclusions/design principles for URCs. This article presents a comparison of nine site visits that allow for the reuse of CDW. The data has been gathered from guided study visits to the different locations, complemented by additional information provided by the managers of the URCs through their yearly reports and follow up conversations. The research took place as part of the project Centers for Urban Resources, Reuse and Remanufacture (Cure+), which aims to establish URC pilots in the four project cities (Riga, Tartu, Kavala and Barcelona).

Introduction

In European Union (EU) CDW is the largest waste stream accounting for 37.5% (374 million tons) of all waste generated (European Environment Agency, 2023; Eurostat, 2023).

Greenhouse gas emissions from material extraction, manufacturing of construction products, as well as construction and renovation of buildings are estimated at 5-12% of total national GHG emissions. Greater material efficiency could save 80% of those emissions¹.

Due to its intense resource usage and negative climate impact, the CDW sector was identified as a priority sector of the European Green Deal and the Circular Economy Action Plan.

¹ https://single-market-economy.ec.europa.eu/industry/sustainability/buildings-and-construction_en

The EU Waste Framework Directive had set a 70% recovery, but currently this target is achieved mostly by low value recovery, such as backfilling, downcycling and recycling (Gálvez-Martos et al., 2018).

Most policies and regulations to promote a CE are on the European (Green Deal) and national levels, but cities play key role in the transition as well. Waste management is typically organised on the urban or regional level, and cities increasingly promote circular construction & demolition through green procurement regulation. Cities can also play an active role in facilitating sustainable, circular consumption and efficient resource management.

CE practices in the CD sector among cities, businesses and citizens are not yet widely adopted. Most practices focus on recycling such as use of CDW for backfilling of roads and recovery via incineration. The challenge for cities is to go higher in the R-ladder such as to refuse, rethink and reduce to have more circular impact. As a rule of thumb, the higher the R-level of circularity with refuse and rethink being the highest, the fewer the natural resources needed and hence less pressure on the environment. Achieving these levels however is challenging for many cities due to several barriers, which are categorized in literature as economic, regulatory/legislation, technical, and behavioural (Mahpour, 2018). Addressing these barriers is key to enhance the adoption of CE practices (Christensen, 2021).

Several studies have studied CE in CD sector and the role of cities. Most focus on the challenges, barriers, and opportunities to adopt CE practices in CDW management (Mahpour, 2018; Menegaki & Damigos, 2018; Negash et al., 2021). Others focus on the adoption of CE as part of policy and business strategies in CD management (Christensen et al., 2022; Esa et al., 2017; Zhang et al., 2022) or study the effect of CE-related policies on CD management (Yu et al., 2022).

A relatively new way for cities to promote the CE is through the establishment of Urban Resource Centres (URCs). URCs are physical centres that promote the circular economy at local level, prioritizing reuse, preparation for reuse, upcycling and remanufacturing activities over material recycling (Partnership on Circular Economy, 2019). Even if URCs are an emerging concept in Europe, some frontrunner examples have been in operation since the 1970s.

The literature on URCs is very limited. One of the rare comparative studies was published by the Partnership on Circular Economy implementation of the Action plan in 2019². They classify a set of 12 case centres according to their functions (economic, social, environmental), their organisational structure (public, private and public-private) and identify barriers and success factors.

So far there have been few systematic analyses of URCs, their operation and their impact. The goal of this paper is twofold: 1) to understand how frontrunning URCs currently operate and 2) to derive conclusions/design principles for URCs.

This paper is a result of the *CURE+ Centres for Urban Resources, Reuse and Remanufacture* project, that was initiated with the ambition of learning from existing URCs to establish four new pilot URCs in two Baltic and two Mediterranean cities (i.e. Riga, Tartu, Kavala and

² https://ec.europa.eu/futurium/sites/futurium/files/classification_of_urban_resource_centres_0.pdf

Barcelona). The project started in December 2022 with a baseline study of the current situation of waste management, focused on Construction and Demolition Waste (CDW) in the four partner cities. In addition to the baseline study, desk research was done to identify existing URCs and other good examples of CDW recovery. Twenty-six example cases were collected by the project team and plotted onto a map to define the two study visits that the project team would do to learn from the best examples. Other than the available information and apparent relevance of each URC identified in the desk research, the selection of the locations to visit also had to take into consideration short distances between sites for each trip, prioritizing locations with several URCs in a reduced area.

This article presents the findings from the visits done to 9 URCs located in the Netherlands, Denmark and Sweden during the CURE+ study visits, concluding with a comparative analysis of the sites.

Framework and Methodology

Two study trips were organized in January and February 2024: the first one to the Netherlands, and the second to Denmark and Sweden. In each country 3 locations were visited. Seven of the nine locations visited allowed for CDW reuse and seven were open to the public.

The study visits were organized to understand how frontrunning URCs operate and derive conclusions, and design principles for future URCs. The project team contacted the selected URCs to schedule guided tours which lasted between 1-3 hours each. Between 11 and 16 people participated as visitors to the different locations, including the project team members, and other stakeholders relevant for material recovery in the partner cities. At each tour, the visitors used a template to take individual notes about the following four topics: Business models / administration, Activities, Materials / Tools, and Challenges. These individual templates were later grouped into collective notes for each visit, that served as the base for the descriptions of each URC in this article. Additional web research was done to collect any missing information, and some clarifications were requested by email to the contacted URCs.

The information collected can be structured as characteristics of each URC, or as characteristics of the material supply or demand for each case (as seen in Figure 1).



Figure 1: URC Framework used to analyse the collected information.

Study Visit Review

This section presents each of the places visited, describing the main aspects of their operations and the main takeaways from each site. Table 1 provides an overview of the visits described in this section.

Holland	Denmark, Copenhagen	Sweden
<p>Hof van Cartesius, Utrecht</p> <p>Circularly built workplace for creatives and sustainable entrepreneurs, that operates as a cooperative.</p> <p>www.hofvancartesius.nl</p>	<p>Verlandsgade Gengbrugstation</p> <p>Recycling Centre with space for direct reuse operated by the municipal company ARC</p> <p>verlandsgade-genbrugsstation</p>	<p>Återbruket, Gothenburg</p> <p>URC focused on construction material, operating at the municipal recycling centre in Alelyckan</p> <p>@aterbruketalelyckan on Insta</p>
<p>De Terugwinning, Woerden</p> <p>“The Recovery” is a Circular Crafts Centre, that works as a social enterprise that reuses waste and trains people with distance to the labour market.</p> <p>www.deterugwinning.nl</p>	<p>Grønne Gengbrugshal, Christiania</p> <p>Independent URC focused on deconstruction run by a cooperative since 1978</p> <p>www.gronnehal.dk</p>	<p>Fixoteket, Gothenburg</p> <p>Neighbourhood reuse and repair centre operated by a housing company</p> <p>@fixotekethammarkullen</p>
<p>Refunk / Maakhaven, the Hague</p> <p>Consultants focused on creative reuse for interior and itinerant architecture</p> <p>refunc.nl</p>	<p>Sydhaven Gengbrugstation</p> <p>Recycling Centre with space for direct reuse operated by the municipal company ARC</p> <p>sydhavn-genbrugscenter</p>	<p>Återbyggdepå, Malmö</p> <p>URC focused on construction material, run in collaboration with the municipal company Sysav</p> <p>www.malmoabd.se</p>

Table 1: Overview of the nine site visits organized in the CURE+ project.

Hof van Cartesius, Utrecht

The Hof van Cartesius, is a circularly built workplace for creative and sustainable entrepreneurs. Some of the entrepreneurs that currently work there started this space, by gaining a public tender to make use of an empty lot next to the Utrecht train tracks. They built the space together, in collaboration with some contractors, using an “agile”, Material Driven Design, construction plan. The results are that 90% of the material used in the construction site were reused from diverse sources, they included biodiversity and rainwater management criteria in the construction, and they managed to use 35% less cement in the foundation given that they allowed it to dry for 3 days. It was a very labour-intensive way of building, depending a lot on the energy, knowledge and desire for experimentation of people involved, that donated their time for free during the building process. They managed to create a showcase

project, that helps to spread awareness of what can be done with waste materials in construction.

The space is currently administrated as a cooperative, where the members rent office space and do part of the maintenance work. The fact that the users must care for their space through maintenance, is a nice habit that is not that common, and might make the space feel exclusive for more “creative/hippie types”. Different companies and entrepreneurs share the space, but they also share the earnings or losses that the collective might have. One of the organizations, can be considered a URC on its own right: Buurman, is a spin off from the work done at the Hof, that sells second hand construction material and teaches citizens to do DIY refurbishment. Unfortunately, Buurman was closed at the time of the visit.

De Terugwinning, Woerden

De Terugwinning is a social enterprise with several legal entities dedicated to the different operations they run. The common feature for all the operations is that they work to recover value from otherwise discarded materials. One of their operations focuses on work relocation and is subsidized for providing people with a distance to the labour market (including refugees) with opportunities to transition back into new employment roles through training in bike, wood or textile workshops. These workshops do tasks for the other operations the social enterprise administrates, mainly: a bicycle repair and maintenance program to provide bikes for for underprivileged children, door remanufacturing, and the reuse and repurposing of discarded textiles.

The business-to-business operations they do are their main source of income. Specifically, for the door remanufacturing, they obtain old doors from deconstruction and renovations, they sort out the good wood that is then returned for door manufacturing, while leftover wood is used to make smaller tables, boards, insect hotels and other elements that they resell to the construction companies that provide them with doors (see Figure 2). They also get paid to collect reusable materials from municipal recycling centres, that they then sort to resell, reuse or repurpose. They collect some furniture, clothes, and other varied household items. Even though they could collect more reusable items from the recycling centres, they do not have the capacity to get rid of much more material than they collect. They have one second hand shop but also collaborate with regular local retailers to sell their products. In total, they have about 350T euros/year turnover, with an estimated 4.3M euro/year impact due to the social and environmental benefits of their operations. They have about 100 people working, with 9 fully paid coaches/production leaders.

They claim that their success relies on looking at what people really need and their possibilities rather than their limitations, not depending on local authorities for their operations, and having three main competence areas: business, social and resource management.



Figure 2: Door remanufacturing process at De Terugwinning. Left, container filled with collected doors. Middle, doors with metal and glass elements removed. Right: Exhibitor of products made from leftover wood from the remanufacturing process.

Refunc at the Maakhaven, The Hague

The Maakhaven is an old Shell building that was renovated with used materials, dividing the interior area to house some 50 companies (mainly SMEs) that rent space to cover the maintenance of the building. It is operated as a foundation, has been running for 15 years, and recently got an indefinite lease of the building.

Refunc is one of the companies that started the Maakhaven and that still operates partially from the space. Refunc is a creative office that reuses discarded materials in temporary constructions and installations, with the aim of challenging preconceptions and fulfilling functions with materials that are readily available in several locations. More than focusing on specific projects or materials, they work with a specific mindset that is relevant as an inspiration to others. They usually use materials temporarily for some function, “borrowing” items that then can go back to their previous use. With this perspective they say, “Everything is a half product” (Refunc, n.d.).

Vermlandsgade Recycling Centre, Copenhagen

The Vermlandsgade Recycling Centre in Copenhagen is a facility operated by the municipal company ARC, it works as a regular recycling centre, with one exception: It features a designated area of approximately 500 m² for materials that can be reused (see Figure 3). Citizens can leave items they no longer need and take whatever they want from the reuse area for free. People are allowed to take as often as they want, but only what they can carry. While individuals benefit from the free exchange of items, companies are charged a fee of around

20 euros per visit to the recycling centre. If companies only donate reusable material they are not charged.

Vermlandsgade was the first recycling centre to test the free reuse area, which has now been implemented in four more centres in Copenhagen. The project of the reuse area has been “over-performing”. Even though they do not count the material that goes in and out, it is considered a success story that they want to expand on and replicate to other sectors.

The centre employs five staff members along with several "Reuse spotters" who assist in organizing the materials and relocating reusable items from the recycling containers to the reuse sector. Reusable items are not considered waste at any moment. They do not repair or test functionalities of the reusable items. They do not put electronics or valuable things for reuse because it generated fights among the users. Given that the reuse of items is for free, it is an expense for the municipality and is financed through the waste tax.



Figure 3: Vermlandsgade reuse area. Top, visitors accessing the reuse are at the recycling center, passing in front of the first section dedicated to smaller household items. Bottom, one of the sections of the reuse area dedicated to furniture.

Grønne Genbrugshal, Christiania Copenhagen

Grønne Genbrugshal is a cooperative with eight members, featuring a balanced 50/50 gender distribution. Established in 1971, the cooperative originally consisted of a group of women who focused on deconstruction, collecting materials from Copenhagen to support the Christiania community. Today, Grønne Genbrugshal continues to operate, open to customers from outside Christiania since 2011, covering its running costs, wages, and maintenance, while also making donations to social organizations (see Figure 4).



Figure 4: Grønne Genbrugshal interior. Top, project team during the site visit in the hall.

The cooperative works doing demolitions to get materials, that they then sell at 50% of the price of new materials. To make the business more profitable they also sell new items, that are necessary for construction (such as tools, work gear, hardware, etc). Their "Reuse hall" boasts some 20-30.000 different items, that are not inventoried. Being one of the oldest URCs, they see that the demand for reused materials has gone up in the last 10-15 years and that clients appreciate quality and special materials. Even their local is special, the hall is in a wooden horse training space that was built in 1847, with no indoor columns, that is protected cultural heritage.

This organization is very site and time specific, making it quite difficult to replicate. It has always had the focus of serving their direct community, and the strong ideology with which it started is still a crucial part of their governance model, always reaching a consensus. They remain a vital part of the Christiania community.

Sydhaven Gengbrugstation, Copenhagen

Sydhaven Gengbrugstation in Copenhagen is a flagship recycling centre project, with an investment of approximately 10 million euros. The circular construction of the recycling container area allows visitors to easily access the different fractions by vehicle, and the main building houses a workshop, storage for reuse, and an educational space (as seen in Figure 5). It is one of the recycling centres in Copenhagen that allows for free reuse. Initially, the centre was expected to generate 10,000 euros in sales per year, it reached only half of that target during the first years and after a change in the Danish regulation, they no longer sell materials. The change in regulation since the centre was established until now, has made them have to reevaluate their objectives and performance indicators, leaving the centre managers uncertain about what they are allowed to do. Despite this, the facility continues to monitor material flows, counting them in kilograms twice a year, while also tracking the number of visiting cars daily.

The resources available at the centre include ample space, a variety of reusable materials, and facilitation in the form of tools. Their flexible reuse area can be re-furnished and adapted depending on what they would want to use it for. Management hopes to use the space for local communities and create a supportive network, which could help boost material reuse and community engagement. They would like to bring in Upcycling entrepreneurs and organize an incubator program, but that is yet to be developed.

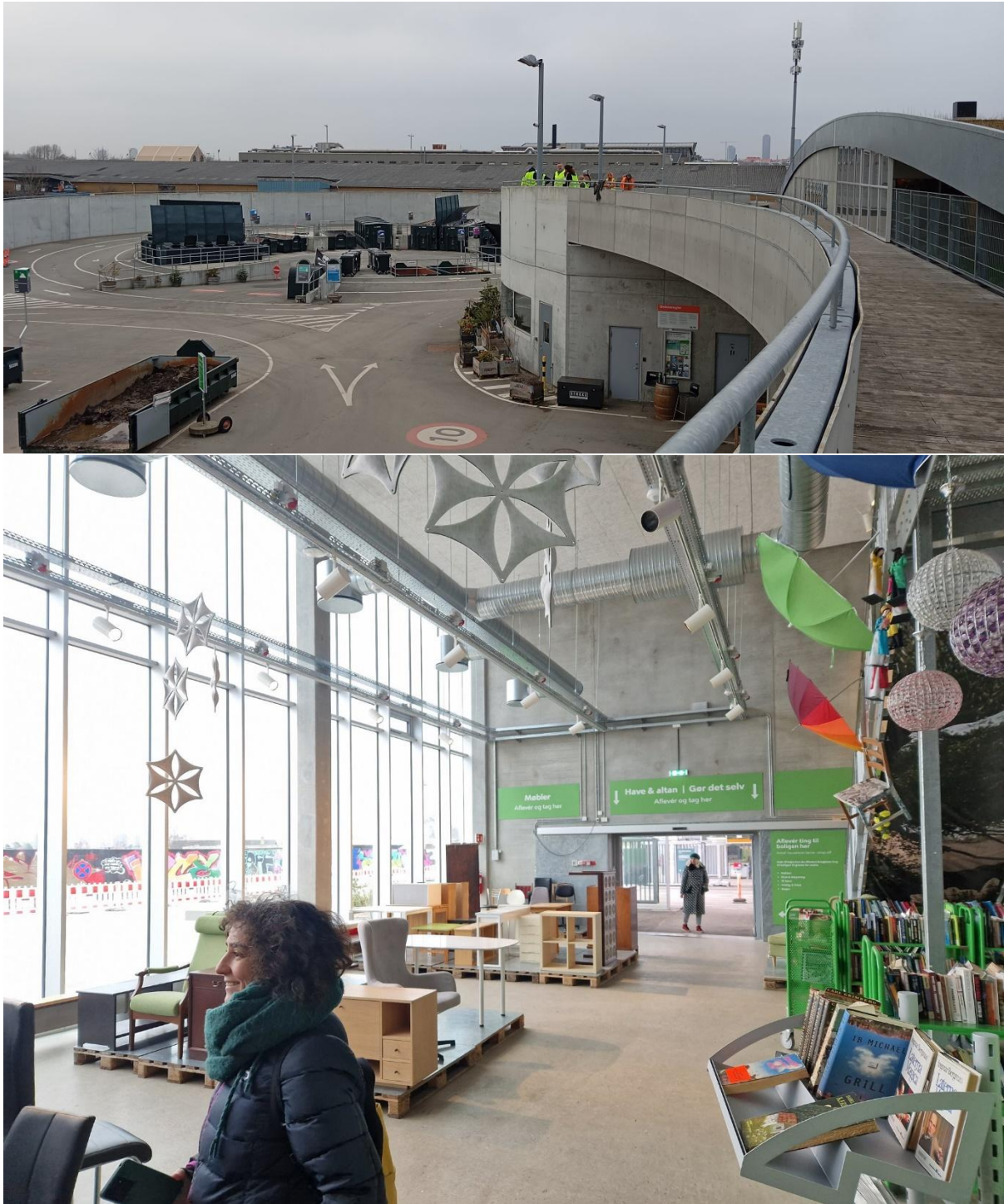


Figure 5: Sydhaven Gengbrugstation. Top, exterior showing the drive through area with the recycling containers, next to the main building. Bottom, flexible reuse area in the interior of the main building.

Återbruket, Alelyckan Göteborg

Återbruket, located at the Recycling Centre Alelyckan in Gothenburg, is a URC that mainly focuses on selling construction materials. The operation sources materials from 15 different recycling centres and is self-sustained economically, covering salaries and rent through its own revenue. The project breaks even each year, allowing it to reinvest any profits back into its

operations. It has had stable income and growth since it opened. The team consists of one person responsible for overseeing operations, seven salespeople, one individual managing the garden and workshop, and three to four "waste stoppers" who help collect and manage reusable materials.

Materials are sold between 30-50% of the new market price. Besides collecting materials from recycling centres around the Gothenburg area, big construction companies donate reusable material, to reduce their waste management fees. Recently, five big companies started requesting them to weigh the donated material for them to report it as diverted for reuse. Återbruket does not have an online shop but has an active presence on Instagram. The staff does not do repairs on items, but they do clean and test electronics, white goods and used toilets. Their inventories and data systems are all done in a haste, but they register all sales using broad categories, being "Miscellaneous" the most used one. Since 2022 they weigh everything that comes in. They discard 7-8% of what they bring in. Their best-selling items include doors, windows, toilets, and white goods, while they try to avoid window blinds, office furniture and partitions (Figure 6).



Figure 6: Backstage area at the Återbruket URC. Top, area for storage and organization of the materials brought from other recycling centres or by construction companies. Bottom, toilets and water basins waiting to be tested.

Fixotekets, Göteborg

Fixotekets are public meeting places for reuse, repair and waste collection, aimed at serving neighbours in residential areas. The name is a Swedish play on words combining fixing and libraries. A project led by the City of Gothenburg during 2017-2019 tested establishing 4 Fixotekets in different areas to see if such spaces could: increase waste collection for recycling and treatment, increase the reuse of gadgets and materials and raise awareness regarding sustainable consumption, reduce littering, and create employment and well-being through local meeting places. The places were located at floor level, in residential areas, and counted with spaces to: donate and pick up clothes, toys and other household items; lend tools for home improvement; fix bicycles; mend clothes and do other community activities.

The two-year project evaluated the performance of these places, finding that for the users of these spaces, the Fixotekets raised awareness of resource conservation and waste management. In total, 5.7 tons of materials were collected for reuse at the swap corner, which was the most popular part of the activity, with 25% of visitors. The mini recycling centre collected 1.3 tons of waste for recycling and treatment, which is low compared to the total amount of waste generated in the areas. However, it was not possible to determine whether the total quantities of materials for reuse, recycling and treatment increased collection, or shifted materials between different collection options. User surveys made it evident that the neighbours appreciated the social interactions that were made possible in these spaces, providing a social hang for many, contributing to a sense of connectedness and wellbeing for some users. Some of the Fixotekets were particularly popular with the kids of the neighbourhood, which was sometimes challenging.

After the project concluded, 3 of the 4 Fixotekets continued working, after a redefinition period. Two of these are currently maintained by the housing company that provided the space, because they consider that it is a beneficial service to provide to the residents of their buildings. The third one was the Fixoteket that had most volunteer organization involvement and continues to be kept open by volunteers in agreement with the space provider.

Återbyggdepå, Malmö

Återbyggdepå in Malmö is a URC primarily focused on construction materials. The centre collects reusable materials from eight recycling centres across the Skåne region. It was established in 1996 when the municipality deconstructed a hospital building and chose to store the material. The crisis in 1996 motivated decision-makers to undertake such an ambitious project and involve manual work in the selective dismantling of the hospital in order to reuse construction materials. It was also a political ambition at the time, given that there was high unemployment. Later it was officially inaugurated in 1998, growing organically, initially storing mainly bricks, doors and other construction elements.

Återbyggdepå operates with a dedicated team of five full-time employees, along with eight to ten part-time "social" workers who assist in various roles. The facility spans an impressive 2,000 square meters indoors, with an additional similar-sized outdoor area, providing ample

space for material storage, sorting, and reuse (see Figure 7). They do little repair but would like to increase that in the future. They check the functionality of windows, doors and some electronics, but do not provide guarantee on the items. They have a waste management license, being it a site where waste is prepared for reuse, changing its status through revalorization.

The amount of materials collected by Återbyggdepå has been constantly rising, handling 1300 tons of different material in 2023. If things are in good condition they sell quickly, at roughly 50% of the new price. If things are more worn the price is about 30-25% of the new price.

Construction companies have to pay for waste treatment and report the amount of waste they generate per construction project. Alternatively, they can bring their residues directly to Återbyggdepå for free if it is dismantled correctly, that waste reduction through reuse also gives them bonus points in public procurement processes. Some construction companies sometimes also buy materials from them.

Other cities have tried to replicate the model, but they sometimes go over the top, investing too much and never get the money back. Rather than letting the project grow organically. According to their experience, URCs such as theirs take a long time to set up, because you need the whole picture: clients, providers, construction companies, etc.



Figure 7: Återbyggdepå. Top, area for windows, doors, and other office furniture. Middle, front outdoor area with ceramic roof tiles and fire wood sacks in the background. Bottom, area for smaller items such as door handles, diverse hardware and tools.

Cross-case analysis

Reviewing the different locations visited, most reused CDW, with Fixoteket being the exception focusing only on clothes and other household items. Given the characteristics of the ways that these URCs have of operating we can describe five typologies of URCs:

- Remanufacturer: focused on repurposing and/or remanufacturing the materials obtained to create new products or materials that can be sold. Such activities require production capabilities and to train staff in the specific production, maintenance or repair processes they develop. De Terugwinning represents this typology.
- Recycling Centres “plus”: Municipal recycling centres, that allocate a space to deposit reusable materials, that can then be taken by other users. These spaces do not necessarily register the reused items and might have different limitations to the number of items each user can take each time. In the case of the Danish Recycling Centres, users are allowed to take reusable materials free of charge, while Återbruket catalogues and sells reusable materials.
- CDW Resellers: These URCs resell material from construction and demolition sites. They can combine a mix of new tools and materials, to make it more convenient for the customers, but focus on reselling materials with little to no interventions. The staff is dedicated to receiving the material and preparing it for reuse, often checking functionalities, but performing very limited repairs on the items. Buurman (one of the companies located at Hof van Cartesius), Grønne Genbrugshal, Återbruket and Återbyggdepå represent this typology.
- Residential reuse and repair spaces: Are URCs aimed at reusing common household items and clothing. They are smaller in size, located near residential areas, and thought as a swapping spot for neighbours, that can also engage in some repair and/or social activities. Fixoteket represents this typology.
- Demonstrator: a building made or refurbished making use of CDW. These spaces help demonstrate the possibilities of reusing CDW and help raise awareness of the wastefulness of the current linear construction systems. Hof van Cartesius, Refunc/maakhaven and houses built in Christiania using materials from the Grønne Genbrugshal are in this typology.

Buurman at Hof van Cartesius and Refunc at the Maakhaven are special cases that serve as inspiration but do not entirely fit the URC definition. Hof van Cartesius is a flagship project that developed a business district built with reused CDW and other types of discarded materials, demonstrating that large constructions can be done with CDW. From that experience the spinn-off Buurman facilitates CDW reuse, and as such can be considered a URC. However, the Hof van Cartesius is not a URC, but rather a circular business district. The Maakhaven was also built using CDW for the interior renovation of the space, while Refunc works by providing examples of how to use commonly available materials to solve different functions. Refunc’s work, documented through their extensive online catalogue (Refunc, n.d.), is proof that good results can be obtained by reusing available material, but they are rather a creative studio that stores reusable material for their own purposes, rather than a URC open to public. Table 2 provides an overview of key aspect of all the URCs visited.

Name	City	CDW	Open to public	Organization	Typology
Grønne Gengbrugshal	CPH	Sell for reuse	Yes	Cooperative	CDW Reseller
Sydhavn recycling centre	CPH	Allow reuse	Yes	Municipal organization	RC with reuse area
Vermlandsgade recycling centre	CPH	Allow reuse	Yes	Municipal organization	RC with reuse area
Återbruket	GBG	Sell for reuse	Yes	Municipal organization	RC with reuse area CDW Reseller
Fixoteket	GBG	No	Yes	Private or volunteer	Residential reuse And repair spaces
Malmö Återbyggdepå	Malmö	Sell for reuse	Yes	Municipal organization	CDW Reseller
De Terugwinning	WDN	Doors mainly	Not all areas	Private	Remanufacturer and Repair organization
Hof van Cartesius	Utrecht	Sell for reuse Built with CDW	Yes	Cooperative	Circular business district, built with reused CDW
Refunc / Maakhaven	The Hague	Use in projects Renovated with CDW	No	Private	Repurpose creative studio, building renovated with CDW

Table 2: Overview of the sites visited, considering if they have CDW, how they are open to public, what type of workforce they have and which of the described typologies they represent.

The typology Recycling centres with reuse spaces, has two modalities: One where visitors can take reusable material for free, and another where the material is sold to customers. Both modalities work, however, the reseller URCs can finance their operations, while the free reuse areas must be financed through the waste tax (in the Danish case). The free reuse areas do not register the amounts of materials that go through the system, so it is difficult to argue what mode has higher material recirculation.

Most URCs employ subsidised workforce, providing skill training for people distant to the labour market. This has evident social benefits but also reduces their operating costs. De Terugwinning also trains subsidised workers and in addition have some operations that are aimed at poverty reduction (e.g. donating used clothes in good condition to charity, provide bike leasing for vulnerable children).

URCs help save waste management costs to municipalities given that they reduce municipal waste volumes while providing employment and training. However, the costs of running URCs remain to be compared to the waste management costs avoided. Additionally, URCs offer material that is 30-50% cheaper than their virgin counterpart, making these products more accessible to the public.

Most URCs struggle to keep an adequate inventory, due to nature of the work at URCs, the sheer variety of items reused, the lack of standardised information about items and sometimes due to a lack of commercial mindset and competencies. In the case of the free reuse areas in the Danish recycling centres there is no moment that would allow registering reused materials, since materials can come in and out mostly unsupervised. All the URCs that sell material do however keep a rough registry of what comes in and what goes out, mainly unaware of their detailed stock. Usually, broad product categories are used when registering sales, making it nearly impossible to do accurate environmental impact estimations. Some URCs do have yearly reports and statistics, and if environmental or social impacts are assessed they are done by sampling moments of operations, rather than through continuous monitoring of their operations.

Material Supply

Regarding the supply of materials, the URCs that focus on CDW normally work with demolition teams (e.g. Grønne Genbrugshal), or construction companies that dismantle existing buildings to help generate high-quality supply of materials. Construction companies interested in supplying reusable materials are motivated to do so by sustainability demands from their clients, as for example through Green Public Procurement protocols. This in turn, requires professionalisation from the URC, to provide for example a certification of reception of material, that would weigh or somehow count the supply from each provider.

The recycling centres that allow for reuse require a smart selection mechanism to obtain an adequate supply from citizens, normally having some staff to help categorize and select the reusable items (e.g. Vermlandsgade).

Both Återbruket and Återbyggdepå, organise logistics from smaller waste stations to a central larger one, that acts as the concentrated selling point for reusable construction material. In this way, they aggregate the reusable material generating a larger centralized offer.

Material Demand

The demand for materials can be hyper local, as the case for the Danish recycling centres and the Fixotekets who attract mostly neighbours to their sites, or regional, as in the case of Återbruket and Återbyggdepå, that concentrate the CDW from several recycling centres in their regions.

URC clients include both companies and professionals, to citizens engaged smaller DIY projects. In the case of De Terugwinning, most of their operations are financed through B2B collaborations, whereas the large CDW Resellers attract clients of all types.

One of the main problems in reusing CDW for new construction is the quality assurance of the reused materials. Some sort of certification process is needed, but for the time being URCs provide limited or no warranty on the items sold, leaving the clients to evaluate the risk of their desired application.

All URCs visited agree that the demand for reused materials has gone up in the last 10-15 years, with most URCs that have operated the longest experiencing a slow but stable growth of their operations. Quality and good materials are said to be appreciated by the clients, with the appreciation that older construction materials were of higher quality and made to last.

Costs, benefits & Business models

Running an URC (like any economic activity) involves expenses and revenues. Expenses include costs of spaces, equipment, staff, materials, logistics/transport, waste treatment, taxes, interest. Revenues come from sales, subsidies (on labour, land, space), donations, or service fees.

Municipal-owned URCs tend to be funded by waste tax revenues. From the municipality perspective, the avoided costs for waste treatment (thanks to reuse or even upcycling) must be included into the operational cost equation.

Most URCs would struggle to make ends meet without government support of some sort, voluntary work or donations. The revenues from selling used or upcycled CDW (typically are 30-50% of the “new” retail price) are insufficient to cover the costs. Grønne Gengbrugshal has a special section in their store where they sell new products, to cross-subsidize the loss-making sales of used items. Most URCs partly rely on volunteers and make use of certain types of subsidized labour in the form of wage subsidies for staff, by employing people on social benefits. Both Återbruket and Återbyggdepå stated that they could not fully cover the personnel costs needed to operate the URC if they would not use subsidised workers. Moreover, there can be indirect subsidies when the city provides the URC with land or space below the market price. Some URCs (such as de Terugwinning) critically rely on donations of individuals or NGOs.

Environmental and societal benefits

URCs generate several environmental and social benefits that are not translated into hard Euro's. Environmental benefits from reuse, repair or upcycling come in form of avoided CO2 emissions, avoided extraction of virgin materials, avoided biodiversity loss etc. There are increasingly sophisticated methods to calculate the value of reduced CO2 emissions (per re-used item), based on the CO2 prices. The societal benefits include the following: For employees with distance to labour market: improve road to work, training; For citizens/clients: access to cheap building materials

Conclusions

The challenges to reduce virgin material use and waste in the construction and demolition sector are massive. Most waste is downcycled or ends in the incinerator or even landfill.

URCs play a pioneering role in the circular economy, giving discarded construction (and other) materials a second life, hence contributing to reduced CO₂ emissions and other planetary boundaries. They offer social benefits for citizens (access to cheap materials), work/training opportunities for disabled people or refugees, and raise awareness among citizens about the environment and the need for sustainable consumption.

As our study reveals, their operations are still on a relatively small scale. Moreover, for their survival they tend to rely on donations and/or government support in the form of subsidized labour, cheap land, subsidies. Apart from some niches where secondary construction materials are traded commercially (rare or valuable items such as wood or metals), there is not yet a viable commercial market. Moreover, due to resource, capacity and data constraints, many URCs fail to keep adequate inventories and lack professionalism in their marketing, sales and logistics.

A key problem for the scaling up of URCs is that professional and retail markets for secondary construction materials are in their infancy due to information deficits (risks associated with unknown quality of materials), competition from cheap new material, logistics challenges, conservatism in the industry, and the fact that social and environmental costs are not priced. Our study reveals that urban policies can make a difference. In particular, green procurement regulations by municipalities can force construction companies to use secondary materials, which will increase their value and boost markets. Also, stricter rules for selective demolition can save materials from incineration. Moreover, Green Deal initiatives such as Corporate Sustainability Reporting Directive (CSRD) will encourage a more sustainable approach to business practices.

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